DEVELOPMENT OF

NUTRITIONALLY-BALANCED SNACK PRODUCT

FOR URBAN SCHOOL-AGE THAIS

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ABSTRACT

A product development system for developing a nutritionally-balanced snack product for urban school-age Thais was designed. Systematic quantitative methods and techniques were planned and used in the major steps of the product development process. Five prototype models for the major product development activity steps evolved during the research. These included a model for formulation development, a model for process development, a model for sensory analysis development, a model for product evaluation, and the overall model for systematic nutritional product development (NPD model).

A fruit and nut snack bar was designed and then a commercial process developed to produce a product that was acceptable to the child consumers in Bangkok schools. Thai snack foods were classified scientifically and then three types -- Thai cookie, Thai pastry, and "rice-crisp" -- were identified as the most suitable for nutritional snacks for school children. The selection of appropriate ingredients, method of cooking and snack-type was based on a consumer survey with school children from 7-18 years old in Bangkok. Product ideas were generated by brainstorming and a literature review, and then were systematically screened and evaluated using the collected statistical data and also predicted information on the aspects of finance, technology, market and consumer. The "ideal product profile" was determined from the children's attitudes and behaviour towards snack foods.

The effective and reliable method developed for the formulation system comprised the major steps of "best-estimate" experimentation, experimental trials, linear programming experiments, acceptability tests and final adjustment of the formula. Selection of suitable formulae was based on acceptability tests with a laboratory taste panel using a profiling technique.

For process development, a Plackett and Burman experimental design was used for screening the process variables and factorial experimentation for optimising the process. Stepwise Regression and Yates' analysis methods were compared in the analysis of the results. The latter was considered more suitable for this project because it was easy to use, needed less time and money, and was effective.

A ratio profile test developed at Massey University was used in the development of product profiles through the whole system to develop the product. This technique was found effective in distinguishing the difference of the samples from the "ideal" product. A profile test using linear scaling was found suitable for a panel with some level of training, while that using category scaling for a panel with lower capabilities for sensory judgment. Four types of taste panels used during the sensory analysis development process were laboratory panel, special panel, consumer panel and consumer survey. The sample numbers of the panels were 6, 5, 30 and 1094 respectively. In general, the laboratory panel could predict the reactions of the consumer panel and the consumer survey in evaluating the product subjectively, and the special panel could differentiate the characteristics of the intermediate products desired by the next process.

An evaluation system used in this study comprised nutritional quality test, microbiological test, and storage test. Accelerated Shelf-Life Test using a factorial design was found an effective method for a storage test, while the Arrhenius Relationship Model was used for product shelf-life prediction. The most suitable factorial matrix was found to be "70, 90% RH; 25, 35, 45 C". These conditions of storage could be used for optimisation of storage condition, by Yates' analysis of the product quality at each storage time, and for estimation of shelf-life, by linear plotting technique of the product quality during the whole time of storage.

This project is worth continuing for commercialization by the private sector, and the designed prototype models are recommended for use in the systematic PD process to develop nutritional snack products.

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CHAPTER 1

INTRODUCTION

AND GENERAL LITERATURE REVIEW

Bangkok, the capital of Thailand, with its 5.33 million inhabitants in 1981 on the area of 1,565 square kilometres has the highest population density in the country. With over half of the country's urban population and a population size more than forty times that of Chieng Mai, the next largest city, Bangkok provides one of the most striking examples of urban primacy in the world (Arnold and Cochrane, 1980). In 1980, the average population growth rate of Bangkok was 3.9%, whereas that of the whole kingdom was 2.3% (Working Group on Population Projections, 1981). With this growth rate, the population in Bangkok would be 7.0 million people in 1990.

The rapid increase in Bangkok's population has exacerbated a whole range of social and economic problems in the capital city, where private wealth and public poverty meet in one place and where the large majority are non-food producers and depend on the market for their food supply. One of the major problems justifiable for serious concern is that in relation to nutrition.

Although many studies show that, compared with the rural population, the town dweller has more varied food including fruit and vegetables, has a higher consumption of animal protein, and has less seasonal influence on his diet (den Hartog, 1981), a FAO analysis of a number of food consumption surveys showed that the average per capita intake of calories was lower in the urban areas (FAO, 1973). The relative index for the household per capita income of Bangkok (141.2) was higher than those of other rural-urban locations (59.1 for Northeast, 69.5 for North, 80.2 for South, and 100.0 for Central). But the poverty line, which is derived from the cost of a minimum nutritional diet and a minimum level of expenditure for other basic needs, of the urban dweller is higher than that of the rural dweller (The World Bank, 1980a). In 1976, poverty lines in Thailand were 1,980 Bahts (U.S. $99) for rural dwellers and 2,960 Bahts (U.S. $148) for urban dwellers.

Although the percentage of the urban population below the poverty line (16%) is less than that of the rural (35%), the urban people, especially those in Bangkok, cannot grow their own food. Contrary to the situation in rural areas, all foods have to be bought. The supply of local traditional commodities is often inadequate and there is not always sufficient time for lengthy food preparation. On the other hand the supply of non-traditional foods, which are both more attractive and more highly priced, is abundant in Bangkok. This can cause problems for those Bangkok people who depend on medium and low cash incomes for nutrition.

1.1 MALNUTRITION AND EATING PATTERNS IN BANGKOK

The study on early protein-calorie malnutrition in slum areas of Bangkok Municipality showed the early and persistent growth retardation in all groups of children studied: Bang Pa-In (rural), Bangkok middle class, and 3 Bangkok slum districts (Khanjanasthiti and Wray, 1975). Also, the study on nutritional status among school children, aged between 6 and 17 years in Bang Khen area (Chandrapanonda et al., 1969), which is 15 kilometres north of Bangkok, showed the incidence of clinical signs of malnutrition. Although the children were larger and heavier than those measured in previous Thailand surveys, there was biochemical and clinical evidence of deficiencies of riboflavin, thiamine and vitamin A, and anaemia. Since most of the population in Bang Khen earn a living as labourers, skilled craftsmen and clerical workers in Bangkok (Chandrapanonda et al., 1969), those school children could be regarded as being from lower middle and low class families. Although the studies were conducted only in part of Bangkok, it can be presumed that malnutrition is widespread throughout this city, where approximately 90% of its people are categorized as middle and low income classes. Therefore it has been concluded that there is a necessity for a nutrition intervention programme for school children in the Bangkok area.

The problems of malnutrition in Thailand are not simple, the causes are many and varied (NSEDB, 1982), but undoubtedly, food habits are in general one aspect of the nutritional problem (Todhunter, 1973). A number of reports on Thai food habits and dietary patterns are available (de Young, 1958; Insor, 1963; National Statistical Office, 1964; Thompson, 1967; Chu, 1968; Janlekha, 1968; Moore, 1974; Calavan, 1976; Office of the Prime Minister, 1979). Some recipe books provide food patterns for different regions, and weekly menus as well. Scientific investigations were conducted on Thai food habits and dietary patterns by a number of nutritionists (Suvarnakich, 1950; Chandrapanonda, 1955; van Eekelen, 1957; Hauck, et al., 1958; Hauck and Hanks, 1959; Hauck and Sudsaneh, 1959; Participants of First Statistical-Training Program, 1973; Rajatasilpin and Temcharoen, 1976; Institute of Nutrition, 1978; Chong, 1979; Ngarmsak and Earle, 1982), but none are specific to urban school-age Thais.

These studies showed that rice, which supplied about 80 percent of the daily calorie intake and more than half of the protein, was the basis of almost all meals, at every income level. Small amounts of fish, meat, egg, vegetables and fruit were supplemented in the form of "with rice (GAB KAO)" dishes. One or more of these dishes was included in each meal. Fruits were seldom included in meals, but were eaten as snacks, principally by children. Milk was seldom given to children after weaning. The estimated average nutrient intakes were in general lower than the required allowance, particularly in protein, fat, certain minerals and vitamins. Taboos, food processing and communication were responsible for nutritional deficiency diseases (van Eekelen, 1957). Children were discouraged from eating large amounts of "with rice". This is one of the taboos worth noting here. The lack of nutritional balance in sources of calories and protein intake was another cause of malnutrition diseases.

In its basic form, the Thai meal was similar for all classes and all parts of the country (Blanchard, 1958) and eating habits varied only slightly between urban and rural areas (Anderson, 1975). In the urban areas there was a tendency to eat little but often, especially among the lower classes. Like the rural residence, the urban household devoted about 50 percent of the total household expenditure to food. Approximately 25% of the money spent on food in the urban area was spent on snacks (National Statistical Office, 1969 and 1976).

Even though the general eating pattern for the Thais is three meals a day, with all meals of equal importance and similar structure, one of the meals, usually breakfast, is always skipped by some of the urban school-age Thais for various reasons (from self observation). In addition, the only snack break time available during the week day at school is the time when the classes are over in the evening. Long journeys to and from home, which is the way of life in the urban area, together with the long school day, lengthen "between meal" time from 3 to 4 hours for average Thais to 5 to 8 hours for urban school-age Thais, particularly in the Bangkok area. As a result of these problems, "between meal" consumption of food could play an important role in the dietary pattern of many urban school-age Thais. Since eating at mid-morning or afternoon break would increase the intake of energy by children (Bresard and Chabert, 1968), snacks could be used to improve the nutritional status of school-age Thais. For this type of nutritional intervention, special emphasis should be given to snack type items purchased from vendors in schools, local grocery stores, small sweet shops, or other possible food outlets used by school-age Thais.

1.2 DEVELOPMENT OF NUTRITIONAL PRODUCTS

To insure the population a balanced diet, it is suggested (Hansen et al., 1979) that fortification of snack foods with a broad spectrum of nutrients should be considered. Until the public can be better prepared to evaluate nutritional values, a more extensive enrichment or fortification programme of snack foods is needed. However, since protein-calorie malnutrition is most widespread among Thai children, special interest should be given to protein and fat sources. No investigation has been conducted on the ideal nutrient intakes from snacks for school-age Thais. The application of 20 percent of total energy requirement was used in developing Thai home-made snacks (Intarampan et al., 1981). General studies (Post and de Wijn, 1969; Harju, 1981; Westin, 1981) showed that snacks with 10-20 percent of total energy requirement seem to be practical.

Although the development of nutritional products to help solve the nutrition problem has been recognised as a necessity by the Thai Government in the last two or three decades, it was only 15 years ago that the Institute of Food Research and Product Development (IFRPD) in cooperation with the Public Health Ministry succeeded in formulating the high protein low cost foods to be used for supplementation to the diet of the target group. The above project was part of the Food and Nutrition Policy and has been in the National Social and Economic Development Plans. However, the policy changed and the project was abandoned before the goal of combating malnutrition was fulfilled.

The main nutritional deficiency diseases which still exist are protein-calorie malnutrition, diseases of vitamins A, B1, and B2 deficiencies, simple goitre, iron deficiency anaemia, and gall bladder stones, with the protein-calorie malnutrition having the most prevalence and severity (NESDB, 1982). In solving these problems, IFRPD started with the Protein Food Development Project (Bhumiratana and Nondasuta, 1969; Bhumiratana, 1975). Foods produced included: Kaset cookies, Kaset biscuits, Kaset noodles, Kaset protein, soya milk, and infant food. Food products still currently produced are those used for food supplementary programmes, i.e. Kaset soya milk, Kaset infant food, and other high-protein low-cost products which include: Kaset protein, full fat soya flour, protein cookies (KANOM PING KASET), puffed baby food (KROB KROB KASET), Kaset noodles (Bhumiratana, 1978), soya protein sauce (Personal communication, 1983).

Great effort has been put on developing products -- formulation, process, quality control -- and reporting the results of investigations, whereas few consumer and marketing studies have been conducted. One market feasibility study on protein food supplement (meat analog) was carried out in the Northeast of Thailand, with several recommendations on product, price, place and promotion of the product (Bhumiratana and Co-workers, 1981). Although some investigations on the development, acceptability, and analyses of nutritional food products were conducted by other research workers (Siegel et al., 1975; Siegel et al., 1976), none has been found to include an investigation of consumer and marketing prospects.

Normally, the IFRPD developed products are distributed through two main channels. The greater part of the products is supplied to groups or programmes - day care centres and school lunch programmes - in collaboration with other government organisations or private groups. The minor part of the products is introduced to the general public through a limited number of distributors. Limitation of production, distribution, advertising, results in a blocking of the IFRPD products to the general population (Bhumiratana, 1978). According to the same report, improper marketing systems and distribution of food in Thailand cause unreasonable prices of foods to general consumers and result in nutritional gaps.

1.3 MARKETING OF NUTRITIONAL SNACK PRODUCTS

For commercial success, a developed protein-rich product has to be desired on its own merits; be priced at a figure that people can and will pay; have advantage over its competitors in quality, price, or nutrition; have an identifiable, attractive packaging and presentation; and be easily available where people will expect to buy it (Mauron, 1975). A clear marketing concept and advertising strategy needed to be associated with this marketing strategy. For the advertising strategy, local demonstrations, radio and press advertising, door-to-door sample distribution were suggested. The strategy for introducing a nutritionally developed snack food should include careful collection of information relating to foods already available and acceptable to the population. Since introducing new foods into a community involves major changes in attitude and behaviour, traditional food, of a taste and appearance known to be acceptable to the target population, might be possibly more suitable as a carrier of supplements. This would minimize a new taste, smell, colour, or texture that is foreign to the recipient, and would make the innovation of the nutritionally developed snack more likely to be accepted.

To ensure a positive attitude towards a new product as suggested by Robson, 1976, an understanding of current food behaviour of the target population as well as the ability to predict or determine public reaction to the developed food is required. It might be possible that studying past experiences of consumers and their attitudes and behaviour towards snack foods and selected traditional snacks would help identify specific factors and circumstances that have facilitated or motivated changes in food behaviour. In this way, existing foods and food habits of the Thais would be utilized to their best advantage in the introduction of a nutritionally developed product. However, the developed food for an intervention programme, as suggested by Robson, 1976 must not only be acceptable in taste, colour, and texture, but it must also be stable, economically and aesthetically.

Unfortunately, even though there are a wide variety of Thai snack foods in the market place, they are mostly made by hand on a trial and error basis in the home or on a small scale. This results in short storage life, high price, distribution inconvenience and low market share. A certain level of food processing technology and marketing is needed firstly to improve the products' nutritional value and storage stability so that they are easy to store, distribute and market, and secondly to reduce the costs.

It has been suggested (Edwardson, 1974; Anderson, 1975; Chittaporn, 1977) that through the proper use of indigenous food raw materials and with suitable supplementation, acceptable food products of high nutritive value with low cost could be designed. It would be possible, with the application of a quantitative procedure, to design formulated snack foods used as nutritional supplements for urban school-age Thais. In particular, typical baked or roasted products made from local raw materials, would have a long storage life potential, and should be readily accepted by the consumers.

For the people at subsistence level in the urban slums, with no possibility of growing crops, it was suggested (Mauron, 1975) that supplementary food must be given away or, better still, sold at a very cheap price by government agencies through welfare centres and institutional feeding. However, past studies of IFRPD which seemed to follow this method showed that the existing supplementary foods are distributed on a relatively small scale and seem to be unsuccessful commercially. For the time being, the surest way for a product to be a success, as suggested by Mauron (1975), is for it be offered on the market and become accepted and bought by the consumer. In other words, the deciding factor for a nutritionally developed product to succeed will be the marketing approach. The rapidly increasing sales of the amino acid fortified broth cube in Nigeria was given as an example of what an appropriate marketing strategy can do.

Even though in Thailand, there is a majority group of low income people there is also a more or less expanding middle class, and a small upper class. The lower income segments have some limited cash available above mere subsistence. In Thailand as in most developing countries, it is mainly urban communities that have cash for buying processed foods, and a realistic food processing programme should have the urban population as its initial target (Sai, 1975). Therefore, it would be possible that by proper adaptation of the food industry classic market approach, the formulated nutritional supplements could reach some segments of the target school-age Thais and become accepted and bought by them. In this case, a snack food seemed to be a suitable product as a nutritional supplement because of the large amount of money spent on snack foods and the frequent snacking habits of the urban people.

1.4 LITERATURE REVIEW ON THAI SNACK FOODS

1.4.1 Introduction

For a guaranteed success in the introduction of any nutritionally developed product, various aspects of existing foods of the target population should be utilized to their best advantage. For this study, a large number of Thai snack foods were investigated to find a suitable one to develop. From a preliminary study on Thai snack foods, it was found that recipes and descriptions of the making of Thai snacks were not in a scientifically-organized form, and many more were not written down. It is the purpose of this section to present in usable form the basic technical information on Thai snack foods -- historical background, classification, quality and acceptance, basic ingredients, formulae, processes, and equipment.

Since there can be no common understanding of food language without a resolution of terms, definition and/or explanation of Thai terms under appropriate categories was unavoidable. English names, given to all Thai foods described, are based on either the methods of preparing and cooking the snack food or the forms of the finished products, depending on their suitability for describing the product. Thai names are given in Phonetics (Appendix 1.1).

1.4.2 Eating of Snacks in Thailand

Excluding rice, the staple food, the Thai diet is classified into 5 categories: "with rice" dishes or savoury dishes (GAB KAO), desserts (AHHAHN WAHN and KANOM), fruits and vegetables, drinks (excluding alcoholic drinks), and snacks (AHHAHN WANG or KONG GIN LEN). The Oxford English Dictionary characterized a snack as a light or incidental repast or a mere bite or morsel of food as contrasted with a regular meal, and to be eaten between meals. Snack is regarded, by the Thais, as food eaten outside a meal time. This includes "a bite" or "a sip", of any food category, between meal times. Also, it includes certain foods not classified under the above classes, e.g. chewing betel nut and chewing fermented tea leaves which could be regarded as foods for pleasure or for fun, as opposed to foods for survival.

1.4.2.1 Historical Background Of Thai Snacks. The Thais have had snacks as a part of the daily diet since ancient times. This is supported by the verses, composed by King Rama II (1809 - 1824), concerning varieties of snacks - gruel or boiled rice (KAO TOM), tapioca pudding (SAKOO), steamed fluted rice flour tartlet (KANOM JEEB), fried dried-cooked-rice (KAO TANG), steamed coconut milk rice with green papaya salad (KAO MAN SOM TAM), which are still popular among the modern Thais (Division of Literature and History, Department of Fine Arts, 1982). Organoleptic properties, such as colour, flavour, texture, and temperature, for those snacks were described in these verses, from which one can learn their ideal characteristics. Among the typical rice-snacks, rice in cold water (KAO CHAH) and fermented steamed-rice (KAO MAHG) were regarded respectively as popular "monk offering" food and as traditional snacks for the water festival (WAN SONGGRAHN).

1.4.2.2 Thai Snacks In Four Regions. As in most other countries, the dietary pattern varies slightly in different regions of Thailand depending on factors such as geographical location, economic status, customs, beliefs. The two latter, practised for generations, play an important role in the "do" and "don't" in the diet and result in specific food habits. Even though snacks, like other Thai food categories, vary only slightly for the Thais in different regions, the traditional or "typical" ones do differ, especially those which are regarded as food for local festivals.

Generally, the sensory characteristics of foods in each region also apply to its regional snacks as well. Northern food is milder than that enjoyed in other regions. Northeastern food is mostly sour, salty, and chilli hot. The Southern Thais prefer foods that are spicy-hotter, saltier, and sourer when compared with foods of the other regions. Central Thai food is generally rather salty, hot, and mild sweet. As for Bangkok, diet patterns vary. This results from the fact that it consists not only of actual Bangkok dwellers, but also new-comers from other parts of the country and from other parts of the world as well.

1.4.2.3 The Confused Classification Of Thai Meals, Snacks, Desserts and Sweets. A considerable number of cook books provide recipes for Thai food (Ruegsasarn, 1954; Ruegsasarn, 1957; Pranakorn Tai Vocational College, 1974; Jarupan, 1976; Pinsuvana, 1976;

Kritikara and Amranand, 1977; Suban, 1977; Saipanya Association, 1978; Suban, 1978; Suban, 1979; Saipanya Association, 1980; Kachacheewa, 1981; Saowapa Vocational College, 1981; Anonymous, 1982; Varied Food Book Programme, 1982; Na Songkhla, 1982; Suban, 1982a; Suban, 1982b; and Xoomsai, 1982). Food items are classified mostly under headlines such as savoury food or "with rice" dishes, snack or one-plate dishes, and desserts or sweets. Hors d'oeuvre is categorised separately from snacks by some authors. None of those cook books define their standard of criterion for classification. Some food is listed under different categories by different authors or by the same author in different issues. The reason for this confused classification might be because no clear distinction is made between snacks and meals nor between snacks and desserts and sweets. Also, the change in the way of life of the modern Thais results in a blurred image of meal patterns. The Thais have cooked/uncooked food items that could be considered either as a meal or a snack, e.g. stir-fried rice or noodles, and some items that could be considered either as a snack or a dessert e.g. steamed glutinous rice with various toppings - sweet or savoury (KAO NEAW GRA TONG). Undoubtedly, the Thais do have food items considered as only snacks, e.g. various types of thin sheet rolls (POH PEA), steamed fluted tartlets (KANOM JEEB), steamed folded tartlets (KAO GREAB PAHG MO), balls of steamed tapioca pearls (SAKOO SAI MOO), shredded coconut and prawns in egg sheets (KANOM BUENG YUON), fermented rice sausage (SAI GROG KAO), Thai barbecue (MOO SATE), sauted rice flour square (KANOM HUO PAG GAHD), chicken mixture in fried tarts (GRA TONG TONG), and crispy rice sheets with a pork side-dish (KAO TANG NAH TANG). Fruits are normally taken, fresh or preserved, as snacks by the Thais, especially those of a young age.

Interestingly, the Thais use the word "KANOM" as a noun especially to distinguish a snack, dessert, or sweet from a meal. The New Model Thai-English Dictionary by So Sethputra described "KANOM" as sweets or sweetmeats; but, as well as his examples of desserts and sweet snacks, his list included savoury snacks and hors d'oeuvres under savoury type examples.

A list of selected Thai snacks and KANOM with phonetics and English defined terms were collected and are shown in Appendix 2.1M.

1.4.3 Classification of Thai Snack Foods

In general, Thai snack foods can be classified in different ways depending on the basis one uses i.e. snack-type, main ingredient, organoleptic property, method of cooking, method of storage, held-in-hand convenience, source, and typical or traditional basis (Appendix 1.2). The basis to be chosen depends on the purpose or the goal of one's study.

For this project, a Thai snack with industrial-potential was required; thus, snack classification was done on the basis of method of cooking. This method designates not only the shelf-life of the product but the equipment to be used as well. Using the principal medium of heat transfer for cooking as the basis, Thai snacks were classified under 4 groups of cooking processes: dry-heat process, moist-heat process, heating-in-fat process, and drying.

1.4.3.1 Dry-Heat Processed Snacks (excluding fat cooking). Snacks classified under this category include those cooked by baking, roasting, broiling, baking by direct transference of heat, dry-puffing, and extrusion cooking. Among these, roasting and baking (including baking by direct transference of heat) were the most frequently used for Thai snacks which have long shelf-life potential. Roasted rice-and-nut square and peanut glass are two examples of Thai roasted snacks. Cassava cookies (KANOM PING), baked stuffed buns (KANOM PEAH), rice crisps (KAO TANG), and crispy rolls (TONG MUON) are good examples of baked snacks.

1.4.3.2 Moist-Heat Processed Snacks. Though methods under this category are many, only hot stirring, deep-syrup cooking, and deep-syrup soaking will give long shelf-life products because of their water-reduction characteristics. Fruits that are hot-stirred, deep-syrup cooked, or deep-syrup soaked could keep for months at the room temperatures of Thailand. Apart from fruits, beans and roots are also often prepared using these processes although the storage life of the products is shorter.

1.4.3.3 Heating-In-Fat Processed Snacks. Many Thai snacks, such as fruit and peanut fritters, are cooked by using oils, but none is found to last long without rancidity problems. Therefore, less attention was put on this process.

1.4.3.4 Dried Snacks. Since drying is one of the typical methods of preservation in Thailand, a great variety of dried snacks can be found in the market. Among fruits, dried banana is considered the most popular by Thais of all ages and in all regions. Fruit that is dried is not only used as a snack by itself but is widely used as an ingredient in other snacks as well. The use of mechanical dehydration methods at the present time improves the quality of the Thai dried snack products. This has resulted in a greater interest by the snack food industry.

These methods of processing were used to classify the Thai snack foods (Appendix 1.3).

1.4.4 Thai Snack Quality and Acceptance

From the aspect of product development work, food acceptability and preference depend on consumer sensory responses; Therefore, the sensory qualities commonly identified by the consumer are considered of importance. The Thais, like people of other nations, follow their ancestors in food acceptance. Thai snack food qualities have long been characterized. The verses composed by King Rama II as previously mentioned proved this statement.

Theoretically, sensory qualities of food are those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing. These senses are used for evaluating food at the time of eating. For all Thais, the sensory attributes, appearance, texture and flavour, are recognized as important. For example, the average Thai accepts the roasted nut that is browny cream in colour, crispy in texture, and pure-nutty in flavour; and he accepts deep-syrup cooked banana that is red, chewy, and fruity-sweet.

Although many instruments, nowadays, can be used for measuring some of the Thai snack food characteristics, the results obtained from some of these might not correlate with the food characteristics as recognized by the Thai consumers. Even more, some of these instruments might not measure the same properties as the sensory evaluation. As a result, sensory tests are the only way that the investigator can get a meaningful evaluation of Thai snack food characteristics as a whole. Therefore, analysis of snack characteristics to identify the sensory parameters of a product is necessary for product development work, and so is the use of proper and appropriate character notes, terminology, or descriptive terms. The quality factors for each class of Thai snack foods were collected (Appendix 2.5M), and a considerable number of character notes for appearance, texture, and flavour used by the Thais can be found in Appendix 2.2M, while a chart of the sensory test method adapted from methods of ISO (1982) which could be used to qualify Thai food products is shown in Appendix 2.3M.

1.4.5 Basic Ingredients, Formulae and Processes for Thai Snack Foods

The basic ingredients, formulae, processes and equipment for Thai snack foods were studied and classified scientifically (Sinthavalai, 1984). Thai snack food formulae, their processes or major "making" steps, together with some of their quality factors were collected in a form ready to be used as a guidance for product development work (Appendix 2.5M).

1.5 THE POSSIBLE SNACK PRODUCTS FOR THIS PROJECT

In this project, in which the aim was to develop a long shelf life, nutritional snack that could be produced commercially in Thailand, emphasis was put on the use of cereals, nuts and fruits in the formula, and the use of baking, roasting, puffing, deep-syrup cooking, and hot-stirring in the process. Among the possible products based on these cooking methods, Thai cookie, Thai pastry and rice-crisp might be the most suitable because of their long shelf life and higher acceptance characteristics, and also because the nutritive value improvements of these products could be done by formulation techniques. Thai cookie is basically made of cassava flour, coconut cream, egg, sugar and flavouring ingredients; and Thai pastry is made of wheat flour, lard and sugar for its body and a great variety of mixes for its filling. The baking method of cooking is used for these two types of snack foods. Rice-crisp is made of boiled rice which is later cooked by the "direct transference of heat" method. The great variety of toppings makes it variable in its nutritional values.

1.6 THE NEED FOR A QUANTITATIVE SYSTEMATIC MODEL FOR SNACK PRODUCT DEVELOPMENT FOR URBAN SCHOOL-AGE THAIS

The development of nutritional snack products could follow the systematic process for new product development, or the PD process, divided into 6 steps by Booz - Allan & Hamilton Inc.(1980) as follows: exploration (or idea generation), screening, analysis evaluation (or business analysis), development (formulation & process), testing (storage, production, and consumer/market trials), and commercialization. Each of these steps identifies the activities performed in bringing new product ideas to the marketplace, and each needs suitable methods and techniques to ensure success. Methods and techniques for each step of the PD process are many and varied, and can be found in the literature (Pessemier, 1966; Watton, 1969; Earle, 1971; Pessemier and Root, 1973; Edwardson, 1974; Anderson, 1975; Siegel et al., 1975; Siegel et al., 1976; Chittaporn, 1977; Carson and Rickards, 1979; FTRC, 1979; Twiss, 1980; Anderson,1981; Ngarmsak, 1983; and Earle and Anderson, 1985).

For Thai foods, methods and techniques successfully used included the quantitative models proposed by Anderson (1975), Chittaporn (1977), and Ngarmsak (1983); each of which, in a stepwise manner, applied the quantitative systematic techniques in one or more of the PD step(s) of screening, development, and testing. These are good examples to show how nutritious and acceptable foods -- raw materials, infant food, and traditional regional meals -- could be systematically developed for Thai people and how their acceptability could be evaluated. However, no investigation was found on the development of Thai snack foods, which could be considered as one of the main parts of their diet, especially for those school-age children in the urban area. It is believed that a suitable method and technique for developing nutritionally-balanced snack products for urban school-age Thais could be designed using product development methods developed by other workers. However, further study on some of the product development methods and techniques, especially those used during the development steps of formulation and process development and those used for sensory testing of the products, was considered necessary.

1.7 AIMS OF THE PRESENT PROJECT

The aims of this project, therefore, were to design a suitable method and also the techniques for developing a nutritionally-balanced snack product for urban school-age Thais, and to develop a commercial process to produce a product that was acceptable to the urban school-age Thais. The main objectives were:

(1) To study the attitudes and behaviour towards snack foods of urban school-age Thais.

(2) To study the screening methods for nutritionally-balanced snack product development.

(3) To establish a systematic formulation and process development method, along with its statistical techniques, for nutritionally-balanced snack products.

(4) To establish a systematic method for sensory profile testing during product development and the statistics associated with it.

(5) To study the methods for evaluation of a nutritionally-balanced snack product.

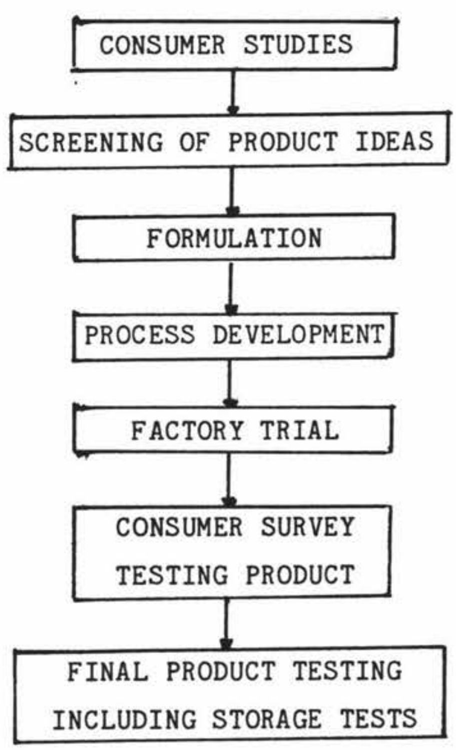
(6) To design prototype models of the major activity steps and of the overall system for a systematic nutritional product development process for Thailand.

CHAPTER 2

PROJECT METHODS

2.1 INTRODUCTION

In this systematic product development project, which was based on the use of the various methods and techniques of the PD steps (see Diagram below), project methods were different in nature. For example, the methods and techniques used for the consumer studies followed the social science discipline, while those used for process development followed the discipline of engineering and those used for product quality testing followed that of food science. Therefore, for ease of reference, this chapter discusses the project methods in general, while specific methods and techniques for certain product development activities are discussed in the chapters associated with them. However, emphasis is put in this chapter on the test methods used for raw materials, intermediate-materials and products because they were used immediately at the beginning of the formulation process.



Project Diagram

2.2 CONSUMER STUDY METHODS

Two major types of consumer study methods used were the consumer surveys, before and after the development step, and the consumer panel test of the developed product at different phases of the formulation. Methods and procedures for each of these studies are under the chapter associated with them, i.e. the consumer surveys in Chapter 3 on "Attitudes and Behaviour of Urban School-Age Thais towards Snack Foods", and the consumer panel test in Chapter 6 on "Sensory Analysis Development and Statistics". Briefly, for the consumer survey, the interviewing method was used, linear and category scaling was used in the questionnaires, and statistical methods were used for data analysis and interpretation. For the consumer panels, the optimum location profile technique was used.

2.3 FORMULATION AND PROCESS DEVELOPMENT METHODS

The formulation methods were mainly based on the optimization techniques, linear programming for formulation and factorial experiments for process development. However, these techniques were used in an interactive way with the product preparation trials and the sensory profile tests. These methods are described in detail in Chapter 5 on "Formulation and Process Development and Statistics".

2.4 TEST METHODS

2.4.1 Introduction

The quality evaluation in this project was conducted differently in various stages of the PD process depending on the aim of the particular experiment. Also, the quality evaluation conducted during phase 1 in New Zealand and phase 2 in Thailand was different in some cases depending on the availability of equipment. However, the tests used were on a similar basis, though not exactly the same. For example, the refractometer and oven drying moisture content determination were used in phase 2 to investigate the moisture available in the intermediate/finished product, in place of the water activity (Aw) analyser used in phase 1 which gave a more precise value of the water content available in the product.

In this project, the quality of the raw materials was not investigated chemically because of the unknown history of the raw materials obtained. The low availability of the local Thai raw materials in New Zealand and the lack of labelling or of specification of those raw materials in Thailand limited the scope of this investigation. However, raw materials were subjectively controlled by using raw materials of the same type, maturity, freshness, and sources. For their quality, they were assumed to be similar to what had been found in past studies. For example, mungbean was assumed to have similar chemical and physical properties to that of mungbean in the market studied by Narkrugsa (1983).

Intermediate materials such as deep-syrup cooked banana (DSC-banana), banana-syrup (B-syrup), 'boiled - hot stirred - evaporated' mungbean (BSE-mungbean), and 'mixed-pressed' snack (MP-snack) were also evaluated for their quality objectively and subjectively. DSC-banana was banana cooked in syrup for a certain period of time until a certain temperature was reached and the cooked banana was saturated with thick syrup. B-syrup was the syrup left from deep-syrup cooking of banana. BSE-mungbean was mungbean which was boiled and then hot-stirred until a dough could be formed and then was evaporated until the moisture content was at a certain level. MP-snack was the snack obtained by mixing the prepared ingredients and pressing the mixture. Standard tests were used wherever possible for the intermediate materials, but in some cases some new tests had to be developed to suit the circumstances.

Methods and procedures for quality evaluation in this project were divided into 4 classes based on the properties being tested. These were -- nutritional quality test, objective test (physical, physico-chemical, and chemical), microbiological test and subjective test.

2.4.2 Nutritional Quality Test

Table 2.1 shows the references for the methods and techniques used for measurements of the nutritional quality of the developed nutritional product.

Table 2.1: References for methods and techniques for nutritional measurements of developed nutritional product.

Nutritional Attributes	References	Remarks
Proximate Analysis		
Moisture content	AOAC, 1984	
Fat	AOAC, 1984	Acid hydrolysis (Ether as extracter)
Protein	AOAC, 1984	Kjeldahl method
Ash	AOAC, 1984	
Carbohydrate	-	By difference
Crude Fibre	AOAC, 1984	
Total solids	-	
Vitamin Determinations		
Ascorbic acid	Roe and Kruther, 1942 Association of Vitamin Chemists, 1966	
Vitamin A	AOAC, 1975	modified
Amino Acid Determinations		
Tryptophan Threonine Isoleucine Leucine Lysine Methionine Cystine Phenylalanine Tyrosine Valine	Hitachi Perkin-Elmer Model KLA-3B Amino Acid Analyser	
Arginine Histidine Alanine Aspartic acid Glutamic acid Glycine Proline Serine		

Chemical scoring, which was used as an evaluation technique for the protein quality of the product, was done by using two methods, and the results from the two were compared and the limiting amino acid determined. In the first method, the chemical score value was obtained by dividing the percentage of the most deficient amino acid, or in other words the limiting amino acid, by the percentage of the same amino acid in the reference protein (FAO/WHO, 1973 as quoted by Nutrition Division, Department of Health, 1983). The value obtained was called the 'A/E chemical score'. In the second method, the actual amount was used instead of the percentage for both the most deficient amino acid and the same amino acid in the reference protein, and the value obtained was called the 'A/T chemical score'.

2.4.3 Objective Tests

Objective methods, other than the nutritional test mentioned above, used for the evaluation of the intermediate/finished product at various stages of the present PD process could be classified into -- physical, physicochemical, and chemical testings. Table 2.2 is the summary of techniques and equipment used for quality testing objectively at major steps of development.

Weight. The weights of the intermediate and/or finished products were measured by an electric weighing machine or by an ordinary spring scale. Where specified, the weight loss was calculated.

The Compression & Extrusion Force. Normally, the consumer evaluates texture in DSC-bananas by finger-pressing and by compressing and chewing during mastication. Because of this, compression and extrusion was the mode considered to be best used in the objective texture measurement of this product. The forces needed for compressing and extruding the cooked and the uncooked bananas were measured by using INSTRON Model 1140. Two replications were conducted for each sample.

The OTTAWA Texture Measuring System food cell with a wire grid insert was used because it was believed that it combined the deformation mechanisms which occur during mastication of the DSC-banana. As the plunger plate was driven into the sample in the cubic cell, the product was compressed and eventually forced to extrude through the wire grid underneath. The depth of penetration was preset so that each test had the same mechanical parameters. The plate then could be extracted and the tested banana returned to the cell and a repeat test performed simulating a second chew. The test description and parameters used are shown below-

: Type Instron Model 1140 with Ottawa Texture Measuring System Food Cell

: Sample* DSC-banana 160 g (approx. 6 cm thick or 120 cc)

: Fixture Plunger plate and rod attached to anvil adaptor

: Drive speed 40 mm/min
: Chart speed 200 mm/min
: Force range 50 Kg (Full scale)

* Calculation of weight of sample:-
Chart length 6 cm (= depth desired)
Thus, sample depth 6 cm
Thus, sample volume 6 x 20 = 120 cc
At about 1.4 g/cc
Thus, 120 cc weighs 120 x 1.4 = 160 g

TABLE 2.2.: OBJECTIVE MEASUREMENTS OF INTERMEDIATE/FINISHED PRODUCT AND EQUIPMENT USED

Intermediate/Finished Product	Measurements	Equipment
DSC-Banana		
Phase 1	Weight	Electric weighing machine
	Compression & Extrusion force	INSTRON Model 1140
	Tristimulus value - X, Y, Z	NEOTEC Colorimeter, DU-color Model 220
	pH	pH-Meter, type PHM28, RADIOMETER, COPENHAGEN
	Moisture Content	Sauter I/R Toppan balance (August Sauter KG. EBINGEN WURTT)
	Aw	Aw-value Analyzer Model 5803 G.Lufft GmbH & Co
	%SS	ATAGO Abbe Refractometer New Type No 301
Phase 2	Weight	Spring Scale
	% SS	Hand Refractometer
BSE-Mungbean		
Phase 1	Weight	Electric Weighing Machine
	Moisture Content	Sauter I/R Toppan balance
Phase 2	Weight	Spring Scale
	Moisture Content	PROTIMETER GRAIN MASTER III (Protimeter Ltd, Meter House, England) and Drying Oven
Snack Bar		
Phase 1	Weight	Electric Weighing Machine
	% SS	ATAGO Abbe Refractometer New Type No 301
	Aw	Aw-Value Analyzer Model 5803 G.Lufft GmbH & Co
	Moisture Content	Sauter I/R Toppan balance
Phase 2	Weight	Electric Weighing Machine
	Moisture Content	Drying Oven
	Aw*	Aw-Value Analyzer Model 5803 G.Lufft GmbH & Co

* For product brought to New Zealand

160 grams of DSC-bananas, in a cut-up form, was placed in the cell for each test. The total travel of the plunger which was represented by the distance of the 'initial compression' and 'compression and extrusion' on the chart is a function of the sample size and the preset travel limit. The portion of this distance which is used for initial compression and the force at the onset of extrusion is a measure of cohesiveness and compressibility of the sample. The recovery of the sample can be investigated from the reduction in travel between the first and second test of the same sample. The change in force between successive tests is a measure of the chewiness of the product. These values can be readily compared between alternate samples to determine the optimum values of the many processing variables in making such a product.

Colour Measurement (CIE Tristimulus Value). Normally, the consumer evaluates the colour in DSC-bananas by its red intensity and glossiness, and also the evenness of the colour in the whole product. Because of this, the description of a colour in terms of luminance, dominant wavelength, and purity in the C.I.E. System was chosen to be used objectively.

In this experiment, the CIE Tristimulus Values (X,Y,Z) were measured by the NEOTEC Colorimeter, DU-COLOR Model 220. The test descriptions are shown below-

: The standard used for the adjustment of X, Y, Z values was Standard Pink (Y = 47.8; X = 55.6; Z = 44.5).

: The adjustments were made every 5-10 minutes.

: The sample container used was a glass sample container (glass window) with a metal ring in the middle.

: The cover was of a plastic type for the sample and of black cloth for the light source.

: The samples were DSC-banana and B-syrup.

: The weight of the sample was 25 g (which was approx. 1-2 cm thick).

pH Value. The pH value of the DSC-banana and the B-syrup in phase 1, was measured by using a pH-Meter, type PHM 28, RADIOMETER, COPENHAGEN. For DSC-banana measurement, 10 g of distilled water was added to 5 g of pulped banana, and the mixture was stirred well before the measurement. Replications were made and the average was taken.

Moisture Content. In phase 1 of the process development in N.Z., the moisture contents of intermediate and/or finished product was measured by using Sauter I/R Toppan balance (August Sauter KG. EBINGEN WURTT). 10 g of samples were used. In phase 2, the moisture contents were measured using a drying oven. A lidded tin was dried at 105 C for three hours and cooled for 1 hr in a desiccator and then weighed. Approximately 5 g of sample was weighed into the tin and then dried at 105 C for 3 hrs (with the lid opened) in the drying oven and cooled in a desiccator for one hour. The cooled sample was weighed and the weight loss calculated. The drying process was repeated until no weight loss was obtained. Replications were done and the average data was used. In optimising the process conditions for BSE-mungbean, the moisture content of the BSE-mungbean was measured by using PROTIMETER GRAIN MASTER III (Protimeter Ltd. Meter House, England).

Water Activity Value. The water activity values of the intermediate and/or the finished products were measured, in phase 1, by using Aw-Value Analyzer Model 5803 G.Lufft GmbH & Co. Half an unwrapped bar was placed in the meter which had previously been standardized with saturated barium chloride solution. The meter was allowed to equilibrate over a period of three hours and then the water activity was read directly.

Percent Soluble Solids. The percentage of soluble solids of the intermediate product was measured using an ATAGO Abbe Refractometer New Type No 301 for phase 1, and using a hand refractometer for phase 2.

2.4.4 Microbiological Tests

The stored-product and the factory samples were tested microbiologically by plating on plate count agar for a total plate count and on acidified potato dextrose for yeasts and moulds. The samples were incubated at 35 C for 2 days. An unopened sample was used for microbiological testings. A 10 g sample was transferred aseptically into a stomacher bag with 90 ml of 0.1% peptone water which was then mixed for approximately 10 seconds. Dilutions of the sample were prepared and plated out on Plate Count Agar and incubated at 35 C for 2 days for the total plate count, and plated out on acidified potato dextrose and incubated at 30 C for 3-5 days for yeasts and moulds.

For the preliminary experiment on DSC-banana in phase 2, a simple technique was used to obtain information on microbiological susceptibility. A visual judgment by counting the days taken for visible mould growth on the sample was carried out and the 'mould growth susceptibility scores' were obtained. These scores designated the keepability of the DSC-banana. Higher scores were preferred. The findings were used as a supplement to the final decision on the process development of DSC-banana.

2.4.5 Subjective Tests

Sensory properties of the intermediate product were assessed by a special panel, and those of the finished product by laboratory panels and consumer panels. This is discussed in Chapter 6 on Sensory Analysis Development and Statistics.

In this study, where information, simple or complex, was collected for use as a guide to a selection of the appropriate methods for testing a nutritional product for the intervention programme in Thailand, sensory properties of the in-process intermediate product were also judged by the operator and the author as well. This included 'in-pan' test, 'in-product' test, specific volume, colour score, handling (convenience) score, and 'sticking-to-mould' score.

In-Pan Test. During the hot-stirring processing of mungbean, characteristics of cooked mungbean were thoroughly subjectively and objectively tested at selected stages and the results of both were related. The subjective test was a visual inspection of the characteristics of the 'in-pan' product, and the objective test was a moisture content measurement. The results of this test were expected to be of benefit in the designing of process instruction procedures.

In-Product Test. Where possible, suitable intermediate products, obtained from the process experimental trials or from the process optimizing experimentation, were experimentally used in the preparation of the finished bar and the quality was subjectively and objectively tested.

Specific Volume. The specific volume of the BSE-mungbean was measured by measuring the BSE-mungbean in a measuring cup (237 ml) and weighing the measured BSE-mungbean. The specific volume value was calculated by using the following expression: Sp.Vol. = Vol.per cup / wt.per cup (of the BSE-mungbean sample). A specific volume value of 2 was considered ideal for BSE-mungbean to be used for the nutritionally-balanced snack bar, while a value below 2 was considered lower in quality because the BSE-mungbean was too dense, caused by too long a cooking time or too short a cooking time. BSE-mungbean which had been cooked for a short time was too soggy while that which had been cooked for a long time was too dry. The latter BSE-mungbean would turn out to be so hard-gritty that it could not be impregnated with the syrup to be added at the later stage of the process.

Colour Score. For mungbean process experimentation, the colour of BSE-mungbean was visually inspected and scored by the operator and the author, then the colour scores were averaged. BSE-mungbean of a bright yellow colour was scored higher than that of a dull yellow colour or that of a greenish yellow. The three category scale used was 1, 2, and 3. Scale 3 designated the bright yellow colour and scale 1 the dull yellow colour.

Texture Score. For the mungbean process experimentation, the texture of BSE-mungbean was subjectively inspected and scored by the operator and the author, then the texture scores were averaged. BSE-mungbean texture without grittiness but with fluffiness instead was assigned a higher score. The three category scale used was 1, 2, and 3. Scale 3 designated a fluffy texture and scale 1 a gritty texture.

Handling Convenience Test. For the mungbean process experimentation, ease in the hot-stirring process during the evaporation step was subjectively inspected and scored by the operator and the author, then its scores were averaged. The three category scale used was 1, 2, and 3. Scale 3 designated the easiest in handling and scale 1 the hardest. For the MP-snack operation experimentation, the convenience in handling or manipulating the mixture and the pressed snack was also inspected and the scores averaged. The ten category scale used was 1, 2, ... and 10. Scale 10 designated the easiest and scale 1 the hardest to handle.

'Sticking-to-Mould' Score. For the MP-snack operation experimentation, the sticking-to-mould of the in-process product was judged by the operators and the author, and the data obtained were averaged. Higher scores were preferred for a lack of sticking-to-mould property. The ten category scale used was 1, 2, ... and 10. Scale 10 designated 'not sticking-to-mould' and scale 1 the 'most sticking-to-mould'.

CHAPTER 3

ATTITUDES AND BEHAVIOUR OF URBAN SCHOOL-AGE THAIS TOWARDS SNACK FOODS

3.1 INTRODUCTION

The need for a systematic process in the development of nutritional products has been mentioned. To ensure a positive attitude towards a new product, an understanding of the current food behaviour of the target population, as well as an ability to predict or determine public reaction to the developed food, has been proved a necessity. A careful consideration of consumer needs during product development is known to be an important factor in product success. Though a number of reports on Thai food habits and dietary patterns were available, none were found to be specific to urban school-age Thais and their snacking pattern. The purpose of this survey research on consumer attitudes and behaviour of urban school-age Thais was to identify, before and after the development phase of the nutritional product development process, the attitudes and behaviour towards snack foods in general and the reactions to various aspects of the developed snack food.

3.2 METHODS AND TECHNIQUES IN CONSUMER SURVEY RESEARCH

3.2.1 Definition And Classification

With the concept of 'consumer orientation' of modern marketing, marketing research deals mostly with information about consumers. Marketing research is defined (Zikmund, 1982) as "the systematic and objective process of gathering, recording, and analyzing data for aid in making marketing decisions". In general, marketing/consumer research methods can be classified into survey, observation, experimental, and historic methods. Consumer surveys can be done by interviewing, formally or informally, of the target samples. Techniques that can be used for formal interviewing include mail-questionnaire, telephone-interview, and personal-interview. Details under each method and each technique can be found in a number of articles (Moser, 1967; Cox and Enis, 1973; Green and Tull, 1975; and Zikmund, 1982).

3.2.2 Methods and Techniques Used in Consumer Surveys on Snacks

Though a great number of reports could be found on consumer surveys and on the development of snack foods, few were on the reactions of consumers specifically to snack foods. Among those few, the emphasis was put on the acceptability of the product rather than the combination of acceptability and marketing aspects which is considered a main part of the product development process.

Steel et al.(1952), as quoted by Truswell and Darnton-Hill (1981), in their study on the role of breakfast and of "between-meal" foods in adolescents' nutrient intake, is a good example of a snacking pattern consumer survey. The dietary questionnaires of Richardson et al. (1981), in their survey research related to dental caries diet, were based on a 24 hr-recall by groups of children. Trained field workers were used in this survey. Musgrave et al. (1981) designed "group interviewing" which was also based on a recall method for use in their study on "Strategies for Measuring Adolescent Snacking Patterns". The group interviews were held in classrooms with a display of food models for assisting the visualization of amounts eaten. This was considered a less expensive method than individual interviewing.

Gillespie (1983) developed methods for collecting data on snacking patterns and utilized those methods to study the snacking behaviour of a sample of elementary school students. The students were interviewed to determine the frequency and time of eating snack foods on a list, both at home and away from home. Systematic evaluation of snack qualities was based on their relative nutritional merits. Snacks selected at home were found to be nutritionally better than those selected away from home.

In a Thai snack study, supplemented traditional snacks were developed by Siegel et al.(1975, 1976) for use in feeding programmes at Child Nutrition Centres in Thailand. Their acceptability was tested by feeding samples to Thai children of different demographic characteristics, and a comparison was made between their acceptabilities. In 1982, a survey on the attitudes and behaviour of Thai consumers towards a traditional Thai cookie was conducted by Sinthavalai. The survey covered all four regions of Thailand, and the total sample of 360 people, with 5 types of different demographic characteristics, was randomly chosen from 12 provinces. The mail-interview technique was successfully used, with 95% of the 360 questionnaires returned; and the objectives of the survey on consumer reactions to various aspects of the product were fulfilled.

3.3 METHODS AND TECHNIQUES USED FOR THE PRESENT SURVEYS

3.3.1 Introduction

This survey research was conducted in 2 stages -- before and after the nutritional product was developed. The first survey was on the attitudes and behaviour of urban school-age Thais towards snack foods in general and the preference for the three suggested products. The product ideas obtained from this survey were used as the profile of the product to be developed for use in the second survey. The latter was the consumer research to product-test the developed product. Though the two were similar in the basic method of interview-survey used, a difference in techniques was unavoidable because of the difference in their objectives. However, comparisons were finally made on selected aspects of the findings between the two surveys.

3.3.2 The First Survey

3.3.2.1 Aims and Objectives. The aims of the survey were to study the attitude and behaviour of urban school-age Thais towards snack foods and to determine their preferences for different snack foods. The principal objectives of this study were to examine -

: The attitudes of school-age Thais towards snack foods in general.

: The behaviour of school-age Thais towards snack foods in general.

: The preferences for selected groups of snack food products.

: The characteristics of the preferred snack food products.

: The types of school-age Thais who are expected to be the target group for the products to be developed.

3.3.2.2 Sample. Judgment sampling was used because of the difficulty of obtaining randomly selected children. Six schools were chosen, 3 public and 3 private schools, in the Bangkok metropolitan area. These, when mixed to cover the whole range of grades, made up 4 categories of schools (Table 3.1). Three of these schools, covering both public and private types, were situated in one area, and another three in another area. The schools were chosen to represent middle class families. 40 children were chosen from each category, 10 from each grade (1-3, 4-6, 7-9, and 10-12) so that there were in total 40 children of each age group: 7-9 years, 10-12 years, 13-15 years, 16-18 years. The ten children, 5 males and 5 females, in each grade in each school were chosen by the teacher. This made a total of 160 urban school-age Thais, 80 males and 80 females. Table 3.1 shows the demographic characteristics of the samples including the number of school children in the household.

Table 3.1: The demographic characteristics of the population sample in the first survey.

		Number	Percent
School attended:			
Public:	SATIT KASET	40	25.0
	SAMSEN COLLEGE & ANUBAHN SAMSEN	40	25.0
Private:	PANAPAN	40	25.0
	SAMITTICHOTE & SAINT JOHN	40	25.0
	Total	160	100.0
Sex:	Male	80	50.0
	Female	80	50.0
		160	100.0
Age:	7-9	40	25.0
	10-12	40	25.0
	13-15	41	25.6
	16-18	39	24.4
		160	100.0
	(one pupil of grade 10-12 was below 16 years of age)		
Number of school-children in household:			
	1-2	72	45.0
	3-4	66	41.3
	5 or more	22	13.7
		160	100.0

3.3.2.3 Questionnaire. The questionnaire (Appendix 3.1M) consisted of 34 questions which were directed response, multichoice, check list, ranking, and scaling types. The questions concerned, what, where, and how often the respondents bought snack products and the frequency of their snackings. The personal self-administered method was used with interviewer assistance where necessary. Questionnaire testing was conducted 10 days before the survey by 20 pupils of Satit Kaset, 4 from each grade-group, and 10 from each sex. Alteration of the questionnaire was made where necessary.

3.3.2.4 Survey Method. Permission to interview was obtained from each school in advance. Sixteen students from the Marketing

Department, Kasetsart University, were used as the interviewers. Survey method orientation for all the interviewers was carried out two days before the survey date to avoid survey error. The importance of communication was explained to the interviewers, who were also thoroughly trained in the use of the questionnaire forms.

The questionnaires were distributed to the children in the schools and then the interviewers explained to the children how the questionnaires should be completed and gave the meanings of any terms not understood by the children. The interviewers had all been taught to give the same explanation for each term e.g. nutritional value, sensory quality. After the questionnaires were filled in, they were checked by the interviewers.

3.3.2.5 Date. The survey was conducted on three consecutive days at the beginning of December, 1982.

3.3.2.6 Data Processing. Before the processing of the data, the questionnaires were checked again by the author and incorrect answers were omitted. The primary data obtained from the consumer survey were processed by computer. The SPSS: Statistical Package for the Social Sciences (Nie et al., 1975) was used for the programming. The detailed results are tabulated in Appendix 3.1.

3.3.2.7 Data Analysis and Interpretation. Statistical methods were used for all the data analyses and interpretation. Where justifiable, logical interpretation was included for the purpose of the application of the findings. Data was analysed for its magnitude, dispersion, association and causation; and the statistical significance of difference was tested with the level of probability of 0.05.

3.3.3 The Second Survey

A nutritionally-balanced snack bar was developed for urban school-age Thais, with children of age 10-12 years as the main target market segment. The product was sweet and pastry-like and had banana as one of the main ingredients. Preparation of the product was conducted by using a combination method of cooking -- roasting, hot-stirring, and deep-syrup cooking -- all of which were previously considered to give a long shelf-life product with industrial-potential characteristic. The product was successfully accepted by the consumer panel which comprised 36 pupils aged 7-15 years at SATIT KASET, a demonstration school in Bangkok. The product was packed in a polypropylene film packet in a size that can be priced below 6 Bahts, when sold through snack stalls at schools.

Before the introduction of the project to the Thai-snack industry, consumer research on the product acceptance and on the market feasibility was necessary. Since children were found to be the main purchasers of the snacks rather than parents, only a sample of school children was interviewed. Variation in certain demographic characteristics from the previous survey was made for the purpose of comparison of selected variables between the two surveys.

3.3.3.1 Aims and Objectives. The aim of the consumer research was to product test the developed nutritionally-balanced snack bar in various aspects. The principal objectives of this study were firstly to examine the product attributes and finally to compare the findings with those in the previous survey. The objectives were to determine -

: The product scaling in terms of colour, size, texture, and flavour

: The level of acceptance for the product.

: The types of school-age Thais who are expected to be the target bùyers for the developed product.

: The child-willingness in buying the product.

: The price expectations.

: The package size.

: The brand name.

: Product value expected by the consumer.

: Difficulties of the product.

3.3.3.2 Sample. Judgement sampling used was based on the previous survey sampling method and on the objectives of the research. Four categories of schools, which were mixed to cover the whole range of grade levels from six schools, were chosen. One category, which comprised two schools in Nonthaburi which could be considered as urban like Bangkok, was not previousely surveyed. The children in this category of school were considered to be from the upper low to middle economic status families, while those of the other two were considered to be from lower middle to lower high economic status families (one public and one private), and those of the last category were considered to be from upper low to lower high economic status families. 270 children were chosen from each category of schools, 30 from each grade (P1-P6 and M1-M3) so that there were in total 90 children of each age group: 7-9 years, 10-12 years, and 13-15 years. The thirty children, 15 males and 15 females, in each grade in each school were chosen on a voluntary basis by the teacher in each grade. Although only 1080 school-age Thais were required for this survey, a total of 1094 children volunteered, 486 of which were males and 608 females. Table 3.2 shows the demographic characteristics of the sample. To qualify for the survey the children had to: be pupils in the levels of P1-P6 or M1-M3 (or in other words, age level of 7-15 years); not mind eating peanuts and sesame seeds; be willing to be interviewed on a voluntary basis; and if possible, refrain from snacking before the interviewing.

Table 3.2: The demographic characteristics of the population sample in the second survey.

		Number	Percent
School Attended			
Previously Surveyed:			
Public:	SATIT KASET	274	25.05
	SAMSEN COLLEGE & ANUBAHN SAMSEN	274	25.05
Private:	PANAPAN	276	25.20
Not Previously Surveyed:			
Public:	PRACHA OOPRATAM & BENJAMARACHANUSORN	270	24.70
	Total	1094	100.00
Sex			
Male		486	44.40
Female		608	55.60
		1094	100.00
Age			
< 10		374	34.20
10-12		421	38.50
> 12		299	27.30
		1094	100.00

Notes: 1. More respondents than expected because extra questionnaires provided.
2. More females because all females in 2-level classes in 2 schools.
3. The number of children in each grade ranged from 250-600 students depending on schools.

3.3.3.3 Questionnaire. Discussion with a teacher coordinator at SATIT KASET about the questions in the questionnaire was undertaken before the survey. The type and number of questions suitable for children P1-P2 was taken into consideration. The questionnaire (Appendix 3.2M) consisted of 15 questions which were directed response, multichoice, and scaling types. The questions concerned the product acceptability in various aspects. The personal self-administered method was completely used for the children in P3-M3; while assisted-self-administered was used for those in P1-P2 (aged approximately 7-8 years). For the assisted-self-administered method, the teacher explained the procedure to the children and read the questions for the children one question at a time. Questionnaire testing was conducted before the survey performance by ten of the staff and students of the Faculty of Agro-Industry. Alteration of the questionnaire was made where necessary.

3.3.3.4 Information Expected to be Obtained. The following information was expected to be obtained from all the children in the sample:

Product information: Opinions on product characteristics (5 point scale for colour, size, texture, and flavour); level of preference of the snack bar (5 point scale); and suggestions for improvement of the product (open-ended probe type question).

Marketing information: Amount suitable for snacking at one time; drink type after snacking; expected price for one-bar and three-bar packets; level of willingness to buy the product; major reasons for buying willingness (probed fully); expected frequency of buying the product; reasons for not buying (probed fully); and suitability of the proposed brand name.

3.3.3.5 Survey Method. A personal interview (by teacher-interviewer) and an experimental method (by tasting the product) were applied in this consumer research. Personal contacts with selected teacher-interviewers were previously made and the ideas obtained from the discussions were applied to improve the procedural instructions to be distributed to all teacher-interviewers. Agreement by the individual schools to participate in the study was obtained by personal contact, and also by official corespondence (Appendix 3.3M). The following were the steps in collecting the information:

: Sample characteristics and sample size defined.

: Agreement by individual school made, and details on objectives, date, and procedure distributed.

: Draft questionnaire prepared, pre-tested, and altered.

: Consumer test date confirmed.

: Product samples, questionnaires, and interview-procedure instructions (Appendix 3.4M) prepared.

: Field work monitored:
- Questionnaires and product sample distributed to teacher coordinator (who acted as a supervisor for each school-area).
- Recommendation on distribution of product samples and questionnaires made as follows:

  Author ---> 6 Teacher-coordinators --->

  Teacher level supervisors ---> 36 Teacher-interviewers

  ---> 1094 Child Consumers

: 'Thank You' letter distributed.

: Questionnaires edited.

: Data processed by computer.

: Data analysed by SPSS program.

: Result interpreted and summarized.

3.3.3.6 Date. The survey was conducted on 4th of February, 1985 for all schools except for SATIT KASET which was conducted on 11th of February. Time for interviewing was between 2:00 and 5:00 p.m.

3.3.3.7 The Product. The product samples were from production runs in a situation simulating a typical cottage Thai snack factory. One 44 gram bar of the product was packed in a sealed 11.4 centimetres polypropylene square pouch (0.1 mm thick). A label was inserted at the top of the packet and the packet was resealed. The descriptions on the label included: POCHA, a nutritionally-balanced snack, Department of Product Development, KU, and Massey University, New Zealand.

3.3.3.8 Data Processing. Before the processing of the data, the questionnaires were firstly checked by the author; incorrect answers were omitted and the direct responses and verbatim comments were tabulated (Appendix 3.2). The primary data obtained from the consumer survey was processed by computer. The SPSS: Statistical Package for the Social Sciences (Nie et al., 1975) was used for the programming. The detailed results are tabulated in Appendix 3.3.

3.3.3.9 Data Analysis and Interpretation. Statistical methods were used for all the data analyses and interpretation. Where justifiable, logical interpretation was included for the purpose of the application of the findings. Data was analysed for its magnitude, dispersion, association and causation; and the statistical significance of difference was tested with the level of probability of 0.05.

3.4 SNACK BUYING BEHAVIOUR AND ATTITUDES IN GENERAL

3.4.1 Snack-Type Preference

It was found that 73% of the school-age Thais studied preferred sweet snacks to savoury snacks (Table 3.3). The test of difference showed that this preference was not affected by sex, age, or type of drink taken with the snack. Also, Table 3.3 shows that vegetables and fruits (49%) were the most preferred group of snacks, followed by meats (26%), and cereal & flour snacks (16%). Eggs and beans were significantly less preferred. While females preferred vegetables and fruits more than males, males tended to prefer cereal & flour snacks and meats more than females.

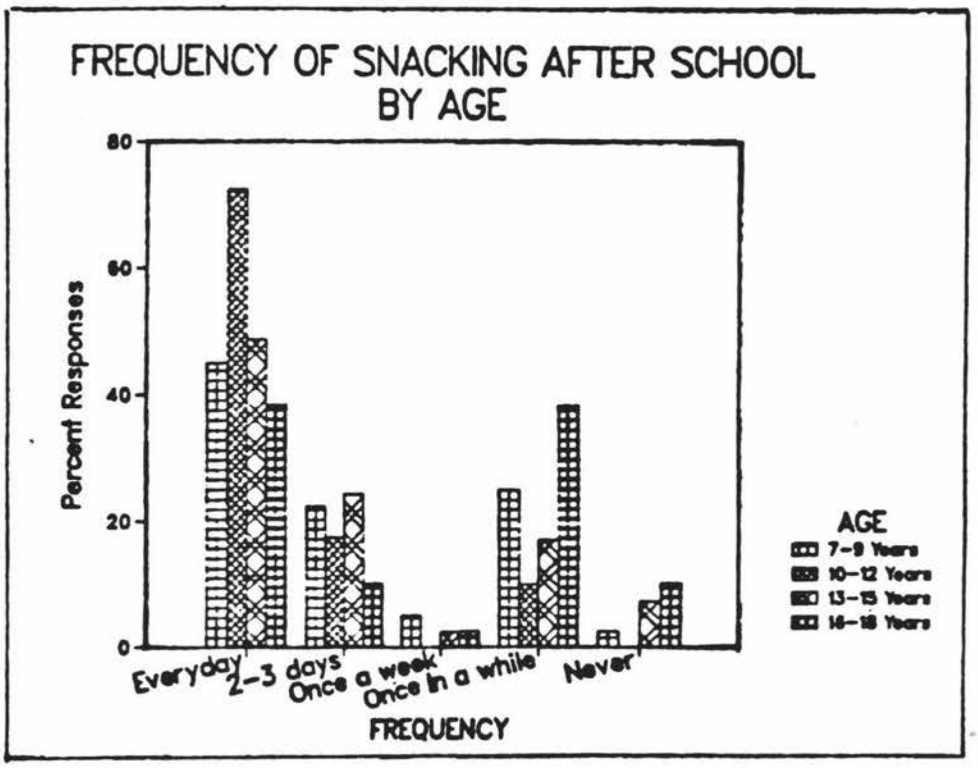
Table 3.3: Snack buying behaviour and attitudes in general.

	Percent
Snack type preferred (N = 160)	
Sweet	73
Savoury	27
Snack group most preferred (N = 160)	
Vegetables & fruits	49
Meats	26
Cereals & flours	16
Eggs	6
Beans	3
Selected cereal snacks most preferred (N = 71)	
Thai pastry type	46
Rice-crispy type	37
Thai cookie type	17
(Responses only of those who had eaten all types)	
Frequency of snacking after school (N = 160)	
Every day	51
Once in a while	22
Every two or three days	19
Once a week	3
Never	5
Person normally buying snack (N = 160)	
Yourself	43
Others (parents etc.)	27
Both	30
Criterion for snack buying choice (N = 155)	
Nutritive value	59
Sensory quality	24
Price	9
Availability	6
Keepability	2
Pocket money per day in Bahts (N = 160)	
5 or less	18
6-10	43
11-15	14
16-20	11
21 or more	14
Money spent on snacks per day in Bahts (N = 160)	
5 or less	28
6-10	40
11-15	16
16-20	10
21 or more	6

3.4.2 Frequency of Snacking after School

It was found from the survey (Table 3.3) that 51% of the urban school-age Thais snacked after school every day and 70% snacked every day or every two or three days. The age affected the frequency of the snacking. Children of 7-15 years of age ate snacks more frequently than the 16-18 year group; children of 10-12 years of age had the highest percentage snacking every day (Fig.3.1). Therefore, the main target segment for the products to be developed was children of 10-12 years of age with the minor segments being the age groups of 7-9 and 13-15 years.

Figure 3.1



3.4.3 Buying of Snacks

Table 3.3 shows that 43% of the urban school-age Thais normally bought their own snacks, while 27% had snacks bought only by others and 30% had snacks bought both by themselves and by other people. Though the test of difference showed that the person normally buying the snack did not relate to age, there was some tendency that the children did more self-buying as they grew older. The child was the main purchaser of the snacks, not the parents.

3.4.4 Criteria for Snack Buying Choice

The study on criteria for snack buying choice showed that 59% of the respondents ranked the nutritive value of the snack products as the most important attribute, while 24% ranked the sensory quality. These two attributes were ranked significantly higher than price, availability, and keepability. However, it was found that the school-age Thais of 16-18 years of age were less concerned with the nutritive quality of the snacks but more concerned with the sensory quality. Interestingly, males seemed to be more concerned with the sensory quality of the snacks than females. When the attributes were ranked from 1 (most important) to 5 (least important), the mean value of the ranks for each attribute coincided with the result from the criterion determination on the basis of the most important attribute (Table 3.3 and Figure 3.2).

3.4.5 The Use of Snack Food Outlets

Figure 3.3 shows that on weekdays, 70% of the children bought from the snack stall at school, 50% from sweet shops, and only 38% through a supermarket or co-op; while at weekends, 44, 44, and 43% of the children bought from neighbourhood groceries, sweet shops, and supermarkets or co-ops respectively. This finding suggested that the most suitable snack food outlets for the urban school-age Thais would be snack stalls at school, sweet shops, neighbourhood groceries, and supermarkets or co-ops.

3.4.6 Pocket Money and Money Spent on Snack Foods

The daily pocket money (for snacks only) was found to be 6-10 Bahts for the average urban school-age Thais studied (Table 3.3). It was 0-10 Bahts for school children of 7-9 years of age, 0-15 Bahts for 10-12 years old, and 6 to more than 20 for 13-18 years old. School-age Thais at private schools tended to obtain more pocket money than those at public schools (0.08 level of significance). Although the average urban school-age Thai obtained 6-15 Bahts for pocket money a day, most of them spent 6-10 Bahts or less on snacks. However, the spending differed depending on age.

3.4.7 Motivation for Snack Food Buying

Television was found to play an important role in food advertising for the urban school-age Thais (Fig.3.4). The advertisement and the snack itself had an equal influence on the motivation for the buying of new snack products (Fig.3.5). The motivation was found to depend on the amount of pocket money. The statistical analysis showed that those with pocket money of 5 bahts or less bought new snack products as the result of an advertisement.

Figure 3.2

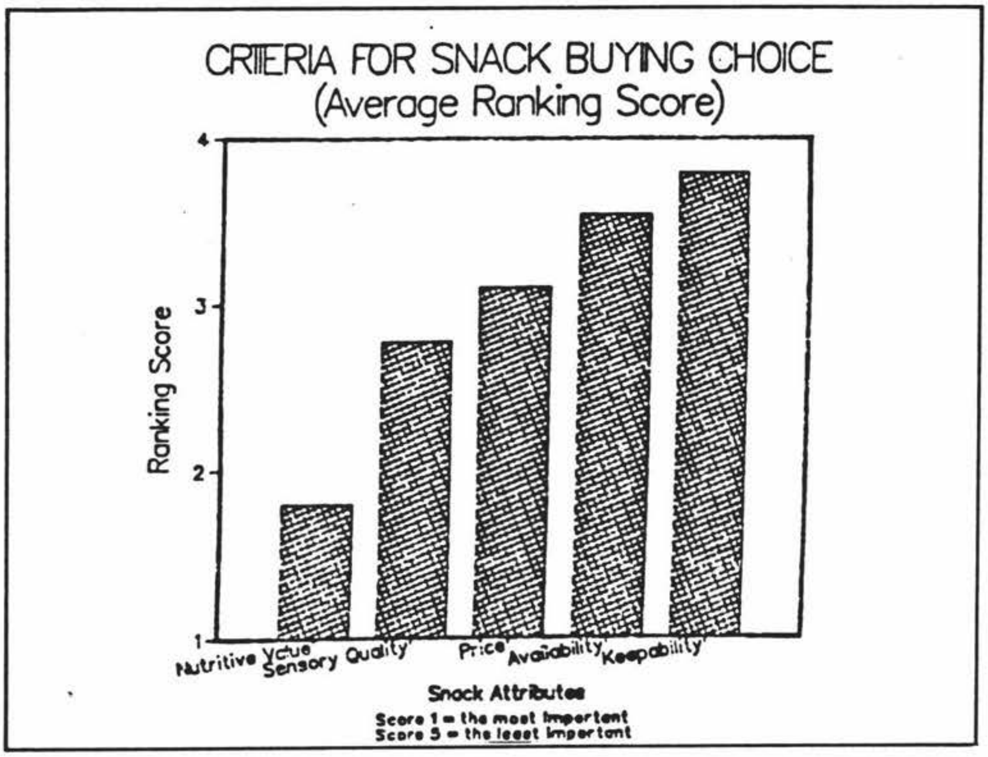


Figure 3.3

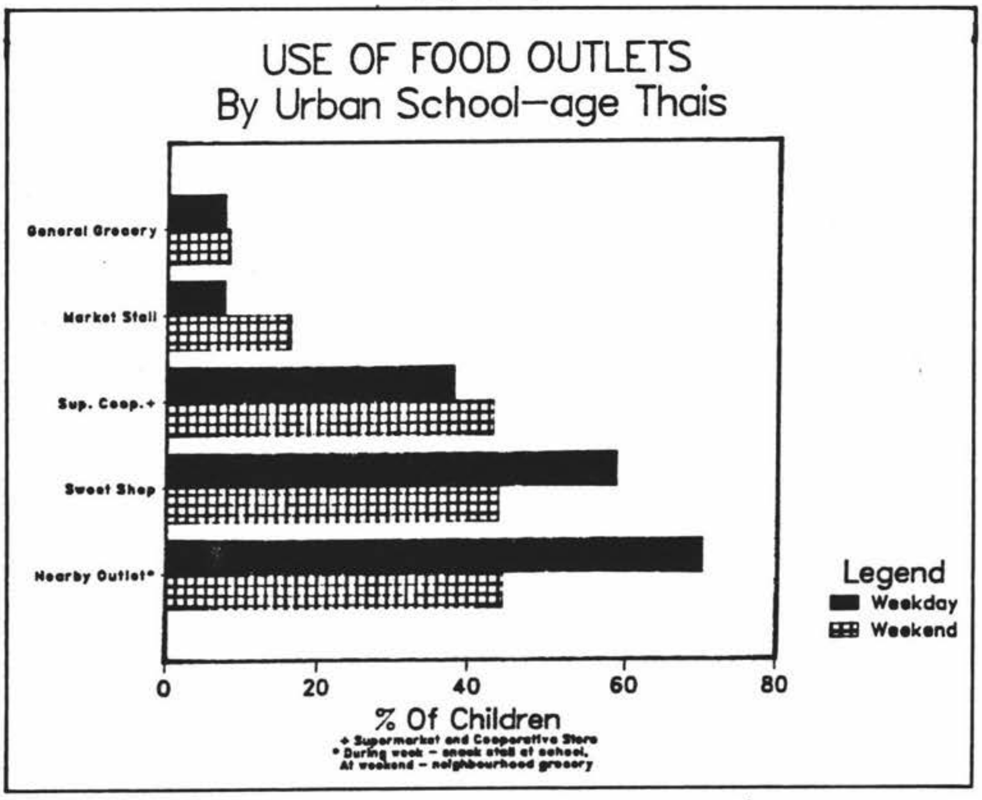


Figure 3.4

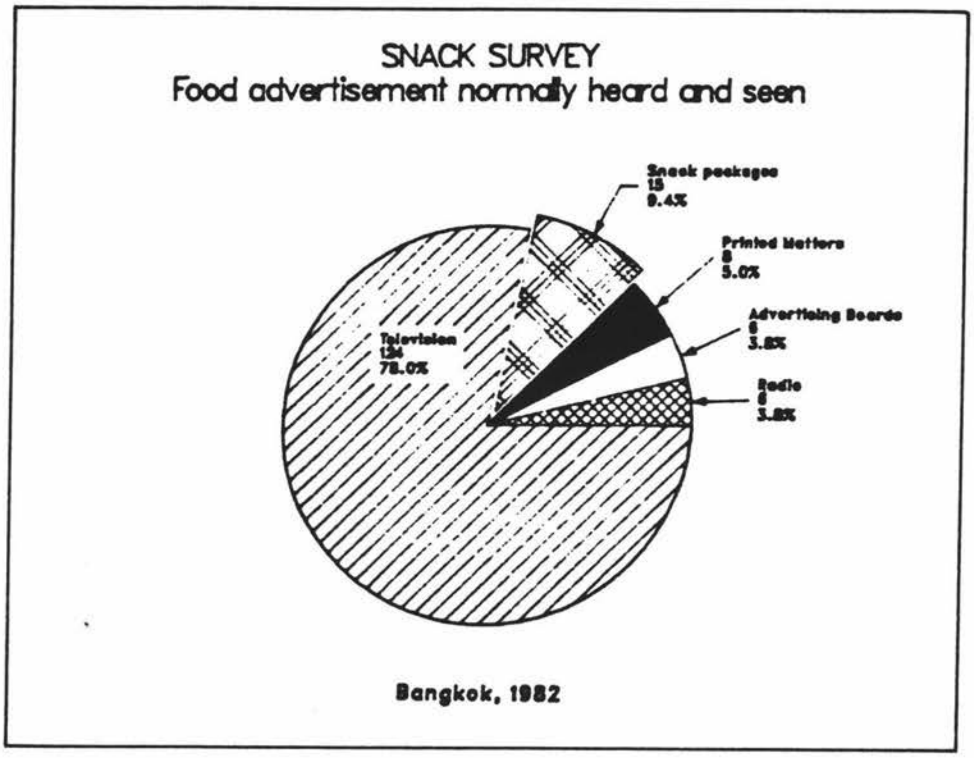
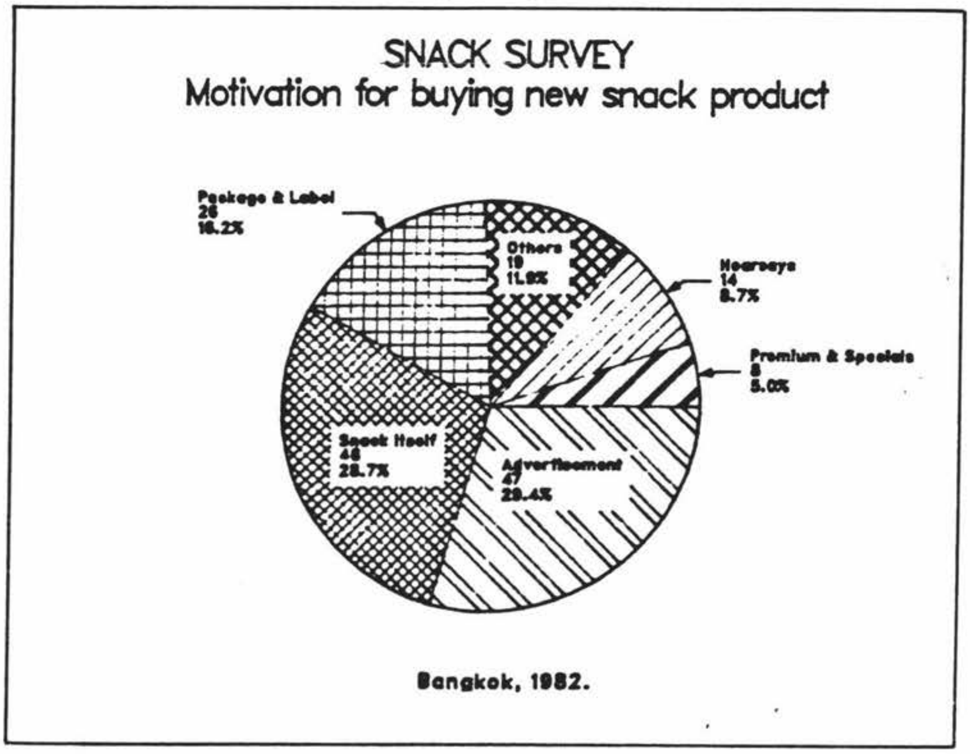


Figure 3.5



3.5 GENERAL BEHAVIOUR RELATED TO SNACKING

3.5.1 Times for Snacks and Dinner

Table 3.4 shows that the most popular snack time for urban school-age Thais during the weekend was in the afternoon. However, snacks were also consumed by many subjects in the morning, afternoon and night. The most common time for snacks during weekdays was after the classes were over, at about 3:30 p.m. or 4:30 p.m. depending on the school. Though the dinner time for most of them was between 6 and 7 p.m., the younger tended to eat before 6 p.m. and the older after 7 p.m. This resulted in a long "between meal" period in the afternoon.

Table 3.4: General behaviour related to snacking.

	Percent
Snack time on weekend (N = 159)	
Afternoon	35
Morning & Afternoon & Night	28
Morning & Afternoon	26
Morning	6
Night	5
Dinner time (N = 160)	
6-7 p.m.	41
Before 6 p.m.	36
After 7 p.m.	23
Drink type after snacking (N = 160)	
Water	56
Carbonated drink	24
Fruit juice	11
Health drink	7
Nothing	2

3.5.2 Drink Type after Snacking

Plain water was the most popular drink after snacking (Table 3.4), with carbonated drink second. The type of drink did not depend on either the type of snack eaten or the snack group preferred. Both the pocket money and the amount of money spent on snacks had no influence on the type of drink.

3.6 PREFERENCE FOR THE THREE SUGGESTED SNACK PRODUCTS

3.6.1 The Most Preferred Snack and the Buying Willingness

Of the three selected types of Thai snacks-- rice-crisp, cookie, and pastry, the pastry type of snack was the most well-known to the urban school-age Thais studied, and the rice-crisp type was the least well-known (Table 3.5). When the children who had eaten all three types of snacks were asked to rank the 3 selected types of snacks on their preference basis, it was found that the Thai pastry type (46%) was preferred to the rice-crisp type (37%), and the cookie type (17%) was the least preferred. Neither sex nor age group had an influence on this preference. A comparison of the frequency of eating for these three types of snacks showed that the pastry type was eaten more than the **Thai cookie** type, and the **rice-crisp** type was the least eaten. The main reasons for the lesser consumption of each type of snack were 'inconvenient to buy' and 'not palatable'. However, the number of children in this category was too small to be representative.

Table 3.5 shows that the expected buying of the selected types of snacks to be developed were in the following order: pastry (66%), cookie (57%), and rice-crisp type (47%). The expected money for buying was 6-10 bahts per day for the average urban school-age Thais studied and less for those of 7-9 years of age.

3.6.2 Preferred Attibutes of the Three Suggested Snacks

The study on the main attributes for the three selected types of snacks showed that different types of snacks had different important attributes. The most important attributes of the three types of snacks in decreasing order were as follows: flavour, topping and texture (crispiness) for the rice-crisp type; flavour, texture (melt-in-the-mouth) and aroma for the cookie type; and stuffing, flavour and texture for the pastry type (Table 3.6). The sex and age had no influence in this ranking of the main attributes.

Table 3.5: Preference for the three suggested products.

	Percent
Eating experience of selected types of snacks (N = 160)	
Thai pastry type	91
Thai cookie type	73
Rice-crisp type	59
(Multiple choice allowed; and percentage based on number of choices)	
Most preferred type of snack (N = 71)	
Thai pastry type	46
Rice-crisp type	37
Thai cookie type	17
The most frequently eaten of selected types of snacks (N = 71)	
Thai pastry type	39
Thai cookie type	37
Rice-crispy type	24
(Responses only of those who had eaten all types)	
Willingness to buy a new rice-crisp product to be developed (N = 160)	
Yes	47
No	14
Not sure	39
Willingness to buy a new Thai cookie to be developed (N = 160)	
Yes	57
No	14
Not sure	29
Willingness to buy a new Thai pastry to be developed (N = 160)	
Yes	66
No	9
Not sure	25

Table 3.6: Preferred attributes of snacks.

	Percent
Most important attributes for rice-crispy snacks (N = 96)	
Flavour	45
Type of topping	30
Texture (crispiness)	20
Size & form	3
Colour	2
Most important attributes for Thai cookie snacks (N = 115)	
Flavour	58
Texture (melt-in-mouth)	25
Aroma	12
Colour	5
Size & form	5
Most important attributes for Thai pastry snacks (N = 144)	
Type of stuffing	44
Flavour	37
Texture	10
Size & form	6
Colour	3

Note: Responses only of those who had ever eaten the particular snack.

3.6.3 Expected Frequency of Buying the Product to be Developed

The expected frequency of buying the products to be developed was at the "moderate" frequency (Table 3.7). Neither the number of school children in the household nor the amount of pocket money nor the amount of money expected to be spent nor the frequency of intended buying affected the willingness to buy those snacks.

Table 3.7: Buying of snack product to be developed.

	Percent
Money expected to buy the product to be developed (Bahts) (N = 159)	
5 or less	28
6-10	49
11-15	15
16-20	5
21 or more	3
Expected buying frequency for the product to be developed (N = 160)	
High frequency	8
Moderate frequency	64
Low frequency	28

3.6.4 Expected Package and Price of the Product to be Developed

It was found that 56% of the urban school-age Thais preferred their snacks to be packed in aluminum foil or a plastic bag in a paper carton, and 64% preferred them to be packed in the 1-6 baht package size (Table 3.8). However, this package and price acceptability were found to depend on the amount of pocket money they had. Those with more pocket money preferred aluminum foil or a plastic bag in a paper carton, while those with less pocket money preferred their snacks to be packed in a plain plastic bag. Those with more than 5 bahts pocket money accepted the price per package in the range of 1-6 bahts, while those with 5 bahts or less preferred it to be in the range of 1-3 bahts.

Table 3.8: Expected package and price of product to be developed.

	Percent
Most acceptable package (N = 160)	
Aluminum foil bag in paper carton	34
Plastic bag in paper carton	22
Plastic bag	21
Opaqùe bag of window type	16
Aluminum foil bag	7
Acceptable price expected in Bahts per package (N = 159)	
1-3	31
4-6	33
7-9	20
10-12	13
13 or more	3
(One incorrect answer)	

3.7 ACCEPTABILITY OF THE DEVELOPED SNACK PRODUCT

3.7.1 Opinions on Product Colour

It was found from the survey (Table 3.9) that the product colour was just right or slightly too intense for most of the respondents (47% and 34% respectively). Age and School significantly affected the opinions on product colour of the children. The colour seemed to be just right for children in both the <10 (58% of children in this group) and 10-12 (48%) age-group, while it seemed to be slightly too intense for those in >12 age-group (43%). Most of the children in PANAPAN, PRACHA-BANJA, and in SAMSEN (58%, 45%, and 50% of the children in each school respectively) thought that the colour of the product was just right, while most of the children in SATIT thought that it was slightly too intense. However, the colour mean score of 2.4 suggested that the colour of the product tended to be very slightly intense.

Table 3.9: Preference for the developed snack product.

	Percent
Colour (N = 1092)	
Too intense	14
Slightly too intense	34
Just right	47
Slightly too pale	4
Too pale	1
Size (N = 1094)	
Too large	5
Slightly too large	15
Just right	72
Slightly too small	7
Too small	1
Texture (N = 1092)	
Too cohesive	6
Slightly too cohesive	14
Just right	44
Slightly too crumbly	29
Too crumbly	7
Flavour (N = 1093)	
Too sweet	6
Slightly too sweet	10
Just right	34
Slightly too bland	25
Too bland	25
Preference (N = 1091)	
Like very much	18
Like	26
Neither like nor dislike	33
Dislike	16
Dislike very much	7

The Chi Square test proved that the product preference and buying willingness of the children were significantly related to its colour. Too intense a colour seemed to lower the preference of the children and, in turn, their willingness to buy. Therefore, the colour of the product could be slightly lightened.

Colour was only mentioned as important by 3% of the children in the first survey, but obviously when they actually saw the product in the second survey, it became important and affected their predicted buying.

3.7.2 Opinions on Product Size

Most of the children interviewed (72%) thought that the size of the product was just right (Table 3.9). However, this depended on age group and school attended. 19% of children over 12 years of age and 23% of those in SATIT thought that it was slightly too large. However, the mean-score size of 2.8 suggested that the size of the product was just right. The Chi-Square test proved that the size of the bar did not influence the price estimated by the children. Therefore the size predicted from the first survey was correct.

3.7.3 Opinions on Product Texture

Texture had been an important attribute mentioned in the first survey. Twenty nine percent of the children thought that the product was slightly too crumbly, 14% thought that it was slightly too cohesive and 44% of the children thought that the texture of the product was just right (Table 3.9). This opinion on texture was influenced by the sex and the age of the children. 32% of female respondents thought that the product was slightly too crumbly; as did 47% of the children over 12 years.

The Chi-Square test suggested that crumbliness seemed to more negatively affect the product preference of the children than the over-cohesiveness; and, this in turn, affected the buying willingness of the children. The texture mean score of 3.2 proved that the snack bar was just very slightly crumbly.

3.7.4 Opinions on Product Flavour

Most of the children thought that the snack bar was just right in sweetness (34%), slightly too bland (25%) or too bland (25%) respectively (Table 3.9). This opinion was significantly influenced by age. 71% of the children over 12 years of age thought that the snack bar was slightly too bland or too bland. The flavour mean score of 3.5 also proved that the bar was slightly too bland; therefore, this inferior characteristic of the product should be remedied.

Opinions on the flavour of the product affected its preference. The Chi-Square test result suggested that both higher and lower intensity of sweetness of the product lowered the preference of the children. Of the children who would not buy the product, 41% thought that the snack bar was too bland, while 22% of them thought that it was too sweet. As stated by the children in the first survey, flavour has an important influence on the buying of the snack product.

3.7.5 The Acceptability of the Product

44% of the children interviewed liked the product, while 33% neither liked nor disliked it. The preference mean score of 2.7 suggested that the children did not mind the product. The level of preference depended on sex, age, and school (Fig.3.6 a,b). Females and those aged over 12 years seemed to prefer it less than those of the other groups. Children in SATIT KASET and SAMSEN preferred the product less.

The preference for the product significantly influenced the price estimated by the children. Those who "liked" or "neither liked nor disliked" the product priced it higher than those who did not like it. Also, the product preference significantly influenced the buying willingness of the children. Most of the children who liked the product had a tendency to buy it and at a higher frequency, while those who disliked it did not.

3.7.6 Expected Amount of Product for Snacking at One Time

49% of the children (Table 3.10) thought that they could eat only one bar for snacking at one time, while 42% thought that they could eat as many as 2 or 3 bars. Sex, age, and school all significantly influenced the amount eaten at a time. Males seemed to be able to eat more than females. Children aged below 12 years and children in PANAPAN and PRACHA-BENJA seemed to be able to eat more than those over 12 years and in the other two groups of schools. Preference seemed to play an important role in the amount eaten. Most of the eat-more-children liked the product more than the eat-less-children.

The Chi-Square test result suggested that children who normally drank nothing, water, or a health drink could eat more bars than those who normally drank fruit juice or a carbonated drink. Also, the test result suggested that the amount of the product eaten at a time significantly influenced the price the children estimated. Those of the eat-more-children seemed to price the product lower than those eat-less-children. Most of the children who were willing to buy the product could eat 1 bar (33%), 2 bars (29%), and 3 bars (25%) respectively, while most of those who were not sure of buying could eat 1 bar (61%) and 2 bars (27%), and most of those who were not willing to buy (80%) could eat only 1 bar at a snacking time. The amount-eaten mean score of 4.1 suggested that 2 bars seemed to be the average amount

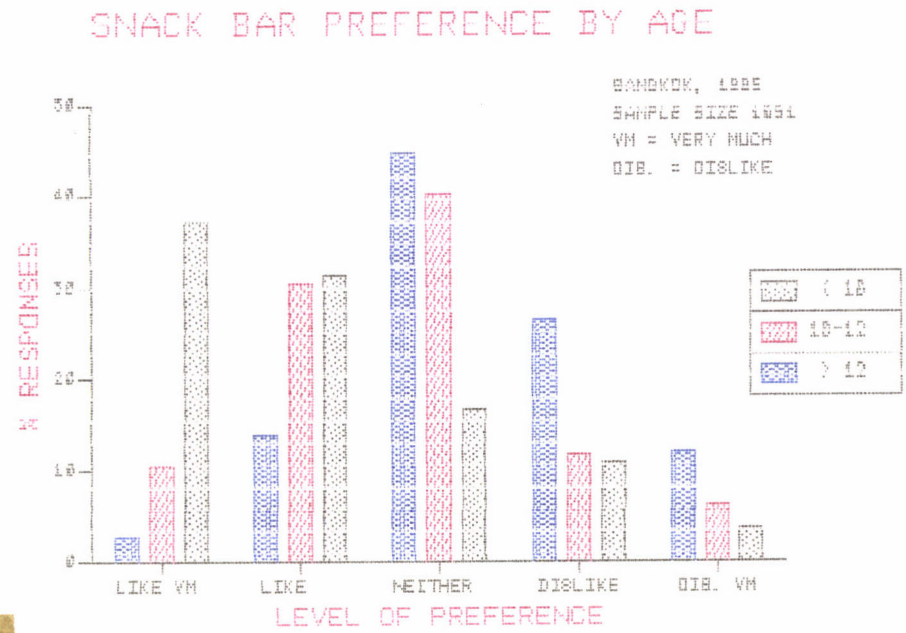


Figure 3.6a: Preference for the Product by Age

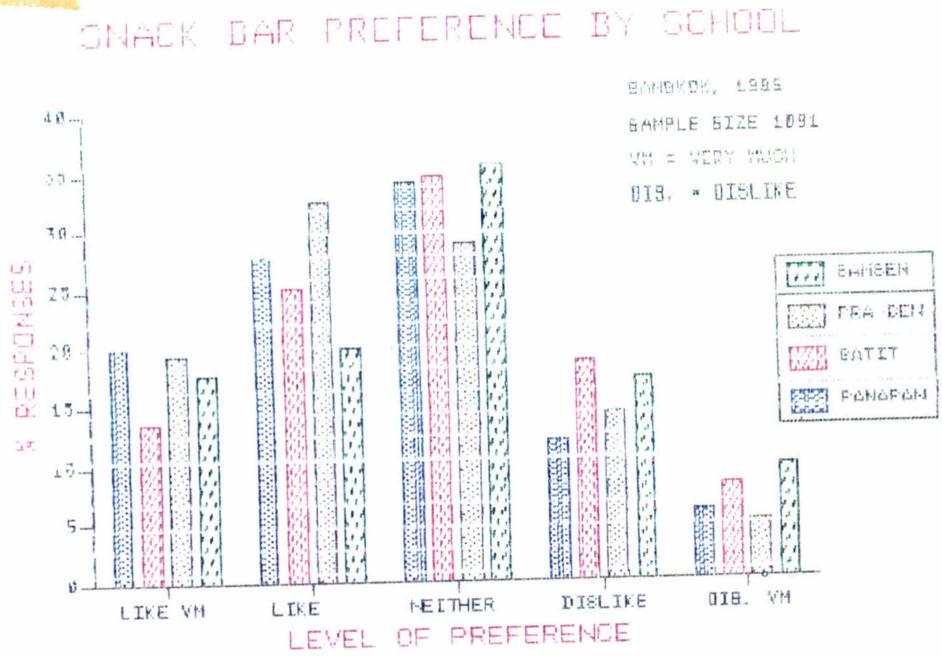


Figure 3.6b: Preference for the Product by School

of product the children would snack at a time. Therefore, 1 or 2 seemed to be a suitable number per packet.

The Chi-Square test on buying frequency showed that 43% of those who would buy the product at a high frequency could eat 3 bars, while 59% of those of moderate-frequency could eat 2-3 bars and 47% of those of low-frequency could eat only 1 bar. This could be influenced by the preference of the children.

Table 3.10: Expected amount eaten, price, and buying of developed product.

	Percent Responses
Expected amount eaten at a snacking time (N = 1089)	
1 bar	49
2 bars	26
3 bars	16
4 bars	4
5 bars	5
Price for 1-bar packet (N = 1089)	
>3 Bahts	6
3 Bahts	21
2 Bahts	48
1 Baht	22
<1 Baht	3
Price for 3-bar packet (N = 1089)	
>6 Bahts	12
6 Bahts	29
5 Bahts	28
4 Bahts	13
<4 Bahts	18
Buying willingness (N = 1091)	
Yes	52
Not sure	34
No	14
Buying frequency (N = 561)	
High frequency	11
Moderate frequency	63
Low frequency	26
(Responses of only those who will buy the product)	

3.7.7 Expected Price per Packet

48% of the children priced the product at 2 Bahts per 1-bar packet, while 21% priced it at 3 Bahts and 22% at 1 Baht (Table 3.10). The major reason for buying had a significant influence on this pricing estimation. 78% of the children who chose the 'peanut & sesame preference' priced the product at 1-2 Bahts, while 77% of those who chose the 'nutritional advantage', 72% the 'Thai product favoured', and

71% the 'palatability of the product' priced it at 2-3 Bahts (Appendix 3.3).

73% of the buy-children and 69% of the not-sure children priced the 1-bar packet at 2-3 Bahts, while 64% of the not-buy children priced it at 1-2 Bahts. The 1-bar packet price mean score of 2.9 suggested that the acceptable price for this group of children was above 2 Bahts per 1-bar packet. (Score 2 is equivalent to 3 Bahts while score 3 is 2 Bahts for this question.)

Age and school showed significant influence on the children's pricing. Children over 12 years of age priced the bar lower than the other age groups. This seemed to be the effect of a lower preference in this older group. As to the school influence, PANAPAN and SATIT children who were considered to be from higher economic status families priced the product higher than those of the other two groups of schools.

Different opinions appeared in the pricing of the 3-bar packet. Higher responses were observed at 5 Bahts (28%) and 6 Bahts (29%). However, the 3-bar packet price mean score of 2.9 suggested that 5 Bahts was justifiable. (Score 2 is equivalent to 6 Bahts while score 3 is 5 Bahts for this question.)

3.7.8 <u>Buying Willingness</u>

52% of the children interviewed were willing to buy the product, while 34%, were not sure (Table 3.10). Sex, age, and school significantly affected the buying willingness of the children. A higher percentage of males than females indicated they would not buy the product. The younger age children indicated 'sure to buy' more than those of the older age who responded more often 'not sure' and 'not buy'.

3.7.9 <u>Buying Frequency</u>

63% of the buy-children would buy the product at a moderate frequency, 26% at a low and 11% at a high frequency (Table 3.10). Age had a significant effect on the buying frequency. The buy-children of a younger age had a tendency to buy more often than those of an older age. However, the buying-frequency mean score of 2.2 suggested that the children could be expected to buy the product at a moderate frequency.

3.8 GENERAL BEHAVIOUR AND ATTITUDES RELATED TO THE DEVELOPED SNACK PRODUCT

3.8.1 Major Reason for Buying and Branding Suitability

61% of the children would buy the product because of its nutritional advantage (Table 3.11). The reason depended on age and school (Fig.3.7 a,b). More children under 12 years would buy because of nutritional advantage. 'Thai product favoured' was the major reason for many of those of over 12 years.

63% of the children interviewed agreed on the branding proposed, while 10% did not agree and 27% were 'don't know' respondents. The branding opinion was affected by sex, age, and the school the children attended. More males than females did not agree. Children of the older age did not agree more than those of the younger age. Among the schools surveyed, SATIT agreed the least.

Opinion on the branding of the product was related to the buying willingness of the children. Most of the buy-children (74%) and of the not-sure children (60%) agreed with the branding proposed, while most of the rest were 'don't know' respondents.

Most of the children who would buy the product because of its nutritional advantage agreed with the branding proposed, as did the children who would buy it for the other major reasons.

Table 3.11: Major reason for buying and branding suitability.

	Percent Responses
Major reason for buying the product (N = 563)	
Nutritional advantage	61
Palatability	18
Thai product favoured	13
Peanut & sesame seed preference	7
Other reasons	1
(Responses of only those who will buy the product)	
Branding suitability (N = 1070)	
Suitable	63
Don't know	27
Unsuitable	10

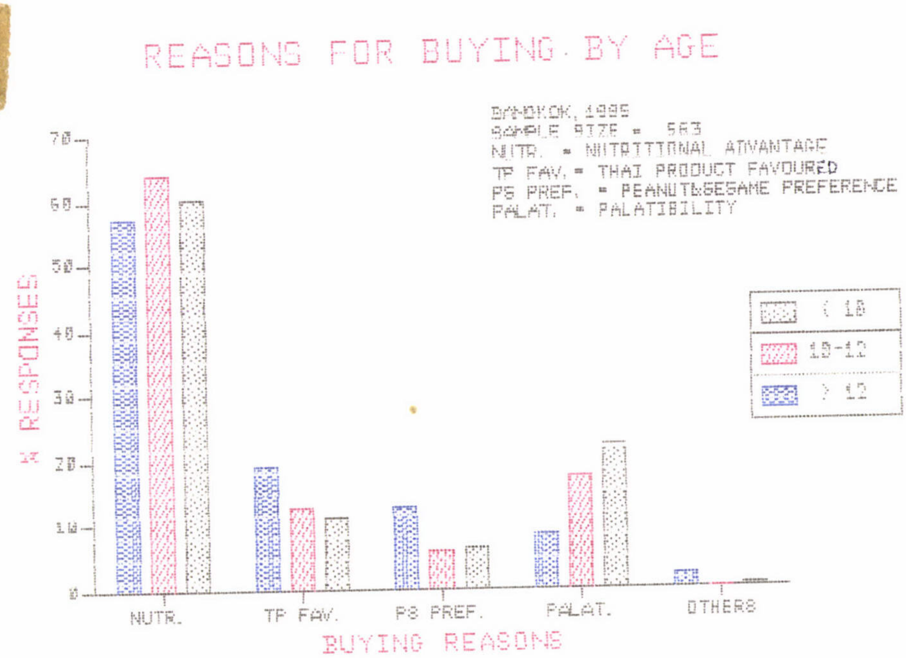


Figure 3.7a: Major Reasons for Buying Developed Product by Age

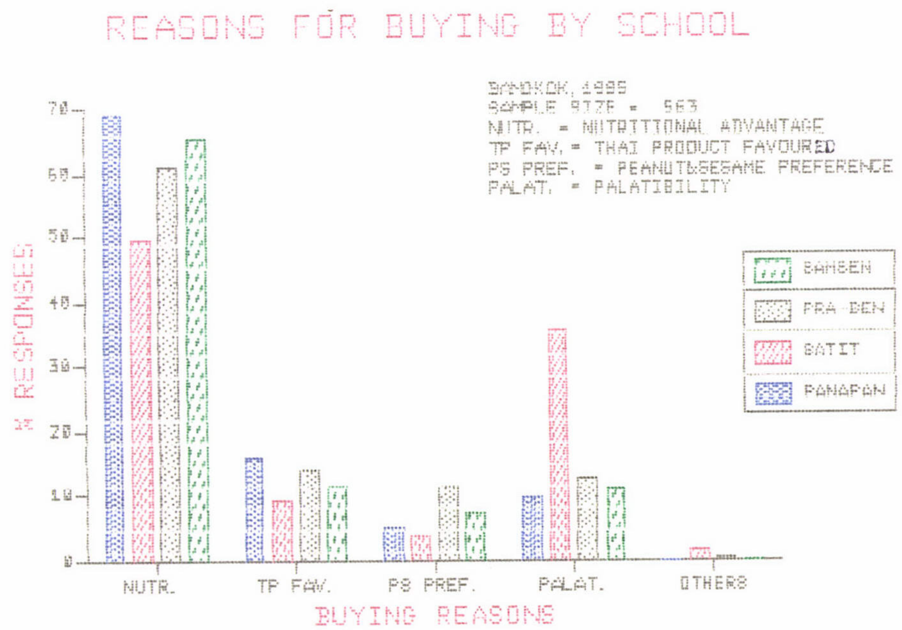


Figure 3.7b: Major Reasons for Buying Developed Product by School

3.8.2 Drink Type after Snacking

A majority of the children interviewed (54%) normally drank water after snacking. Carbonated drink was normally drunk by 20% of them. Health drinks (12%) and fruit juice (11%) were much less popular. The drink type after snacking was affected by sex, age, and school (Fig.3.8 a,b). Females drank more carbonated drink and fruit juice than males, while males drank more health drink than females. Children over 12 years drank more carbonated drink and fruit juice than those under 12 years, while those of the latter group drank more water.

As to the influence of school on the drink type after snacking more children in PANAPAN and PRACHA-BENJA drank health drink and more children in PANAPAN and SAMSEN drank fruit juice (Fig.3.8 a,b). Personal observations during visiting those schools suggested that the availability of drink type played an important role in this aspect. At SATIT, though there are many drink-vendors, only soybean milk was available at one stall. There was no other health drink or fruit juice. All the rest were carbonated drinks. At SAMSEN, fruit juice vendors were available, and fruit juice was normally drunk by as many as 25% of the children interviewed.

The Chi-Square test result proved that most of the willing-to-buy children (42%) were 'water-drink' children; therefore, nutritionally-balanced characteristics of the product were considered important.

3.9 SUMMARY AND RECOMMENDATIONS BASED ON SURVEY RESULTS

3.9.1 Summary and Recommendations from the First Survey

The findings from the first survey portrayed the average attitude and behaviour of the urban school-age Thais towards snack foods. Although all age groups did eat snack foods and 51 % of them snacked every day, the most important group for eating snack foods was the 10-12 years age group.

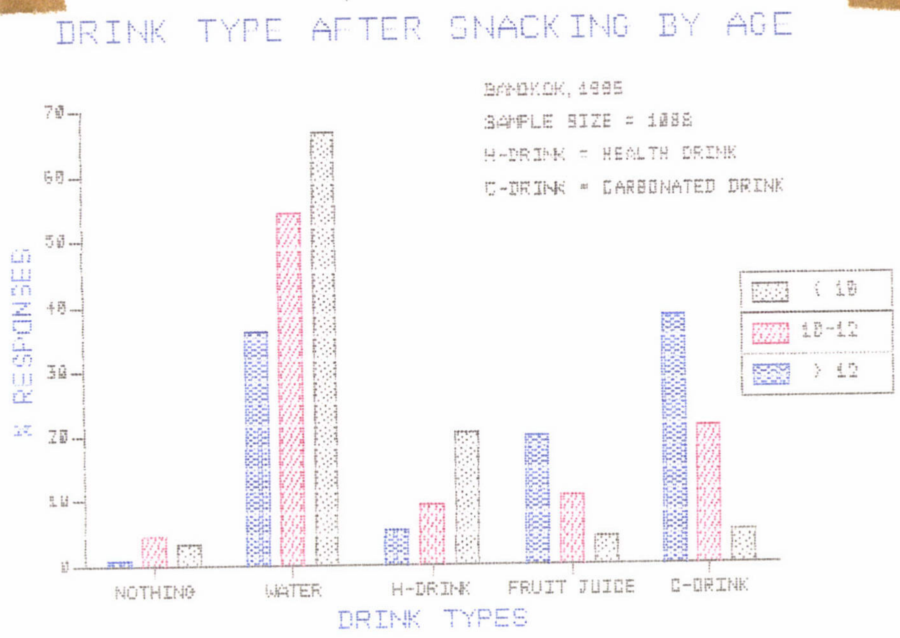


Figure 3.8a: Drink Type after Snacking by Age

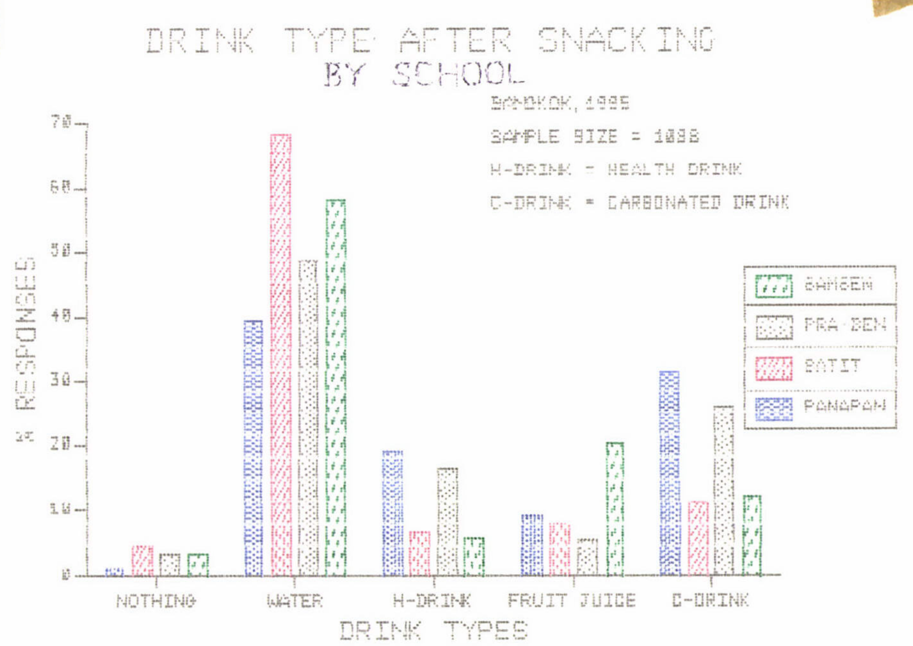


Figure 3.8b: Drink Type after Snacking by School

Sweet snacks were preferred over savoury snacks; and that of the vegetable & fruit group was the most preferred. Of the three cereal snacks-- Thai pastry, Thai cookie, rice-crisp-- the Thai pastry was the most frequently eaten and the most preferred; children would be expected to buy Thai pastry more often in the future than the other two products. The most important attributes in Thai pastry were: type of stuffing and flavour.

The children were the main purchasers of the snacks, not the parents. 68 % of them spent less than 10 Bahts per day on snack foods. The most important attribute for their snack buying choice was nutritive value, followed by sensory quality.

Most snacks were bought at the snack stall at school during weekdays and at the neighbourhood groceries at weekends. Sweet shops, supermarkets and cooperative shops were also important for snack buying.

The children preferred the price of a snack product to be below 6 Bahts per package. The packaging could be an aluminum foil bag in a paper carton, a plastic bag in a paper carton, or a simple plastic bag. Television was the most important advertising media.

It is recommended in the snack product development for urban school-age Thais that:

: The main target segment be children of 10-12 years of age.

: From the consumer acceptability point of view, a snack of the Thai pastry group with a sweet-type vegetable & fruit stuffing be of priority; and that it be packed in a plastic bag in a paper carton in a size that can be priced below 6 Bahts.

: The main outlets be snack stalls at schools, neighbourhood groceries, sweet shops, supermarket and co-op shops.

: Television be used as the advertising media.

3.9.2 Summary and Recommendations from the Second Survey

The developed product was scaled as very slightly intense for color, just right for size, very slightly crumbly for texture, not quite sweet enough for flavour; and over all the children rather liked the product.

Children aged 7-12 years liked the product and were more willing to buy the product at a higher price and also at a higher frequency than the other children; thus, they were expected to be the main target buyers.

Most of the children in this group priced the product at 2 Bahts for a 1-bar packet and 6 Bahts for a 3-bar packet. Since most of them thought that they could eat 1 bar at a snacking time, the product could be packed in a 1-bar size packet of 2 Bahts; or since the amount-eaten mean score suggested that 2 bars was the amount eaten at a snacking time and since this product was to be produced for the nutritional purpose based on % of RDA, the product could be packed in a 2-bar size packet of not more than 4 Bahts.

The major reason for buying the product of over 60% of the children was because of its nutritional advantage; thus, nutritionally-balanced characteristics should be considered as most important in the developed product and as the most important point to be used to aid the promotional campaign.

Most of the children agreed with the brand name of POCHA (meaning: food suitable for consumption). This could be used as a family name. 'A nutritionally-balanced snack bar' could be used to show brand personality which would communicate the functional value and add value into the product.

It is recommended in the snack production for urban school-age Thais that:

: The main target segment be children of 7-12 years of age.

: For an ideal acceptance, the product could be slightly changed in colour (lightened), texture (more cohesive), and in flavour (sweeter).

: The product could be packed in a 1-bar or 2-bar packet size, priced not more than 2 Bahts and 4 Bahts respectively.

: Nutritionally-balanced characteristics be the most important to be considered; and nutritional advantage be used to aid in promotional campaign.

: 'POCHA' could be used as the family name and 'Nutritionally-Balanced Snack Bar' could be used to show brand personality.

3.10 COMPARISON OF THE FINDINGS OF THE TWO SURVEYS

A comparison of selected findings of the two surveys was made on snacking habits, preference for the product, buying of the product, reactions of schools previously surveyed and not surveyed, and on survey methods. In this study, "commercial survey method" was defined as the method normally used by commercial agencies through the private sectors in which budgets for interviewers and field supervisors are a necessity, and "official survey method" as the method normally used by government agencies through public or private sectors in which no budget was prepared for interviewers and field supervisors. Collaboration agreement, formally or informally, is made in the latter case.

3.10.1 Comparison of Snacking Habits

The comparison of the snacking habits (Table 3.12) of the children in the first survey (N = 160) and in the second survey (N = 1089) indicated that the children would buy the developed product at a similar frequency in both surveys (high : moderate : low = 8 : 64 : 28 in the first survey and = 11 : 63 : 26 in the second survey). A thorough examination of this finding indicated that the children of age 10-12 years, who were found to snack the most frequently in the first survey, were willing to buy the developed product at a higher frequency in the second survey. This finding suggested that the product was well-accepted among the children of this group.

When the 'price per packet' in the first and second survey was compared, the price patterns in the two surveys were found to be similar (price ≤ 5 : >5 Bahts = 53 : 47 in the first survey, and 59 : 41 in the second survey). This suggested an acceptability by the children. However, though most of the children normally snacked at a high frequency (51%), they would buy the developed product at a moderate frequency. This suggested a possible space for a high frequency of buying of the developed product, if its ideal profile for children was reached.

When pocket money and money spent on snacks in one day in the first survey were examined in relation to the price for a packet in the second survey, it was found that though 82% of the children had 5 Bahts or more to spend on snacks per day, they (59%) were willing to buy the developed product at a price around 5 Bahts.

The data on the drink type after snacking in the second survey (54%) confirmed the finding in the first survey (56%) that most of the children drank water; and this seemed to confirm a need for the nutritionally-balanced characteristics of the snack product developed because of the lack of a healthy drink to fill a snack nutritional gap.

Table 3.12: Comparison of snacking habits.

Comparison Attributes	Selected Attribute Categories	Relationship Between Data Obtained	
		1st Survey	2nd Survey
Buying frequency of the developed product	high	8	11
	moderate	64	63
	low	28	26
Price per packet for the developed product*	≤5	53	59
	>5	47	41
Drink type **	water	56	54
	carbonated drink	24	20
	other drinks	20	26
Frequency of snacking	high	51	-
	moderate	22	-
	low	27	-
Pocket money (Bahts/day) vs price for developed snack	≤5	18	59
	>5	82	41
Money spent for snack a day (Bahts/day) vs price for developed snack	≤5	28	59
	>5	72	41

* % responses of 'price at 5 Bahts' in the 1st survey was approximated from the data at 4-6 Bahts.

** FIGURE 3-10:

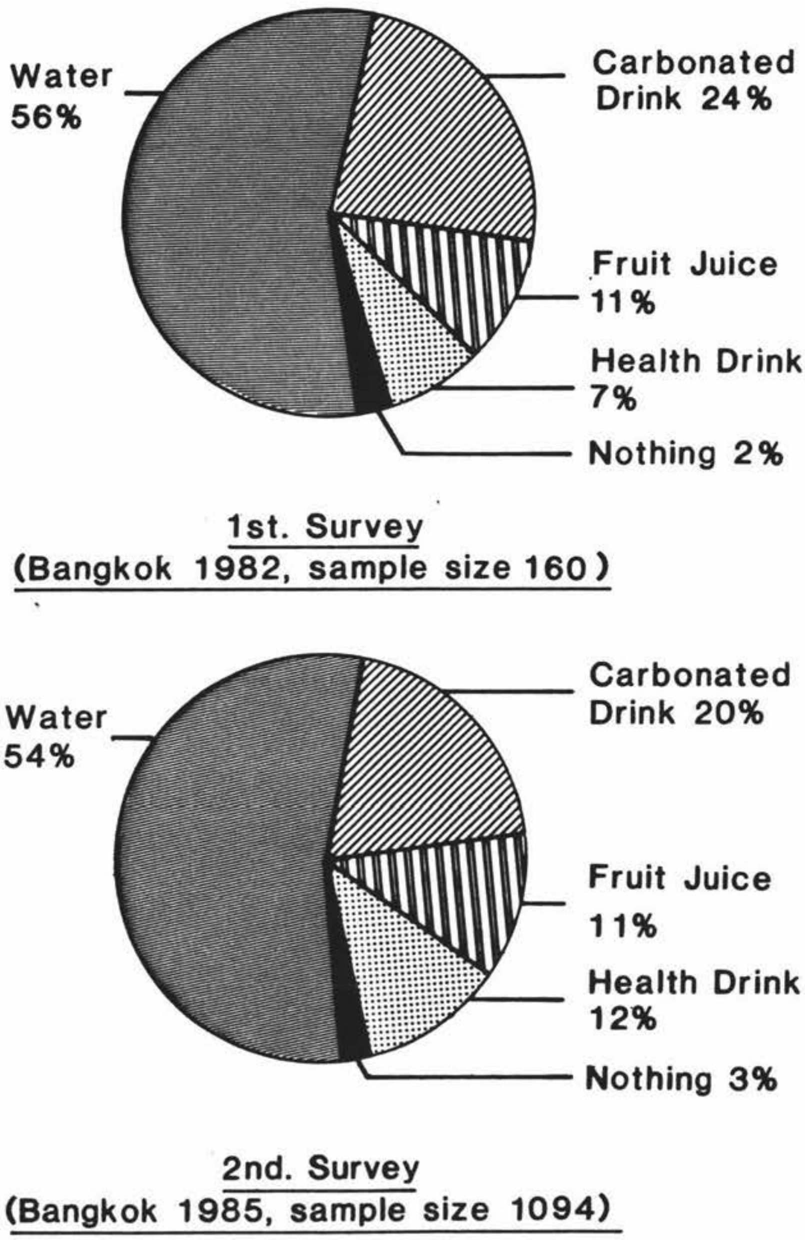


Figure 3.9: Graphical comparison of drinks after snacking

3.10.2 Comparison of Acceptability for the Product

The preference responses in the first survey was compared with the liking responses in the second survey (Table 3.13). A comparison of the past snack types preferred indicated that though the children liked sweet (72%) and fruit (79%) snacks, only 44% liked the developed product which was a sweet-fruit type product. The inclusion of bean, which was preferred by only 4% of the children, into the product suggested the possibility that bean might be responsible for this low preference. However, when the neither-liked-nor-disliked children were included in the data for comparison, the acceptability of the product (77%) was similar to the first survey.

Table 3.13: Comparison of preference for the product.

Comparison Attributes	Selected Attribute Categories	Relationship Between Data Obtained	
		1st Survey	2nd Survey
Snack type preferred	sweet	72	44
	fruit	79	44
	bean	4	44
Most preferred selected type snacks	pastry	46	44
Reason of "lowest eating" pastry vs Reason of not buying the developed product	not palatable	47	6

The proportion of the product-prefer children in the second survey (44%) was similar to that in the first survey of pastry-prefer children (46%). This finding again suggested that the developed product was well accepted by the children.

The lowest eating of pastry of 47% for 'not-palatable' reason in the first survey when compared with 6% (Appendix 3.2) of the 'not-palatable' children in the second survey suggested the successful improvement of the developed snack from the pastry product.

3.10.3 Comparison of Buying the Product

The comparison of buying the product in the two surveys suggested a slightly negative change in the response pattern (Table 3.14) whether consideration was made by using the data from 'all schools surveyed' or 'schools in both surveys only'. The exception was for 'major reason for buying' of which the result was similar in both surveys (59 and 61 for 'all schools surveyed' data; 62 and 61 for 'schools in both surveys only' data). A thorough examination of the detailed data indicated that in both surveys children aged 16-18 years were less interested in the nutritional advantage of the product.

Table 3.14: Comparison of buying the product.

Comparison Attributes	Selected Attribute Categories	Relationship Between Data Obtained	
		1st Survey	2nd Survey
All Schools Surveyed			
Price for a packet*	≤5	53	59
	>5	47	41
Buying willingness	buy	66	52
	not sure	25	34
Major reason for buying	nutritional advantage	59	61
Buying frequency	moderate	64	63
	high	8	11
Schools in Both Surveys Only			
Price for a packet*	≤5	50	57
	>5	50	43
Buying willingness	buy	67	46
	not sure	25	38
Major reason for buying	nutritional advantage	62	61
Buying frequency	moderate	70	64
	high	6	9

* % responses of ' in the 1st survey price at 5 Bahts' was approximated from the data at 4-6 Bahts.

Although more children priced the developed product lower after tasting in the second survey (≤5 Bahts : >5 Bahts = 53 : 47 in the first survey and = 59 : 41 in the second survey for the 'all schools surveyed' data; and = 50 : 50 and 57 : 43 for the 'schools in both suveys only' data), this slight pattern-change was considered to be caused partly by the unspecified amount per packet in the first survey. Taking this cause into consideration, the pricing of the children was similar in both surveys.

For buying willingness, the not-sure and not-buy children increased (25 to 34 for not-sure and 9 to 14 for not-buy) and the buy-children decreased (66 to 52) after the developed product was tasted. These more negative responses were found greater when the 'schools in both surveys only' data was investigated (buy : not-sure : not-buy = 67 : 25 : 8 in the first survey and 46 : 38 : 16 in the second survey). This proved that the developed product was not at the children's ideal profile and further improvement seemed to be a necessity.

A slightly negative change was found in the frequency of buying the products (moderate and high: from 76 to 73%). However, more children would buy at a high frequency (9% from 6%).

3.10.4 Comparison of Reaction of Schools Previously Surveyed and Not Surveyed

Consumer samples in the second survey, whether previously surveyed or not, had a similar pattern of reaction towards the developed product (Table 3.15). The exception was for their preference, price for a 1-bar packet, buying willingness, and branding suitability. The PRACHA-BENJA (PB) children, who were not previously surveyed, preferred the product more than PANAPAN-SATIT-SAMSEN (P-S-S) children, who were previously surveyed (52% compared with 41%). This difference was found to be less if the neither-liked-nor-disliked children were included (81% compared with 76%).

Table 3.15: Comparison of reaction of schools previously surveyed and not surveyed.

Comparison Attributes	Seclected Attribute Categories	Relationship Between Data Obtained	
		P-S-S	PB
Colour	%just right	48	45
Size	%just right	70	77
Texture	%just right	44	42
Flavour	%just right	35	30
Preference	% like	41	52
	%neither like nor dislike	35	29
Amount eaten at a time	1 piece	52	41
	2 pieces	26	26
Drink type after snacking	water	55	49
Price for 1-bar packet	2 Bahts	49	45
	1 Baht	18	36
Price for 3-bar packet	6 Bahts	29	28
	5 Bahts	28	26
Buying willingness	buy	46	69
	not sure	38	22
Major reason for buying	nutritional advantage	61	61
Buying frequency	moderate	64	62
Branding suitability	suitable	60	72
	don't know	33	17

For the 'price per 1-bar packet', although most of the children in both groups priced the 1-bar packet at 2 Bahts, more PB children (36% compared with 18%) priced it at 1 Baht.

Also, a more positive result was found for PB children on 'buying willingness' (69% compared with 46% for buy response; 91% compared with 84% when not-sure response was included), and on branding suitability (72% compared with 60%). The higher preference for the developed product of the PB children seemed to be responsible for the more positive attitude in their buying willingness.

The PB children were considered to be from the upper low to middle economic status families. The schools they attended are situated in Nonthaburi which can be considered as urban like Bangkok. The dining areas including the snack stalls did not have such good facilities or provisions as in the P-S-S group of schools. A smaller choice of snacks at schools might be partly responsible for the more positive responses. Therefore, this would be included in their acceptability comparison judgement.

3.10.5 Comparison of Survey Methods

When the relative rating of the methods was judged subjectively by the author on seven major criteria and when a comparison of the suitability for use in a nutritional intervention project of the two survey methods was made, the "official" method was found to have a lower cost and time and could be used with a higher flexible performance than the "commercial" method (Table 3.16). This suggested the greater suitability of the "official" method at this stage of the development of a nutritional product for an intervention programme.

Table 3.16: Comparison of survey methods.

Comparison Attributes	Relationship Between Data Obtained 1st Survey	2nd Survey
Effectiveness	++	++
Reliability	+	+
Realism	+	+
Flexibility	+	++
Ease of use	+	+
Cost	--	++
Time	-	++

(Subjective relative comparison from better to worse: ++, +, -, --)

3.11 CONCLUSION AND RECOMMENDATION

A consumer survey for an understanding of the current snack food attitudes and behaviour of the school-age children in Bangkok was systematically organized. Product ideas were obtained from the survey, as were the product attributes to be used as the profile for the product to be developed. The consumer test on the product developed from the consumer survey findings, proved that the systematic technique used in the consumer survey was effective for determining the consumer needs in the product. The nutritionally-balanced snack bar was, in general, acceptable by most of the children with different demographic characteristics in Bangkok and Nonthaburi, though minor changes in sensory properties was needed for an ideal acceptance.

This study proved that the main determinant influencing children's responses on buying-willingness was the 'image' of the product as it was 'nutritionally-balanced', not because of the sensory quality. For successful commercial marketing, it was suggested that this image of the product should be emphasized in the promotional campaign, especially through television advertising, the media most used by the urban children.

The comparison of selected attributes based on different demographic characteristics between the two surveys proved that the developed product was accepted not only by children previously surveyed but also by children not previously surveyed. Children of lower economic status families who had a smaller choice of snacks seemed to have higher acceptability than those of higher economic status families who had a greater choice of snacks. This convinced the product developers of the inclusion of related data into the final interpretation of statistical analysis for an accurate judgment. The comparison study also suggested that for a nutritional intervention project with a limited budget which is normally monitored by the government, the application of an 'official' method of survey should be of priority, at least for the surveys at the initial development stage.

This study recommends that one of the best ways to introduce a nutritionally-balanced snack product was to firstly interview a sample of the target group in order to find out what they perceive as relevant and important in choosing among the options for the particular class of product, and then to interview them with the developed product presented to get their reactions on its various sensory and marketing aspects. This was considerred the preferred way especially for a large scale nutritional product development plan because of the consumer orientation characteristic of its methodology.

CHAPTER 4

PRODUCT SCREENING AND EVALUATION

Product ideas were generated by brainstorming and a literature review, and then were screened and evaluated by different methods and techniques using the product ideas obtained from the first consumer survey as the desired product profile. The nutrition intervention suitability and the commercial production capability were also used as the basis for judging whether the product ideas were acceptable. The product ideas were screened using different screening techniques in sequence to obtain the most promising product concepts technically, financially, and with the greatest market potential. Comparisons of selected screening and evaluation methods and techniques were made and the best one determined for use in screening nutritional products which would be commercially produced for a nutrition intervention programme in Thailand.

4.1 INTRODUCTION

The selection of new products for introduction to the market is known to be an extremely difficult and risky decision (Montgomery and Urban, 1969), and the rate of failure is rather high. This failure rate reflects the complexities and difficulties associated with new product decisions. Therefore one of the most important tasks in the product development system is the decisions made during product ideas screening and project selection. This statement is supported by the large number of articles concerning selection and evaluation of products/projects (Pessemier, 1966; King, 1967; Montgomery and Urban, 1969; Watton, 1969; Desrosier and Desrosier, 1971; Earle, 1971; Skinner, 1972; Hamilton, 1974; Blake, 1978; Hughes, 1980; and Twiss, 1980).

Systematically, the process begins with a search procedure designed to generate a large number of new product ideas, after which they are screened to remove products that are not compatible with the company's goals or the new-product policy. The new product proposals that pass through this screening step are then evaluated, in a stepwise manner. At each step in the process, the product can be adopted (GO decision), rejected (NO decision), or investigated further (ON decision) and the evaluation analysis is continued until either a GO or NO exit is made. If a GO decision is reached, the implementation of the new product plan is begun.

A number of investigations were carried out on methods for the screening and evaluation of the new products/projects, subjectively and objectively (Stillson and Arnoff, 1957; Mottley and Newton, 1959; O'Meara, 1961; Harris, 1964; Dean and Nishry, 1965; Freimer and Simon, 1967; Toll, 1969; Watton, 1969; Pearson, 1971; Johnston, 1972; Souder, 1972; Pessemier and Root, 1973; Souder, 1973; Wind, 1973; Hamilton, 1974; Shocker and Srinivasan, 1974; Scheuble, 1976; Green et al., 1981; and Narasimhan and Sen, 1983). A great deal of effort was put on replacing subjective, often irrational, management intuition with objective, quantitative techniques which offer rationality, consistency, and an explicit structure for decision making that can be effectively criticised and improved. There have been literally hundreds of schemes proposed for quantitatively evaluating R & D projects and selecting the best (Blake, 1978).

4.2 METHODS AND TECHNIQUES FOR SCREENING AND EVALUATION

In general, methods for screening/evaluation can be classified under qualitative and quantitative categories, each of which is suitable for application in different screening/evaluation stages. Screening/Evaluation methods and techniques can be divided according to phases through which a new product/project passes from its inception to its final commercialization. Those various phases in the product development system can be divided in a number of ways (Pessemier, 1966). However, for convenience, three principal stages were applied as follows: 1) Screening stage (carried out in the product search phase); 2) Evaluation stage (carried out in the development phase); and 3) Final evaluation stage (carried out after the test-market phase).

4.2.1 Screening

The screening aims at a coarse sieve effect rather than a final commitment, and the information is largely conjectural. However, experience plays the most important part in this stage. If mistakes are made during this stage, one of two undesirable results occurs (Pessemier, 1966): potentially successful products are rejected, or product ideas which will not be commercially successful are started through a costly, time-consuming process.

A large number of screening methods were presented by different authors. Some of them, though based on mixed methods, were grouped and are shown in Table 4.1. Although the proposed criteria for qualitative screening by different authors were many and varied depending on individual cases, they were grouped (Twiss, 1980) under: Corporate objectives, strategy, policies, and values; Marketing criteria; Research development criteria; Financial criteria; and Production criteria.

In this nutritional project, though the mixed methods of different authors (O'Meara, 1961; King, 1967; Montgomery and Urban, 1969; Earle, 1971; Hamilton, 1974; Carson and Rickards, 1979; and Twiss, 1980) were applied, the steps for screening followed mainly the suggestions of Earle (1971) and Hamilton (1974). The method of Carson and Rickards (1979) was chosen for use in the comparison study because of its simplicity.

Earle (1971) divided the product evaluation into 2 main steps: Decide the important factors related to the project; and Rate these factors for each product and compare products. It was suggested that three techniques be used in a stepwise manner -- sequential, checklist, and probability screening. All of these techniques were to be used in this project because of their effectiveness.

Hamilton (1974) proposed three categories of screening in order of increasing cost. The characteristics and judgement for each category could be tabulated as shown in Table 4.2. All screening criteria fall into these three categories. A criterion could be in any category and a particular criterion may appear in different forms at different stages. The minimum value for judgement was defined as that necessary for continued support (investigation) of the concept.

Table 4.1: Some of the screening methods from the literature review.

Methods	Authors (year)	Brief Descriptions
General Screening Methods (Systems)	Byrnes and Chesterton (1973); Hamilton (1974); Carson and Rickards (1979)	Categories of screening were proposed and qualitative criteria defined.
Ranking Methods	Montgomery and Urban (1969); Byrnes and Chesterton (1973); Hamilton (1974)	Remaining ideas after the preliminary coarse screen were ranked in order of merit.
Scoring Methods	Mottley and Newton (1959); O'Meara (1961); Dean and Nishry (1965)	Remaining ideas after the preliminary rough screen were rated against weight-defined factors and subfactors.
Profile Methods	Harris (1964)	The use of profile chart, but the product ideas could not be graded in any quantitative sense.
Combination of Sequential, Scoring, and Probability Methods	King (1967); Earle (1971); Twiss (1980)	The application of qualitative and quantitative methods in a stepwise manner.

Table 4.2: Characteristics and judgement for screening methods.

Screening categories (and relative cost per item screened)	Main characteristics	Judgement (cumulative survival rate, in percent)
1. Culling (1)	Absolute in application Yes or No context Qualitative Each criteria be critical by itself	Pass or Fail (30-60)
2. Rating (10)	Not absolute Could be in Yes or No mode (= could be used as culling criteria) A list of criteria be grouped into cost-homogeneous units. Minimum score be established in each group. More expensive than 'Culling' because more information needed. Be able to be used for preliminary estimates of expensive data. (e.g. market growth rate)	Ideas achieving lower scores are dropped. (12-42)
3. Scoring (25-100)	Neither absolute nor inabsolute. Exist over a range of values. Importance of criteria varies depending on goals. Cost-homogeneous group or stages most expensive. Field trips and extensive analyses of data may be required.	Minimum value defined as necessary for continued support (investigation) of the concept. (6-30)

Adapted from Hamilton, 1974.

Carson and Rickards (1979) proposed three fundamental questions -- new? relevant? actionable? -- for the first screen. Ideas which pass through this 'crude primary screen' are 'filtered' through a 'selective secondary screen' which is comprised of key criteria and a simple bench trial. The evaluation stage is used as a final eliminator for ideas which could not be cleary categorised by the means just described.

4.2.2 Analysis Evaluation

The analysis evaluation is based on an analytical consideration of the factors in the screening stage including demand, cost, and profit. This stage of the evaluation is concerned with economic/financial/business parameters, such as competition analysis, sales revenue, cost of the project, capital cost of the project, profit, contribution to overheads per annum, and probability of success. Unfortunately, probability predictions still contain all the limitations of any human judgment, and they vary from person to person, from optimist to pessimist (Pearson, 1971). Also, it is obvious that a business enterprise is too complex and has too many elements contributing to profit or loss to show an exact (or even approximate) relation between a single factor and corporate profitability (Blake, 1978). Therefore, it is suggested that economic criteria although they are important determinants, should not be used alone when selecting, justifying, or evaluating R&D projects.

Many methods and techniques for new product/project evaluation have been suggested. However, no single method is applicable throughout the entire spectrum of the product development activities (Blake, 1978). Also, different methods seem to be suitable for different situations which depend on the goals of the company, or in other words the company's product-policy. Some of the methods and techniques for new product/project evaluation collected (King, 1967; Montgomery and Urban, 1969; Earle, 1971; FTRC, 1979; and Lynch and Williamson, 1983) include: Break-even point approach; Present-value product evaluation; Return on investment; Payback index; Long run profit margin; Risk analysis.

Specific methods were also presented by a number of authors. These methods include profitability index (Souder, 1972), expected value maximization project selection model (Souder, 1973), FAITH models (Armstrong and Shapiro, 1974), benefit measurement method and project selection and resource allocation models (Baker and Freeland, 1975). However, only the methods which were used in the present project are described in detail in the following paragraphs.

The economic feasibility of a new product can be determined by "net cash flow profile", a technique representing the predicted new product history (FTRC, 1979). Information required for a net cash flow profile includes: a project life cycle for the new product, an estimate of development costs, an estimate of capital costs, an estimate of total costs over each year of the projected life cycle, and an estimate of revenue over each year of the projected life cycle.

'Net present value' a further development from 'net cash flow profile' was the technique chosen for evaluating the present commercial nutritional products because it could determine the probability of successful profits which was considered to be of the most interest to the industry. Under this technique, the 'time value of money' is considered. Net present value was defined (Earle, 1971) as "the possible cash flows for the product from development to the final 'death' of the product in which all values are predicted and discounted to present values". A product/project for which the discounted cash inflow exceeds the cash outflow is considered to be suitable for further study, and the probability of success of the product/project can be determined, whereas that with the cash inflow less than the cash outflow is stopped.

According to Lynch and Williamson (1983), 'discounted cash flow' techniques provide the most reliable appraisals of alternative investment proposals, and 'net present value index' which is the percentage relationship between present value of the cash inflows discounted at the desired rate and the cost of the investment offers ready comparability between projects of unlike size and duration.

4.2.3 Final Evaluation

In general, when the product ideas pass through the screening and analysis evaluation stage, the formulation and process development will be started, followed by the consumer and/or the market test. These investigations will provide information that can be used for final evaluation before the decision on product launching will be made.

"Bayesian analysis" is the method most used to solve the optimization problem at this stage. It provides a useful operational framework for comparing the value (for decision purposes) and the cost of market tests. Major techniques under this analysis method can be found in the literature (Frank and Green, 1967; Earle, 1971; and Kotler, 1971; Green and Tull, 1975). Briefly, evaluation by this analysis is based on the probabilities assigned to the outcome of the activities. This makes it possible to determine, for example, the overall probability of success and the predicted net present value for the project.

Bayesian analysis could effectively be used for the determination of probability of success in the market plan and the product launch of the present nutritional project if information from a test market was collected. Unfortunately, test market activity was out of the scope of the Study Program, and so was this analysis technique.

4.2.4 Selection of Screening and Evaluation Methods for Nutritional Snack Products

A selection of screening and evaluation methods suitable for a certain product/project to suit its circumstances was considered justifiable. For this nutritional product development project, selection was based on cost, time, simplicity, and efficiency of the method. A three-step method was designed for the present project. This method included sequential and checklist screenings, and probability evaluation.

In the first stage of screening, a large number of the least promising generated product ideas were rejected by the simplest but nevertheless efficient method, with low cost both in money and time. Sequential screening was chosen because: it is simple (with the `PASS` and `FAIL` context); it is cost and time saving (with qualitative criteria based on past experience); and it is considered effective (with criteria based on new-investment guidelines set forth by management).

In the second stage, a more efficient method was needed for differentiating the remaining product ideas. A preliminary estimation might be carried out by using available data and experience. A checklist screening technique was used because: it is more efficient (with its factors weighted); it is more reliable (with its numerical rating of the factors for each product and then comparison of the products' total scores); and it is a less subjective approach.

In the final stage, the most efficient method is needed to differentiate between the promising product ideas and to find the best one(s). More detailed quantitative information for this differentiation and more analytical consideration of the factors -- economic, financial, and business -- were considered necessary. Probability evaluation was chosen because its factor weights are further weighted by assigning a probability score to each rating of each factor. Because the probability approach is based on more detailed quantitative information, it was believed to give a more reliable numerical total score for each product for comparison of the product rating against each other.

4.3 A STEP BEFORE SCREENING OF PRODUCT IDEAS FOR THE PRESENT DEVELOPMENT PROJECT

4.3.1 Introduction

A consumer survey on `Attitudes and Behaviour of Urban School-Age Thais towards Snack Foods` was conducted (Chapter 3) among 160 children in Bangkok. Of three suggested product groups -- Thai cookie, rice-crisp, and Thai pastry -- the last was the most preferred by the children and also the most promising for the development project. Snack product characteristics obtained from this survey were used as the profile of the product to be developed. These are shown below:

Profile	Descriptions
PRODUCT	Sweet snack that is high in calories and protein
RAW MATERIALS	Basically, fruits or vegetables
PROCESSING	Process in which the drying stage is important. Emphasis is put on baking.
PACKAGING	Plastic bag with/without paper carton
CONSUMER	School children aged 7-15 in Bangkok areas
MARKETING	Throughout Bangkok as a consumer product at school stalls, neighbourhood groceries, sweet shops, supermarket and co-op shops; and as a nutritious (high protein-calorie) snack.

4.3.2 Methods and Techniques for Idèa Generation

The methods for idea generation can be classified into 2 main categories: analytical and non-analytical. The first one is a quantitative method and needs formal planning. This method includes grid analysis, morphological analysis, multidimensional scaling, technological forecasting. The second one includes those methods that stimulate thinking along unorthodox paths e.g. literature study, brainstorming, consumer study. Techniques under these two methods are many and varied, and a great number can be found in the literature (Buzzell and Nounse, 1967; King, 1967; Diehl, 1969; Montgomery and Urban, 1969; Earle, 1971; Desrosier and Desrosier, 1971; Reilly, 1971; Byrnes and Chesterton, 1973; Hussey, 1973; Pessemier and Root, 1973; Wills et al., 1973; Edwardson, 1974; Hamilton, 1974; Kraushar, 1977; Douglas et al., 1978; Midglay, 1977; Carson and Rickards, 1979; Osborn, 1979; Hughes, 1980; Kotler, 1980; and Twiss, 1980). Two methods were used, in this project, for generating product ideas -- literature review and brainstorming.

4.3.3 Literature Review

Literature concerning ingredients, formulation, process, and equipment for Thai snack foods was investigated. Also, snack products in the Thai market place were studied. All these were combined with the past experience of the author, and the product ideas obtained from this method were divided into 17 groups. The two main parts of Thai snack foods are: the outer layer parts, as the body of the product, which is usually a cereal base, and the fruit and vegetable for its filling.

4.3.4 Brainstorming

Brainstorming is a conference technique by which a group attempts to find a solution for a specific problem by accumulating all the ideas spontaneously contributed by its members. This was conducted for 25 minutes among 6 Thai graduate students and the author, with another graduate student as a secretary at Massey University. Four rules which were followed during the application of this method were: Criticism prohibited; Free-wheeling welcomed; Quantity wanted; and Combination and improvement of suggested ideas sought. The subject for the panel was "Snacks for School Children in Bangkok", and given key words included: children 7-15, snack, stuffed snack, stuffed with fruit and vegetable, peanut snacks, fruit in syrup, and dried fruit. The 96 ideas obtained were later rearranged, and those which were the same were combined while those which were not concerned with the subject were omitted.

4.3.5 Product Ideas Summary

Product ideas obtained from the literature review and brainstorming, which were relevant to the profile of the product to be developed, are summarized on the next page.

4.4 SEQUENTIAL SCREENING OF THAI SNACKS FOR THE NUTRITIONAL PRODUCT DEVELOPMENT PROJECT

4.4.1 Selection of Sequential Screening Techniques

Theoretically, the information needed in sequential screening should not be expensive to develop but it must be effective in rejecting concepts that are not good investment proposals. Since techniques, or more specifically in this case, the type and number of criteria used for the screening are related to cost and time needed, it was considered that a comparison of techniques under the sequential method should be made.

In this project, the screening methods of O'Meara (1961), Earle (1971), and Hamilton (1974) were modified and used for sequential screening of the above product ideas. The method of Carson and Rickards (1979) was chosen for use in the comparison study because of its simplicity. Another method considered the simplest of the three and also used for comparison was the judgement of ideas against the one most important criteria of the product/project.

Thus, the three screening techniques, which were compared, were different mainly in type and number of criteria. The best one for nutritional product development was determined. The precision of techniques was tested by repeating the judgement using different judges.

PRODUCT IDEAS SUMMARY

Products from Literature Review

Product Groups for Body:

- Baked square
- Baked stuffed bun
- Fried stuffed-dough-balls / stuffed pastry
- Crispy rolls or crispy shells with/without stuffing
- Flour cookie -- cassava & coconut cream, wheat & lard
- Peanut glass
- Roasted rice-and-nut square
- Puffed products: extrusion-cooked products
  - fried dried-steamed-cereal products
  - popped cereal products

Fruit & Vegetable Products for Stuffing:

- Glaced
- Deep-syrup soaked
- Deep-syrup cooked
- Hot-stirred with/without leathering process
- Fruit fritter
- Fruit with condimented topping

Products from Brainstorming

Products from fruits & vegetables:

- Dried fruit
- Hot-stirred (natural flavour)
- Mild-flavour fruit product
- Reformed hot-stirred fruit product
- Turnover-like product with fruit stuffing
- Fruit candy
- Crispy product with fruit stuffing
- Deep syrup cooked fruits
- Deep syrup soaked fruits
- Mushroom product

Products from flour:

- Cake, Chocolate cake
- Cake-like product
- Biscuits
- Steamed cup cake or Steamed cup cake-like product
- Baked leavened product
- Tart-like product
- Hot-stirred and long-form cut product
- Fruit product in thin flour product coat
- Flour product with bean product stuffing
- Curry puff - like (= fried pastry)
- Turnover with minced meat + soybean milk curd as stuffing
- Turnover with fruit & vegetable stuffing
- Turnover with dried coconut shreds and minced meat
- Crispy fried flour product with corn flavour
- Puffed product with fruit flavour
- Puffed product with hot-stirred fruit stuffing
- Puffed fruit pastry product (= fruit in the pastry dough)
- Crispy rice mixed with fruit and other ingredients

Products from nuts:

- Fried nuts
- Sugar coated nuts
- Chocolate coated nuts
- Bite-size nuts
- Roasted nuts
- Ground roasted nuts in pressed form
- Crispy nuts
- Hot stirred products coated with sesame
- Peanut fritters
- Peanut brittle
- Pressed product with nut stuffing
- Coconut product with sweet and creamy flavour

4.4.2 Criteria for Sequential Screening

Criteria for the sequential screening were defined using mainly the findings from the first consumer survey as a guide. The product ideas were screened by sequential screening by the author using the profile of the product obtained from the survey as the criteria. Since this project aimed at persuading the private sectors -- food factories -- to produce nutritious snack products for the urban school-age Thais, those criteria generally important for the company's policy and also those important for the Study Program, were included. Table 4.3 shows criteria factors for sequential screening -- their sources and a brief form of factor definition, while a detailed characteristic definition of each factor can be found in Appendix 4.1M.

4.4.3 Experiment on Comparison of Selected Techniques and Judges Under Sequential Screening Method

The sequential screening method was applied by qualitatively rating the product ideas against screening factors. For each idea, the judgment was ceased where a "FAIL" was met under a particular factor, and the idea was rejected. Those that could "PASS" all factors were retained for further screening. The three techniques which were different in type and number of criteria were carried out as follows:

Technique 1 (T1): The product ideas were qualitatively rated against all nine screening factors mentioned in Table 4.3, under the application of detailed characteristic definition of the criteria.

Technique 2 (T2): The product ideas were qualitatively rated against three fundamental questions (criteria) suggested by Carson and Rickards. The questions were: new? relevant? and actionable? Criteria, in this case, were not defined. Thus, variation in the depth of their meaning might be possible depending on the experience of the judges.

Technique 3 (T3): The product ideas were qualitatively rated against the one most important criteria of the product/project. In general, criteria which need to be considered in screening differs with the circumstances of the individual project. For this project on systematic nutritional product development, it was assumed that the most important criteria was the consumer acceptability of the product based on the first survey result. That was -- sweet pastry having fruit as the main ingredient, and being nutritious (possibly to be developed into a product that could provide about 400 calories and 10 grams of protein for a single snack).

Judgements using the 3 techniques were made by both one of the senior Thai lecturers in Food Technology (Food Microbiology) and the author for the purposes of replication and a comparison of these results was then carried out.

Table 4.3: Brief form of factor definition for sequential screening.

Criteria	Definition in brief form	Sources
1. Nutritional Values	$\geq$ 400 Calories, $\geq$ 10 g protein, Protein calorie $\geq$ 13 % total calories (of the amount of snacking at a time)	Consumer survey; Study program goal
2. Matching technical capability	Raw materials, formulation, processing	Study program goal; Generally, company's criteria
3. Matching financial capability	Development budget = NZ $ 1,000 Production & marketing test budget = NZ $ 4,000	Study program budget
4. Market potential	Acceptability to school Children Possibility that young children and adult will eat. Market size	Generally, company's goal
5. Compatibility with distribution pattern	Distribution channels Storage system Storage life of product	Study program goal
6. Sweet snack	Snack regarded by the Thais as 'sweet snack' whether its main flavour is sweetness or not.	Consumer survey
7. Pastry type snack	Snack, made from a dough or a dough-like mixture, with or without stuffing.	Consumer survey
8. Fruit & vegetable snacks	Those products that have fruit and/or vegetable as the main ingredients.	Consumer survey
9. Suitability	Activities of children Drink after snacking (water) Price $\leq$ 6 Bahts Package: Plastic bag	Consumer survey

4.4.4 Results and Discussion of the Comparison of Selected Sequential Screening Techniques and Judges

The results of the experiment on the comparison between techniques and judges is shown in Table 4.4. According to Judge 1, ten product ideas remained after preliminary screening by the first two methods, while sixteen ideas survived by the method using only the one most important criterion. According to Judge 2, nine product ideas remained after preliminary screening by the first method while eight ideas survived by the second and ten by the third method. The sixteen ideas obtained from the latter method by Judge 1 included the same ten ideas from the other two screening methods, while the ideas from all methods by Judge 2 included the same 8 ideas. Comparison between results from Judge 1 and Judge 2 showed that all methods by both judges gave the same 8 product ideas. However, the second method gave 10 product ideas according to Judge 1 but only 8 ideas according to Judge 2. Its flexible criteria was responsible for this difference in result. It could be assumed based on the above results that all methods measure the same things, but the third method, though taking a shorter time and easier to use, is less effective in the screening capability. Moreover, it will take a more costly screening procedure to remove the 6 ideas which do not match the technical capability constraints.

It was found from this experiment that the factors, or in other words the characteristics of the criteria, play an important role in this screening consideration. Although criteria in the first two methods seemed to be different, the factors or characteristics for judgement were similar in meaning. Since the criteria in the method of Carson and Rickard is flexible, they might be judged differently by different persons and in different situations, though the result of comparison among judges in this experiment did not strongly support this statement. Thus, it could be assumed that apart from the screening method, the choice of the judge is of the most importance. In general, the preliminary screening is carried out by one who knows well the constraints concerned -- that means one who has experience in that type of product/project.

Table 4.4: Summary result of experiment on comparisons among techniques and judges under sequential screening method.

No.	Product Ideas	Judge 1			Judge 2			Products Selected
		T1	T2	T3	T1	T2	T3	
	Crispy product with fruit stuffing	P	P	P	P	P	P	*
	Tart-like product			P			P	
	Fruit product in thin flour powder layers	P	P	P	P	P	P	*
	Flour product with bean product stuffing				P			
	Curry puff like product (= fried pastry)			P			P	
	Turnover-like product with fruit&vegetable stuffing	P	P	P	P	P	P	*
	Puffed pastry product with hot-stirred fruit stuffing	P	P	P	P	P	P	*
	Puffed fruit pastry product (fruit in pastry dough)	P	P	P	P	P	P	*
	Product having milk as ingredient			P				
	Baked square	P	P	P	P	P	P	*
	Baked stuffed bun	P	P	P	P	P	P	*
	Steamed stuffed bun			P				
	Fried stuffed-dough-balls			P				
	Fried stuffed-pastry			P				
	Baked stuffed-pastry	P	P	P	P	P	P	*
	Crispy rolls without stuffing	P	P	P				*
	Crispy rolls with stuffing	P	P	P				*
		10	10	16	9	8	10	

Judge 1 = The author
Judge 2 = Senior lecturer in Food Technology (Food Microbiology)

The decision was, therefore, to select 10 ideas, 8 of which were rated as "PASS" by both judges but 2 of which were a "PASS" by Judge 1 only. The reason for retaining the latter two product ideas, in spite of the "PASS" obtained by only one Judge, was because of their strong potential in long storage shelf life, the nutritional improvement of their stuffing, and in the available technological modification.

In conclusion, among the three techniques of sequential screening methods studied, technique 1, which comprised criteria based mainly on the product-profile obtained from the consumer survey and on the objectives of the Study Program, was considered the most suitable for the nutritional product development. Though this technique took more time and money than the other two, it was effective and capable of retaining the potentially successful product ideas while removing the potentially commercially unsuccessful ones provided that it was monitored by an experienced judge.

The specificity of its factors and its number of factors was large enough to cover the product profile required by the consumer and this was responsible for its effectiveness. Overall, this technique was considered as more cost- and time-saving for the further product evaluation process, and also it was believed that it would ensure the consumer acceptance of the product to be developed.

4.4.5 Product Ideas Selected

The product ideas selected for further screening were:

- Turnover-like product with fruit stuffing
- Crispy product with fruit stuffing
- Fruit product in thin flour powder layers
- Puffed pastry product with hot-stirred fruit stuffing
- Puffed fruit pastry product (fruit in pastry dough)
- Baked square
- Baked stuffed bun
- Baked stuffed-pastry
- Crispy rolls without stuffing
- Crispy rolls with stuffing

4.5 CHECKLIST SCREENING OF THAI SNACKS FOR NUTRITIONAL PRODUCT DEVELOPMENT PROJECT

4.5.1 Introduction

Checklist screening, which is a quantitative numerical rating method, was applied for screening the product ideas remaining from the sequential screening. The procedures of Earle (1971) and Twiss (1980) were followed. Since, as noted by Pessemier (1966), preliminary evaluation and economic analysis do overlap to a degree that make it impossible to identify where one ends and the other begins, the latter part of this screening, namely critical screening by a probability technique, was moved under the evaluation to be combined with the economic/business analysis evaluation.

4.5.2 Criteria for Checklist Screening

Marketing and technical factors related to the product/project, whether similar to or different from those of sequential screening, were generated. Those which were similar to each other were grouped, while those less associated with the product/project were omitted. Twelve marketing and technical factors were selected, reordered and weighted (Table 4.6) on their relative importance to the objectives of the project so that the total weight was 100. The following were used for the consideration of the relative importance to the project objectives of the factors.

: Factors affecting the Study Programme, which in turn, affect the National Nutrition Programme.

: Factors affecting the numbers of consumers that could be reached, and the frequency and amount consumed of the product.

: Factors affecting the company's goal of profitability.

: Factors affecting possibility of success, during and after development stage.

The reasons for the relative importance of checklist screening factors are shown in Appendix 4.2Ma and the scores for rating each factor in Appendix 4.2Mb.

Table 4.5: Criteria factors and weights for checklist screening.

Factors	Weight
Ease of enrichment	11
Estimated amount consumed	11
Storage life of the product	10
Ease of distribution	10
Newness (or uniqueness)	9
Pricing and customer acceptance	9
Competition	8
Technical development and production difficulties	7
Possibility of future development of the product	7
Production capacity	7
Development cost and time	6
Problem of processing equipment and other facilities for R&D	5
Total weight	100

4.5.3 Procedures for Checklist Screening

A rating sheet was prepared with the product ideas in the first column and the weight-assigned factors in the first row. Each factor was given a total mark, then each product was given a mark according to the information obtained about the product. Then the marks for all the factors were added to give a total mark for the product. The product ideas then were ranked against each other, and the ideas with the highest ranking chosen for a further evaluation process.

4.5.4 Results and Discussion on Checklist Screening

The result of the checklist screening is shown in Table 4.6. The checklist method of screening was found, in this study, to be more effective than the sequential method for removing potentially unsuccessful products and those products not related to the project objectives, because of its quantitatively defined factors.

However, there is a subjective judgment on the weighting of the factor rating of product ideas, and therefore experience, past or present, of the judges was considered necessary. Most important for this subjective application seemed to be the unbiased attitude of the judges.

Table 4.6: Result of checklist screening.

Product ideas	Scores												Total scores
	F 1	F 2	F 3	F 4	F 5	F 6	F 7	F 8	F 9	F 10	F 11	F 12	
	11	11	10	10	9	9	8	7	7	7	6	5	100
Turn-over like product with fruit & vegetable stuffing	3	7	1	5	6	7	7	2	5	2	1	4	47
Crispy product with fruit stuffing (wafer-like)	7	7	8	9	8	5	6	6	4	5	1	2	69
Fruit product in thin flour powder layer (powder form & pressed)	5	10	8	9	8	5	7	6	5	5	5	4	77*
Puffed product with hot-stirred fruit stuffing (extrusion)	8	7	6	8	9	4	7	3	5	2	2	2	63
Puffed fruit pastry product (= fruit in the dough, extruded or baked for the pastry)	10	6	9	8	8	6	7	6	6	5	4	2	77*
Baked square	5	9	8	9	8	7	7	5	5	5	5	4	77*
Baked stuffed bun	9	7	1	5	4	7	4	6	5	2	1	4	55
Baked stuffed pastry	7	9	7	8	5	7	4	6	5	2	4	4	68
Crispy rolls with fruit stuffing	7	6	9	8	8	6	3	6	5	4	1	1	64
Crispy shells with stuffing	6	6	9	8	8	6	4	5	5	3	1	1	62

F1 = Ease of enrichment
F2 = Amount consumed
F3 = Storage life
F4 = Ease of distribution
F5 = Newness
F6 = Price

F7 = Competition
F8 = Development and production difficulty
F9 = Future development possibility
F10 = Production capacity
F11 = Development cost and time
F12 = Equipment and facility for R & D

4.5.5 Product Ideas Selected

The product ideas selected for further probability screening were-

:Fruit product in thin flour mixture layers
(powder or pressed form)
:Puffed fruit pastry product
(fruit in the dough, extruded or baked to make the pastry)
:Baked square

4.6 FACTS AND FIGURES FOR ANALYSIS EVALUATION

4.6.1 Introduction

Since probability evaluation is based mainly on quantitative information, statistics were collected and predictions were made on various aspects -- finance, technology, market, and consumer. Data was collected and predictions made on the factors to be used in the probability evaluation of Thai snacks for the nutritional product development project in Section 4.7. These included the availability and cost of raw materials, the quality/price relationship, profitability, the expected competitive situation, the effect of processing on nutrients, the ease of enrichment, equipment necessary, and production capacity. These facts and figures were to be the base for judgment on the rating and scoring of each factor and of each product in the probability evaluation.

4.6.2 Generation of Preliminary Product Concepts for Analysis Evaluation of Thai Snacks

Since more quantitative details were necessary for this stage of the evaluation, preliminary product concepts were established to facilitate the estimation of each characteristic of the products to be developed. In the generation of the preliminary product concepts, the three product ideas remaining from the checklist screening were combined with the screened fruit & vegetable products for stuffing which were summarized from the literature review, past experience, and brainstorming. A sequential technique with selected criteria was used for this screening as shown in Table 4.7.

Table 4.7: Sequential screening for. fruit & vegetable products for stuffing.

Products	Criteria 1	2	3	4	Decision
Glaced fruit & vegetable	F				
Deep-syrup soaked fruit & vegetable	P	F			
Deep-syrup cooked fruit & vegetable	P	P	P	P	P
Hot-stirred fruit & vegetable	P	P	P	P	P
Leathered fruit	P	F			
Dried fruit	P	P	P	P	P
Fruit fritter	F				
Fruit with condimented topping	F				

1 = Suitability as stuffing or as a mixture part of the product
2 = Cost & time for process
3 = Availability of equipment and facilities for process in both R & D and production stages.
4 = Storage life

Then, product ideas remaining from the checklist screening and stuffing ideas remaining from the separate sequential screening were used as the key words of ideas for combination to form brief preliminary product concepts for further probability evaluation.

Product Ideas	Stuffing Ideas
Fruit product in thin flour coat or thin layers of pressed flour mixture.	Deep syrup cooked fruit (banana or mango)
Puffed fruit pastry product (fruit in the dough or in the flour mixture)	Hot-stirred fruit (banana or mango)
Baked square with stuffing	Dried fruit (banana or mango)

Nine possible preliminary product concepts were obtained from the combination of product and stuffing ideas as follows -

:Deep-syrup cooked fruits in thin layers of pressed flour-mixture.

:Hot-stirred fruits in thin layers of pressed flour-mixture.

:Dried-fruits in thin layers of pressed flour-mixture.

:Puffed fruit pastry product using deep-syrup cooked fruits.

:Puffed fruit pastry product using hot-stirred fruit.

:Puffed fruit pastry product using dried fruits.

:Baked square with deep-syrup cooked fruits as stuffing.

:Baked square with hot-stirred fruits as stuffing.

:Baked square with dried fruits as stuffing.

4.6.3 Availability and Cost of Raw Materials

It was the purpose of this project that indigenous raw materials be used as much as possible in the product. It was believed that industrial utilization of economical commodities would be one solution for a surplus of agricultural food products and, in turn, result in a benefit to the farmer.

To facilitate the judgement at this step, only the main basic ingredients for each preliminary product concept were examined; and raw materials most feasible for use in the preliminary product concepts were compared. Table 4.8 shows preliminary product concept key words for the feasible main basic ingredients and their percentage ratios. These percentage ratios were adapted to make it possible to have 5 percent of other ingredients to be added later for nutritional or functional purposes. Representative basic recipes for each group of the preliminary product concepts were given (Appendix 4.3Ma) for the study of the feasibility of making the product. For example, for the baked square product group, a Thai pastry recipe was used. The basic recipe for Thai pastry after rounding off the figures and the percentage ratio of the recipe for the preliminary product concepts of the baked square product group were as follows:

Recipe for Thai Pastry

	%
Wheat flour	13
Lard	18
Mungbean	31
Sugar	33
Cool water	5
Other ingredients	-
Total	100

Percent Ratio of Recipe for Baked Square

	%
Wheat flour	12
Lard & coconut cream	16
Fruit	31
Sugar	32
Water	4
Other ingredients added later	5
Total	100

Using past experience for comparison of the above two recipes, it was considered that the latter recipe was feasible from the preparation point of view.

Appendix 4.3Mb presents the availability and price of those main raw materials in the Bangkok market, and Appendix 4.3Mc the reasons for using banana or mango in the recipe.

Table 4.8: Preliminary product concepts and key words for the most feasible main basic ingredients and their ratios.

Preliminary product concepts	Most feasible basic ingredients	Percent ratios (adapted (percent ratios)
Deep-syrup cooked fruits in thin layers of pressed flour-mixture. Hot-stirred fruits in thin layers of pressed flour mixture Dried-fruits in thin layers of pressed flour-mixture	Glutinous rice flour: sugar: banana(mango): water	15:49:15:21 (14:47:14:20:5)
Puffed fruit pastry product using deep-syrup cooked fruits Puffed fruit pastry product using hot-stirred fruits Puffed fruit pastry product using dried-fruits	Glutinous rice: banana(mango): palm sugar	45:22:33 (43:21:31:5)
Baked square with deep-syrup cooked fruits as stuffing Baked square with hot-stirred fruits as stuffing Baked square with dried fruits as stuffing	Wheat flour: lard: fruit: sugar: coconut cream: water	13:4:32:33:13:5 (12:4:31:32:12:4:5)

Notes:

1. Other certain main ingredients were not included because similar raw materials would be used. For example, egg might be used as a source of protein and coconut as a source of fat.

2. Other local flours e.g. cassava flour, non glutinous rice flour, and soy flour might be used in the products for certain functional and nutritional properties and also for the lower cost benefit.

3. Products of the same type were assumed to have similar ratios of ingredients.

4.6.4 Quality/Price Relationship

The price of the product was determined from the consumer survey. The school-age respondents indicated they would be willing and expected to pay 6 Bahts/package or below for acceptable products developed. From the consumer survey, the pocket money (for snacks only) per day was found to be 6-10 Bahts for the average urban school-age Thais studied; and those at public schools tended to obtain less pocket money than those at private schools. Thailand's money system is made up of 25 and 50 stang coins, 1 and 5 Baht coins, 5, 10, 20 and 100 Baht notes. Thus, the price per package of the amount that can provide enough nutrients for the school children (1/4 of the daily dietary requirement) was justifiably set at 5 Bahts.

Assuming 10 and 30 % wholesale and retail margins respectively, the list price of the product, which included the factory cost plus overheads, the distribution cost, the marketing cost, and a profit, would be 5 - 2 = 3 Bahts.

"Quality", at this step, comprised only those qualities that were suggested by the respondents in the consummer survey, which included organoleptic, nutritional, packaging, and distributing qualities. The product should be a sweet snack of the fruit pastry type, provide approximately 550 Calories and 18 grams protein (25% of the nutrients in the daily dietary requirement of Thai school children aged 10-12), packed in a plastic bag, and distributed through snack stalls at school, neighbourhood groceries, sweet shops, supermarkets and co-op shops.

The qualities and prices of the products on the Bangkok market were studied and compared with those of the products to be developed (Appendix 4.4M). The products which would have a quality close to that expected by the consumer and that could be priced at or below 5 Bahts were preferred.

4.6.5 Profitability

Profitability, in this project, was considered to be the most important factor because it leads to investment or noninvestment by a company. It was determined by an economic evaluation. Nine preliminary product concepts were discriminated by a net cash flow profile technique suggested by Earle (1971). This technique generates information on the financial rate of return for each product concept, so that product concepts with higher rates of return were scored higher because they promised to be more profitable.

For profitability of the nine preliminary product concepts, the predictions and estimations were made on life cycle , market potential, costs, and revenue. The life cycle was projected to be 8 years for all products from personal knowledge of the Bangkok markets. The consumer survey indicated that 66.3% of the children would buy the product, therefore the target market in Bangkok was estimated at 586,700 school children.

The consumer survey indicated that the children would buy 24 packets/head/year but this was thought to be optimistic and the maximum yearly sales potentials were set at 5, 5 and 6 million packets for stuffed pressed flour mixture type (Group 1), puffed fruit-pastry type (Group 2) and stuffed baked square type (Group 3) respectively. The predicted growth to these maximum sales potentials is shown in the product life cycles in Figure 4.1. Because of the children's preferences in the consumer survey it was considered that the Group 1 products would grow more slowly in sales than the other products. The retail price and the company price were set at 5 Bahts and 3 Bahts respectively and the yearly total sales revenue throughout the product life cycle determined by multiplying the predicted sales potentials by 3 Bahts.

The detailed estimation of the product costs are shown in Appendix 4.5Mb. Raw material costs were determined for each group of products and the same standard cost (1.392 Bahts/200 g packet) was used for all other expenses. This gave total costs of 2.6646, 2.8570 and 2.8968 Bahts/200 g packet for Group 1, Group 2 and Group 3 products respectively.

The net revenue was determined by subtracting the total production costs from the sales revenue as shown in Appendix 4.1. The capital investment included the R & D costs, the fixed capital costs and the working capital costs. The same R & D costs were assumed for each product, the fixed capital investments were the costs of additional equipment only; it was assumed that there was no need for buildings.

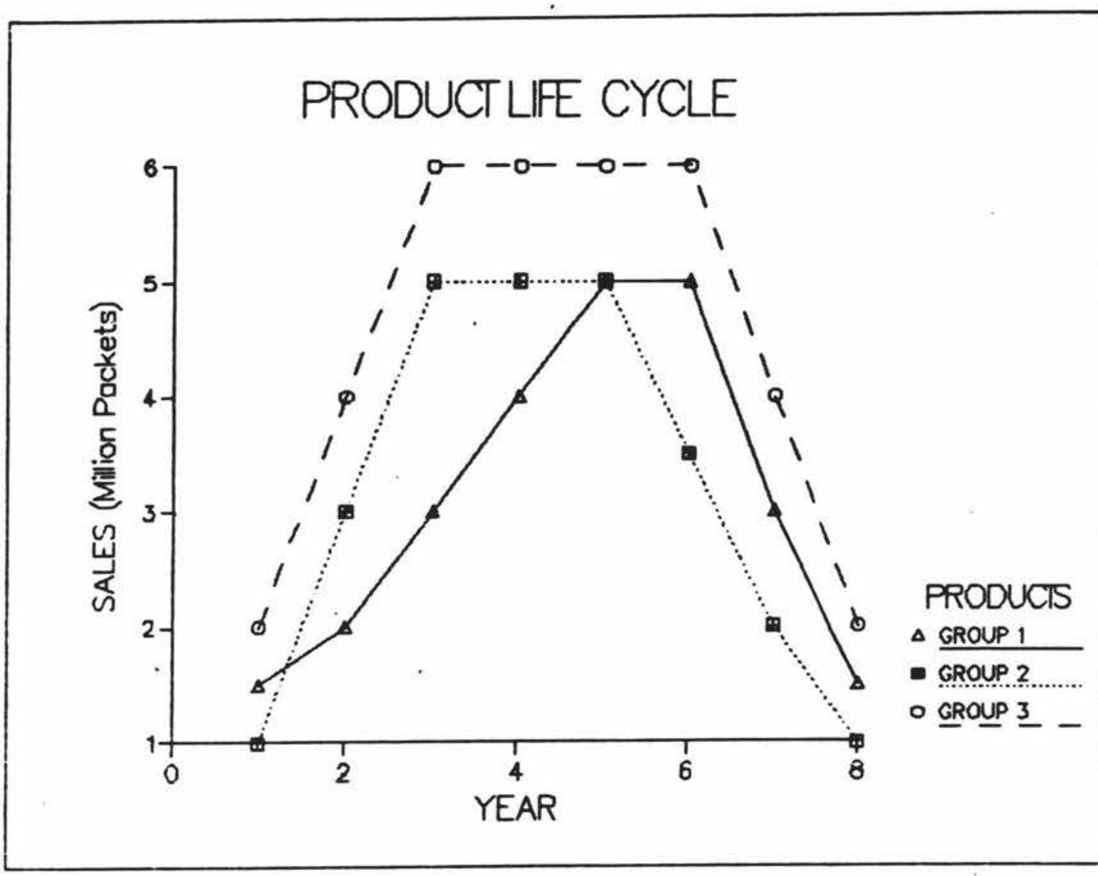


Figure 4.1: Life-cycles of 3 groups of preliminary product concepts (see Appendix 4.5Ma for details)

The working capital costs was taken as 15% of the fixed capital costs. The method of cost estimation described by Peters and Timmerhause (1981) was used. Details are shown in Appendix 4.5Mb and summarized in Table 4.9. The R & D costs and the fixed capital costs were assumed to be spent in year 0, and the working capital costs in year 1 as shown in Appendix 4.2. The cash flows for all the products are shown in Appendix 4.5Mc. The 'capital return index' values were determined by dividing the total net revenue after tax by the capital investment (Appendix 4.5Mf).

Table 4.9: Comparison of profit-ranking results from different methods of discountings

No	Product	Total Net Revenue ('000 Bahts)	Capital Investment ('000 Bahts) Fixed	Working	Capital Return Index	NPV year 9 IR 40% ('000 Bahts)	NPV-Index (%)
S1	Deep-syrup cooked fruits in thin layers of pressed flour-mixture	4,192 (1)*	909	113	4.10 (2)*	332 (2)*	144.0 (2)*
S2	Hot-stirred fruits in thin layers of pressed flour-mixture	4,192 (2)	959	120	3.89 (3)	276 (3)	131.1 (3)
S3	Dried-fruits in thin layers of pressed flour-mixture	4,192 (3)	859	105	4.35 (1)	389 (1)	158.6 (1)
S4	Puffed fruit pastry product using deep-syrup cooked fruits	1,824 (7)	609	68	2.69 (7)	-21 (6)	69.5 (6)
S5	Puffed fruit pastry product using hot-stirred fruits	1,824 (8)	659	75	2.49 (9)	-78 (9)	56.3 (9)
S6	Puffed fruit pastry product using dried fruits	1,824 (9)	559	60	2.95 (5)	35 (4)	85.2 (4)
S7	Baked square with deep-syrup cooked fruits as stuffing	1,858 (4)	609	68	2.74 (6)	-27 (7)	69.0 (7)
S8	Baked square with hot-stirred fruits as stuffing	1,858 (5)	659	75	2.53 (8)	-75 (8)	57.7 (8)
S9	Baked square with dried fruits as stuffing	1,858 (6)	559	60	3.00 (4)	29 (5)	84.7 (5)

* = Profit-Rank

The net present values were determined by firstly determining the profit after tax by subtracting 50% from the net revenue and then discounting both the capital investment and the profit after tax firstly at 16% (see Appendix 4.2) and then discounting the profit after tax at 22%, 28%, 34% and 40%. Details for all products are shown in Appendix 4.5Md and 4.5Me.

The nine preliminary product concepts were then compared by using the net present value profile technique presented by Earle (1971). Also, 'net present value index (NPV-Index)' was calculated. 'Net present value index' or in other words 'profitability index' is the percentage relationship between the present value of the stream of future payments at the desired rate of return and the initial investment. The 'earning cash flow' or the 'total net revenue after tax', which is the sum of the net revenue after tax over nine years without the application of present value factor for discounting, was also presented for comparison.

A comparison of profit-ranking results from the different methods is shown in Table 4.9, while the detailed results can be found in Appendix4.5Mf. The NPV in the table was calculated discounting the profit after tax at 40% and the capital investment at 16%.

Table 4.9 shows how the nine preliminary product concepts were ranked in accordance with the comparative values shown beside each ranked value. In this study, where a budget constraint was not set, the ranking considerations were based mainly on the relative values; and the following would be accepted from the ranking point of view, depending on the method used.

Total Net Revenue:	S1	S2	S3	S7	S8	S9	S4	S5	S6
Capital Return Index:	S3	S1	S2	S9	S6	S7	S4	S8	S5
Net Present Value:	S3	S1	S2	S6	S9	S4	S7	S8	S5
Net Present Value Index:	S3	S1	S2	S6	S9	S4	S7	S8	S5

Although the four methods used seemed to give similar results in profit-ranking, a closer look did suggest some difference which could be used as an identifier of the superiority of the method. The 'total net revenue' estimated the product's total earning in nine years but neither the investment cost nor the true value of money was included in the expression. The 'capital return index' did give an indication of the return in investment but the true earning could not be obtained because of the exclusion of discounting the money value of the yearly earnings.

The 'net present value index' gave a similar ranking pattern to the 'NPV' method because it took into consideration the investment needed and the time value of money. This similarity was valid for the ranking of the nine product proposals which had similar life cycles in this project. However, the superiority of the NPV-index method did show in the comparability it afforded between investment proposals of different magnitudes. For example, at a desired rate of return of 16%, S1 investment costing 1,005,726 Bahts showed a net present value (9 years) 1,448,241 Bahts; while S7 costing 666,756 Bahts showed only 460,395 Bahts (Appendix 4.5Me and 4.5Mf). The S1 proposal would be viewed more favourably, however, in view of a net present value index of 144.0% as compared with that of S7 of 69.0%. Under such circumstances, it was conceivable that, if there were enough smaller proposals having net present value indices higher than 69.0%, the one costing 666,756 Bahts with an index of 69.0% would be rejected. Thus, if this had been the final judgment for this project, S7 would have been rejected, while S6 (costing 610,291 Bahts; NPV-Index 85.2%) and S9 (costing 610,291 Bahts; NPV-Index 84.7%) would have been accepted.

It could be concluded, based on this comparison result, that, for a profitability estimation, NPV and NPV-Index may be used because they are based on discounted cash flows. Between the two methods, NPV and NPV-Index, the latter was preferred because: it offers ready comparability between products/projects of unlike sizes; it is based on the discounted cash flow technique which is considered the most reliable appraisal of alternative products; the use of present value tables made this technique reasonably simple to use. This result supported the statement of Lynch and Williamson (1983) on the advantages of the use of the NPV-Index for evaluating project proposals.

4.6.6 Expected Competition

The expected competition was subjectively judged and based on product and process as follows:

Stuffed pressed flour mixture product:

Similar typical Thai products and processes available, but all are small-scale productions.

Puffed fruit pastry product:

Similar products available and industrially produced. Though process is somewhat different, the characteristic of the finished product is similar.

Stuffed baked square product:

Similar products and processes available. Though all are small-scale production, a great number of factories exist which should be taken into account.

4.6.7 Effect of Processing on Nutrients

The degree of the destruction of important nutrients was used as the basis for judgment on the effect of processing. Important nutrients needing careful consideration in the nutritional snack for the urban Thai children are essential amino acids, in particular lysine, and vitamins B1 and B2. Other nutrients -- fats, vitamin C, and minerals for example -- though also important, were not seriously considered at this stage because fats and minerals are more stable, and vitamin C is not the cause of a nutrient deficiency problem for Thai urban children.

To facilitate the nutrient retention judgment, the nutritive values of the foods used as the main raw materials were collected (Appendix 4.6Ma), and the relative stability of nutrients under various conditions of the process was investigated (Appendix 4.6Mb). Five keywords for the nutritional evaluation at this step were dehydration, hot-stirring, and baking for the process, and protein, vitamin B1 and B2 for the nutrients. Also, to facilitate comparisons of these preliminary product concepts, the destruction predicted to occur in each product (stuffing and body of the snack) was subjectively estimated and tabulated in Appendix 4.6Mc.

4.6.8 Ease of Enrichment

Since the preliminary product concepts were made mostly from fruits, flour, and sugar which are carbohydrates, improving the nutritional value of the product was considered a necessity. Undoubtedly, optimisation of formulation was considered the best way and was the first choice. Enrichment with chemical nutrients e.g. amino acid compounds, vitamins, minerals, and fats was another possible method to be used for improving the nutritional value of Thai snacks. The existing process chosen for the product should easily incorporate the enrichment process.

The factors considered when comparing the products on the "ease of enrichment" factor were: the ease of optimising the formulation to give the desired nutritional value; the types and amounts of nutrients needed to be added because of nutrient losses during processing; the ease of adding nutrients during the processing; the effects of added nutrients on the product quality. However, these were only subjectively judged. For example, baked square product group had basic ingredients which could produce a nutritionally balanced product on optimising the formulation. Thus, it was considered that this group of products needed the least synthetic nutrients added and also might encounter the least difficulty in adding nutrients. Therefore, it was scored the highest. In comparison, the lower nutritional values of the basic ingredients of the pressed flour-mixture product group might result in many more types of nutrients and in larger amounts for the enrichment. Thus, it was scored lower than the baked square product group. Table 4.10 shows the results of the comparison of the products for ease of enrichment.

Table 4.10: Estimated judgment of the "ease-of-enrichment" factor.

Preliminary product concepts	Enrichment process			
	Protein	Vitamins	Minerals	Fats
Deep syrup cooked fruit in thin layers of pressed flour-mixture	+	+	-	+
Hot-stirred fruits in thin layers of pressed flour-mixture	+	+	-	+
Dried-fruits in thin layers of pressed flour-mixture	+	+	-	+
Puffed fruit pastry product using deep-syrup cooked fruits	-	+	-	-
Puffed fruit pastry product using hot-stirred fruits	-	+	-	-
Puffed fruit pastry product using dried-fruits	-	+	-	-
Baked square with deep-syrup cooked fruits as stuffing	++	+	++	++
Baked square with hot-stirred fruits as stuffing	++	+	++	++
Baked square with dried-fruits as stuffing	++	+	++	++

- = More complex enrichment
+ = Simpler enrichment
++ = Simplest enrichment by formulation control

4.6.9 Equipment Necessary

Assuming that a cookie factory would be used for the stuffed pressed flour product, a wafer factory for the puffed pastry product, and a biscuit factory for the stuffed baked square product, the equipment existing, needing adaptation, and needing acquisitions, is shown below.

Symbol Definitions

+ = equipment existing

* = equipment not existing, but adaptation is possible.

- = equipment not existing, buying is necessary.

	Existing of Equipment
Stuffed pressed flour product: (Cookie factory)	
Measuring & weighing equipment	+
Mixer	+
Depositor	+
Pistle presser	*
Baking chamber	+
Cooking assembly with control system (Kettle with agitator)	-
Dehydrator	-
Packaging equipment (or line)	+
Chiller	+
Puffed fruit-pastry product: (Wafer factory)	
Measuring & weighing equipment	+
Mixer	+
Plates of hydraulic press (Molder-baker)	+
Cooking assembly with control system (Kettle with agitator)	-
Dehydrator	-
Packaging equipment	+
Chiller	+
Stuffed baked square product: (Biscuit factory)	
Measuring & weighing equipment	+
Dough mixer	+
Depositor	+
Baking chamber	+
Cooking assembly with control system (Kettle with agitator)	-
Dehydrator	-
Packaging equipment	+
Chiller	+

4.6.10 Production Capacity

For the evaluation of production capacity, it was assumed that the output of food products of the type being considered was limited by the capacity of the plant and factories. In judging this factor, it was assumed that an existing process that was similar or related to the product would be used. For example, for the baked square product, the baking process in a bakery factory was assumed. Estimations were made of the target segment, production requirement, and production capacity as shown below.

Target segment (66% of Bangkok children aged 7-14)	≃	0.6 million
Target + strong potential (Children aged 7-14 + aged 5-6 and 15-19)	≃	1.2 million
Target + strong potential + moderate potential (Children aged 7-14 + aged 5-6 and 15-19 + adult aged > 20)	≃	1.8 million

The market share was estimated at 25 % for stuffed pressed flour mixture products, 20 % for puffed fruit pastry products, and 30 % for stuffed baked square products; and the average market share for all products was taken as 25 %. Estimated consumption/head at a time was

100 grams for puffed type product and 200 grams for stuffed pastry type product; thus the estimated consumption for the average product was 150 grams.

Assuming a frequency of consumption of the products studied of 24 times/head/year, resulted in the production requirement of:

600,000 x 25/100 x 150 x 24
= 540,000,000 g/year
= 540 metric tons/year.

Assuming that production will take place over the whole year because of the surplus availability of the fruits to be used, the need for production capacity is:

= 540/300
(assuming 52 days for weekends,
13 days for holidays,
thus, working days = 365 - 65 = 300 days)

= 1.8 metric tons/day, for target market

= 3.6 metric tons/day, for target + strong potential market

= 5.4 metric tons/day, for target + strong potential + moderate potential

The total production capacity of each product was estimated by the size of factory observed in the Bangkok area.

1. Stuffed pressed flour mixture product:

Small scale factory.
Cookie or biscuit lines could be adapted for it.
Size of cookie factories existing: Small, Medium, Large

Production Capacity	No. Factory
Small approx. <1 metric tons	Many
Medium approx. 1-10 metric tons	Average
Large approx. > 10 metric tons	Very few

2. Puffed fruit pastry product:

Home-made type product
Wafer lines could be adapted for it.
Size of wafer factory in Bangkok: Medium

Production capacity	
Medium approx. 1-10 metric tons	Very few

3. Stuffed baked square product:

Compared to mungbean-stuffed pastry (KANOM PEAH)
Small-scale factories (Many)
Biscuit line could be adapted for it.
Size of biscuit factories: Medium and large

Production capacity	
Small scale approx. < 1 metric ton	Many
Medium scale approx. 1-10 metric tons	Average
Large scale approx. > 10 metric tons	Few

The comparison of the three preliminary product concept groups, based on the above estimations, proved that the baked square product group would be ranked first for the "least problems for production" point of view, because the available factories which could be adapted for use were of a large size and numerous enough for the estimated production requirement per day. The pressed-flour-mixture type was considered the second best because there were very few large factories. The puffed-fruit-pastry type was ranked last because the factories for use were so few. Moreover, most of the present production of puffed pastry product was on a home-made scale.

4.7 ANALYSIS EVALUATION BY PROBABILITY TECHNIQUE OF THAI SNACKS FOR NUTRITIONAL PRODUCT DEVELOPMENT PROJECT

4.7.1 Introduction

The probability technique for analysis evaluation of product ideas is based mainly on quantitatively detailed information, especially that of a statistical and forecasting type, on financial, technical, market, and consumer aspects. For forecasting information, predictions were considered necessary. In this project, the procedures suggested by O'Meara (1961), King (1967), and Earle (1971) were used as a guide.

4.7.2 Criteria for Analysis Evaluation

In selecting criteria for the probability evaluation of the Thai snack preliminary product concepts, it was assumed that profitability and market growth potential were the most important criteria that would interest the companies in investing in this nutritious snack product (as is the goal of this project). Therefore, these main criteria were taken into consideration more seriously and quantitatively in order to help make the GO, NO, or ON decision as valid as possible. In doing this, these two main criteria were divided into factors to make them easier for preliminary analyses and make them clearer for visualization (Table 4.11).

Since these 9 preliminary product concepts were very close in structure, use, and acceptability (from the previous screening); technical criteria were set to help with their discrimination. Factors for the technical criteria, which were justifiably reconsidered more deeply at this stage, were those concerned with the nutritive value of the products and the production capacity feasible for a factory of middle or large size. Thus, the overall factors were subjectively weighted (Table 4.11) according to their relative importance to the objectives of the project so that the total weight was 100.

Table 4.11: Factors and weights for probability evaluation.

Factors for Probability Evaluation	Factor Weight
Those concerned with profitability and market growth potential:	
Availability and cost of raw materials	10
Quality/price relationship	10
Profitability	30
Expected competitive situation	5
Those concerned with technical feasibility related to product nutritional value and production capacity:	
Effect of processing on nutrients	10
Ease of enrichment	20
Equipment necessary	5
Production capacity	10
	100

4.7.3 Procedures for Analysis Evaluation

The nine preliminary product concepts were scored by using a probability evaluation technique in order that only product concepts with scores above an acceptable point were worthwhile for bench work or laboratory development of the product. At this stage, detailed data for each preliminary product concept were re-examined more deeply and more quantitatively, so that the differences in the benefits of the product concepts could be discriminated.

Five levels, namely very good, good, average, poor, and very poor, were used and the rates of 10, 8, 6, 4, and 2 were assigned for these levels respectively. Factor descriptions were defined for each rate (Appendix 4.3), based on facts and figures which were thoroughly investigated for this judgment. For example, for the profitability factor, a rating of 10 was described as the NPV-index which was more than 100%, while the NPV-index which was between 80% - 100% was rated at 8. For the production capacity, the number of metric tons of products that could be produced per day were used. And the percentage destruction of important nutrients was applied for the effect of processing on the nutrients of the product.

After the factors were weighted and the levels described, the probability that each preliminary product concept would reach any of the levels of fit was assessed. This assessment was quantitatively based but a subjective judgment still had to be made. The probability was multiplied by the value of the level of fit and summed up, and the expected value of the product concept for that factor was obtained. This, when multiplied by its factor weight, would give the factor rating, after which an overall rating for each product would be obtained by the addition of all the assessed factor ratings. An example of this assessment on dried-fruit in thin layers of pressed flour mixture is shown in Table 4.12, while the probability assessment for the nine preliminary product concepts can be seen in Appendix 4.7M.

4.7.4 Results and Discussion on Analysis Evaluation

The summary results of the evaluation by the probability technique are shown in Table 4.13. Probability evaluation, because of the more detailed quantitative information on financial, technical, marketing, and consumer aspects, was found to be the most effective screening/evaluation method used for this nutritional product development project. The time and budget necessary for this effectiveness was considered worthwhile. However, care was taken in the comparison investigation among product ideas because subjective judgment was still in use.

A "Good guess" based on the available past statistical data was used for accuracy of the decision.

4.7.5 Product Ideas Selected

The three product ideas selected were:

: Dried-fruits in thin layers of pressed flour mixture
: Baked square with dried fruits as stuffing
: Deep-syrup cooked fruits in thin layers of pressed flour mixture

4.8 DISCUSSION ON A SCREENING SYSTEM FOR NUTRITIONAL SNACK PRODUCTS

This study proved that systematic screening and evaluation of the generated nutritional product ideas in a stepwise manner, from low-cost to high-cost methods and techniques namely from sequential and checklist screenings to probability evaluation, was effective. It could, in a stepwise manner, differentiate firstly the promising from the unpromising product ideas, secondly the more promising from the less promising ones, and finally the best among the more promising ones. The effectiveness of this three-step method was found to depend partly on careful selection, definition, and weighting of factors.

Table 4.12: An example of probability assessment on dried fruits in thin layers of pressed flour mixture.

Factors	Factor weight	Level					Expected Weight level	Contribution to Total expected utility
		Vgood 10	Good 8	Ave. 6	Poor 4	Vpoor 2		
1. Availability and price of raw materials.	10	0.1	0.8	0.1	0.0	0.0	8.0	80
2. Quality/price relationship.	10	0.0	0.2	0.8	0.0	0.0	6.4	64
3. Profitability	30	0.2	0.7	0.1	0.0	0.0	8.2	246
4. Expected competition	5	0.1	0.7	0.1	0.1	0.0	7.6	38
5. Effect of processing on nutrients.	10	0.2	0.6	0.1	0.1	0.0	7.8	78
6. Ease of enrichment	20	0.1	0.1	0.5	0.2	0.1	5.8	116
7. Equipment necessary	5	0.0	0.1	0.4	0.3	0.2	4.8	24
8. Production capacity	10	0.1	0.1	0.4	0.3	0.1	5.6	56
Total	100							702

Table 4.13: Summary result of critical evaluation by probability technique.

Preliminary product concepts	Total expected utility	Rank
1. Deep-syrup cooked fruits in thin layers of pressed flour-mixture	684	3*
2. Hot-stirred fruits in thin layers of pressed flour-mixture	677	4
3. Dried-fruits in thin layers of pressed flour-mixture	702	1*
4. Puffed fruit pastry product using deep-syrup cooked fruits	640	8
5. Puffed fruit pastry product using hot-stirred fruits	627	9
6. Puffed fruit pastry product using dried-fruits	648	7
7. Baked square with deep-syrup cooked fruits as stuffing	676	5
8. Baked square with hot-stirred fruits as stuffing	659	6
9. Baked square with dried fruits as stuffing	688	2*

Project aims, consumer product profiles, and experience and unbiased attitudes of the judges played an important role in this decision. The quantitatively detailed information was responsible mainly for the efficiency of the techniques.

Thus, among the three techniques used, probability evaluation was the most effective; and checklist was more effective than sequential screening. However, it is suggested that all these techniques in a stepwise manner should be used for a systematic screening/evaluation of a nutritional product for an intervention programme, because by this method a reliable result would be obtained with less cost and time needed.

Criteria factors, which were generated based on project objectives (Study Program goal), consumer product profile (consumer survey result), and a company`s general goal (profitability, technical & financial capability, and marketing potential), were found to be capable of differentiating the product ideas. However, for an accurate comparison of those ideas, care was needed to subdivide the main criteria into factors for the sequential screening technique, and for the weighting of these factors in the checklist screening and probability evaluation techniques.

In the circumstances of this project, emphasis was put on consumer acceptability in the first sequential screening; technical, marketing, financial and consumer possibilities in the checklist screening; and mainly on profitability, marketing, technical & production capabilities in the probability evaluation.

It was found that the application of those factors was suitable for this nutritional product development project because product ideas which were not potentially accepted by the consumer were rejected with the least cost and time in the sequential screening step, while those not technically possible were rejected in the checklist screening. Profitability and technical feasibility effectively differentiated the best ideas. Moreover, the application of five scale categories for the level of fit in the probability evaluation suggested that it was a practical number of rating categories for an accurate judgment. A smaller number than five was considered as so tight that it could not differentiate the products effectively, while a larger number than five was too loose so that it could lead to uncertainty on the judgment.

Although some of those factors in each step could be combined e.g. `sweet snack` and `pastry type snack` in the sequential screening technique, and `effect of processing on nutrients` and `ease of enrichment` in the probability evaluation technique, it was not suggested because of the possibility of the change in factor weight and of the misunderstanding in this wide range of definition. Generally, a factor with a limited definition could be more accurately considered than that with a wide range of definition.

Therefore, this study suggested that for the selection of nutritional products to be developed for an intervention programme, a three-step method of screening/evaluation was preferable. The application of this method was to start with a sequential screening technique to remove the potentially unacceptable product ideas. Then, the quantitative checklist technique was applied to remove the technically impossible product ideas. Finally, the detailed quantitative probability technique was applied to retain the most promising ideas. The selection of suitable criteria and factors was emphasized in accordance with the aim of each screening/evaluation step, that is consumer acceptability in the sequential screening, technical capability in the checklist screening, and profitability and technical capability in the probability evaluation. However, variations from this suggestion are possible depending on the circumstances of each project.

4.9 FINAL PRODUCTS SELECTED

From this study on product screening and evaluation, three product ideas were selected as final products to be used for formulation and process development. These included: dried-fruits in thin layers of pressed flour mixture, baked square with dried-fruits as stuffing and deep-syrup cooked fruits in thin layers of pressed flour mixture.

CHAPTER 5

FORMULATION AND PROCESS DEVELOPMENT AND STATISTICS

5.1 INTRODUCTION

The development of formulation and process is considered an important step in the PD process. In contrast to the product/project screening, it is known to be of a technical nature. Systematic methods and planned techniques are needed for satisfactory results in minimum time and at a minimum cost.

After the critical probability evaluation of the generated ideas, the product concepts remaining are defined, and the prototype products are developed. Some product concepts might be rejected because they are not technically possible. Also, if the prototype product is unacceptable to the consumer, re-defining the product concept might be necessary and re-developing the prototype product is unavoidable. If the product is acceptable to the consumer, it is further defined for pilot plant development. After pilot plant development the final product is obtained. In the same manner, unacceptability of the product at the pilot plant development step will result in a need for an improvement of product characteristics and a re-development of the process as well.

In general, the prototype product for consumer testing can usually be processed in one or two ways. This results in an overlapping of the formulation and the process improvement. However, generally, systematic and planned experimental design techniques for process development will be started only after the formulation is considered acceptable.

As previously mentioned, the development of nutritional products to help solve nutrition problems in Thailand started many years ago, but it was not long ago that the formulation of high protein low cost foods to be used for supplementation to the diet of the target group was successful. And just recently an agreement between IFRPD and a private company has been made for the mass production of KASET baby food in a fully commercial venture (personal communication). This delay in commercialisation is believed to be due, in part, to the lack of explicit models for nutritional food formulation and process development appropriate to the industrial application in Thailand.

The purpose of this study was to design a development model for formulating and processing nutritionally-balanced snacks for urban school-age Thais. The three product ideas selected in the previous chapter were used as the basis; systematic methods and planned techniques, and also appropriate statistical techniques were developed for the model. The designed model treated nutritional food formulation and process development as an optimization problem; the solution was approached through the application of linear programming technique for the formulation and of factorial experimental design technique for the process. The systematic formulation and process development of the nutritionally-balanced snack for urban school-age Thais was conducted mainly following the steps of the PD process described by Earle (1971) and Sidel and Stone (1983) as shown in the master diagram in Figure 5.1. Modifications were made where necessary to make it suitable for the specific circumstances of this project. Briefly, the main steps included -- objective setting, development planning, testing and validation, and marketing research.

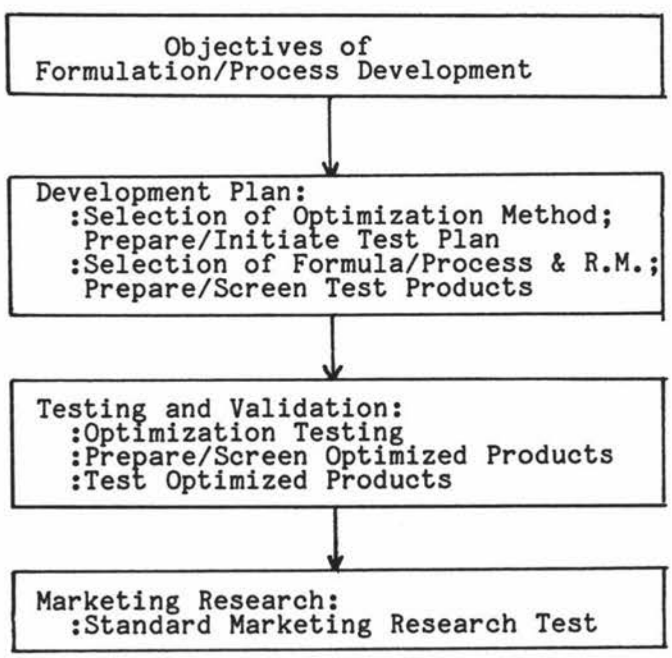


Figure 5.1: Master Diagram for Systematic Formulation/Process Development

5.2 METHODS AND TECHNIQUES IN FORMULATION AND PROCESS DEVELOPMENT

5.2.1 Introduction

Though a number of reports could be found on the formulation and on the processing of snack food products, none was on an explicit model for formulating and processing of snack product to be used for nutrition intervention programmes in Thailand. The following discussion is on methods and techniques for formulation and process development, on quality testing of the developed products, and on statistical analysis, considered applicable to the development of Thai-snack products.

5.2.2 Methods and Techniques for Formulation and Process Development

A number of methods and techniques for food formulation and process development can be found in the literature (Peryam, 1959; Smith, 1959; Stowe and Mayer, 1966; Kissell, 1967; Inglett et al., 1969; Hare, 1971; Walsh et al., 1971; Cavins et al., 1972; Stark et al., 1975; Anderson, 1975; Calavan, 1976; Carmel, 1976; Hsu et al., 1977a; Hsu et al., 1977b; Box et al., 1978; Chittaporn, 1977; Nicklin, 1979; Wadsworth et al., 1979; Anderson, 1981; Bender et al., 1982; Evans, 1982; Fishken, 1983; Schutz, 1983; Gacula and Singh, 1984; Ngarmsak, 1983; and Earle and Anderson, 1985). Among these, the methods and techniques proposed by Anderson (1975), Calavan (1976), Chittaporn (1977), and Ngarmsak (1983) were the most quantitative used in the development of Thai food products for one or more of the following steps: selection of materials, formulation development, process development. In their studies, the linear programming technique was effectively used for the selection of raw materials and for the development of Thai food formulations, and factorial experiments were used for the development of the process.

Linear programming was described by Nicklin (1979) as a mathematical technique used to determine the optimum allocation of a limited supply of resources, subject to certain constraints, to either maximise or minimise a specified objective. In food formulation problems, the resources are normally food raw materials, the constraints are based on the functional properties of the final product or nutritional or compositional requirements, and the objective is usually cost minimisation.

A factorial experiment was described by Lipson and Sheth (1973) as an experiment which extracts information on several design factors more efficiently than can be done by a traditional test. The traditional test is the classical approach of keeping everything constant except one varible whose effects on the output variables are investigated. The main objective of a factorial experiment is to determine the effect of various factors (independent variables) on some characteristics of a product (dependent variables). According to Chatfield (1975), "the overall objective of a factorial experiment may be to get a general picture of how the response variable is affected by changes in the different factors or to find the overall combination of factor levels which gives a maximum (or minimum) value of the response variable."

According to Box et al.(1978), to perform a general factorial design, an investigator selects a fixed number of "levels" (or "versions") for each of a number of variables (factors) and then runs experiments with all possible combinations. Two of the reasons for the importance of factorial design mentioned by them are:

: They require relatively few runs per factor studied; and although they are unable to explore fully a wide region in a factor space, they can indicate major trends and so determine a promising direction for further experimentation.

: The interpretation of the observations produced by the designs can proceed largely by using common sense and elementary arithmetic.

For industrialized Thai snack products in the past, the formulation and process development were carried out on the basis of trial and error. In the formulation, the raw materials were selected and then one ingredient at a time was varied in each experiment. Products prepared by using different quantities of ingredients were subjected to a taste panel test for comparison, and the formula of the most acceptable product was chosen as the developed formula (Siegel et al.1975, 1976; and IFRPD, 1970-1982). For the processing development, each input variable was studied one level at a time; and a panel test was conducted to compare the samples of products from the different treatments. Currently, more quantitative methods are being applied to formulation and process development. The work of Anderson, Calavan, Chittaporn and Ngarmsak previously mentioned supports this statement.

5.2.3 Methods and Techniques for Quality Testing

Quality tests for foods can be grouped into subjective and objective methods, each of which can be categorized into different techniques. Though a great number of reports could be found on methods and techniques for these tests, few were on their application to developed industrialized snack foods in Thailand. Among the available articles, the work of Kramer and Twigg (1970, 1973) seemed to be the most useful to consult because it provides methods and techniques for quality tests in a well-organized form. The studies of Siegel et al.(1975), Siegel et al.(1976), and IFRPD (1970-1982) applied those methods and techniques to the development of Thai snack foods. In their studies, a hedonic scale technique was used to rate the "developed-product" acceptability.

For the objective testing of industrialized Thai snack foods, the emphasis was on the application of chemical analysis, especially of moisture content and nutritive values, and of microbiological analysis of the product. No reports were found on either the application of physical methods and techniques or on the correlation of the results from different methods. None of the past work was on the optimization of the product quality.

5.2.4 Methods and Techniques for Statistical Analyses

Statistical analysis methods and techniques used for the data from the formulation & process development and quality testing were many and varied depending on the individual cases, and these were normally presented with systematic experimental methods and techniques. References under 5.2.2 are applicable here also. Few studies have been carried out on the development of Thai snack foods, and there were seldom statistical methods associated with them. The statistical methods and techniques most used were the T-test and ANOV to test the quality differences between/among samples of different formulations/processes. Nothing was found on the comparison of methods in order that the most suitable could be used in the snack food development model.

5.2.5 Summary and Conclusion

Past studies on Thai snack product development were rare. Among the few studies, the emphasis was on improving the methods and techniques associated with Thai snack product processing so as to keep abreast with modern technology. However, there is a need for the design of a model system including the methods and techniques for formulation & process development, quality testing, and statistical analysis that can readily be used for Thai snack product development. A possible way to do this seemed to be by the application of the available methods and techniques which were used successfully with other categories of Thai food or with foods in other countries. Modification of these methods and techniques might be necessary to make them suit the circumstances of this project.

5.3 AN APPROACH TO FORMULATION DEVELOPMENT

5.3.1 Introduction

As previously mentioned, past formulation of nutritional snack products for nutrition intervention programmes in Thailand was made on a trial and error basis. In this study, a systematic quantitative formulation model for nutritional snack products was designed (see Figure 8.1). This model was used in the formulation development of a nutritionally-balanced snack product for urban school-age Thais. The following discussion illustrates how an approach was made, step by step, on the application of the designed model to develop the screened product ideas into an acceptable product in the shortest time. In this study, the formulation stage, or in other words, the product design step, was conducted using, firstly, an empirical approach, and then, a planned stepwise experimentation in which critical evaluation was made basically on the four main interacting factors -- economics, consumer acceptability, formulation, and process. The main systematic steps followed the steps in the master diagram in Figure 5.1. Briefly, the steps were -- objective setting, data preparation, formula optimization, technical and acceptability testing.

In the development of the prototype product, the aims of the formulation were set in accordance with the defined product concept based on the previous consumer survey (Section 3.9.1). The aims were-

: To investigate the effects of different raw materials on product characteristics and to select a nutritionally suitable formula that would give a product of acceptable texture, flavour, and appearance.

: To formulate a nutritionally balanced snack which would provide at least 25% of all the nutrients required daily by Thai children aged 10-12 years from the following basic raw materials.

Main Ingredients:
Flour: wheat and/or glutinous rice
Sugar: white and/or brown
Banana: GLOUY NAMWA or GLOUY HOM
Nuts: peanuts and/or white sesame seeds

Possible Ingredients:
Rice, soybean oils, glucose-syrup, coconut cream, food additives (vitamins, minerals, amino acids; firming agents, anti-browning agents, antioxidants)

The moisture content of the filling should be approximately 30-35% (or water activity approximately 0.80).

5.3.2 The First Defined Product Concept Based on the Consumer Survey Results and the Project Objectives

The preliminary product concept was firstly defined as shown in Table 5.1. Most of these concept descriptions were based on the results of the previous consumer survey. The storage life of the product, which was defined as 3 months or longer at the ambient temperatures and humidities of Bangkok, was included. Also the product was classified under "intermediate moisture food" with Aw value below 0.8. The product had to comply with the regulations under the Thai Food Act 1979.

Table 5.1: The first defined product concept.

NAME	NUTRITIONALLY-BALANCED FRUIT AND NUT BAR
SNACK TYPE	SWEET TYPE OF PASTRY-LIKE PRODUCT
CHARACTERISTICS	SWEET, NUTTY, AND BANANA FLAVOUR RED SCATTERED IN BROWN CRUNCHY AND GRITTY BAR FORM
STORAGE LIFE	3 MONTHS OR LONGER AT AMBIENT TEMPERATURES AND HUMIDITIES OF BANGKOK
SAFETY	INTERMEDIATE MOISTURE FOOD Aw BELOW 0.8
NUTRITIVE VALUE	NUTRITIONALLY-BALANCED with 25% (or 13%) of RDA for Thai Children aged 10-12 years, in the size that can be eaten as a snack at one time
LEGAL RESTRICTION	UNDER THE THAI FOOD ACT 1979

5.3.3 "Best-Estimate" Experimentation

After the definition of the first defined product concept, the prototype product development was started. A "Best-estimate" technique, or in other words, a "mock up" trial was necessary for the initial formulation and "in-house" evaluation was practised. The findings from this technique were applied in the detailing of the first defined product concept to obtain the second defined product concept.

Three products in this trial included: deep-syrup cooked fruits in thin layers of pressed flour mixture, dried fruits in thin layers of pressed flour mixture, and baked square with dried fruits as stuffing. All of these products were considered as pastry-like products. The "best-estimate" trials were conducted in two phases: the study on fruit preparation to be used in the stuffing, and the study on whole product preparation.

5.3.3.1 Phase 1: The Study on Fruit Preparation. From the economic and feasibility study in previous chapters, it was decided that the main part of the stuffing should be bananas. In phase 1, the "best-estimate" trials on bananas to be used as stuffing were conducted in two different ways: drying, deep-syrup cooking. Different conditions -- presence and absence of food additives -- were tried to find the most suitable way of preparation. Food additives used included: vinegar (3% in water) for anti-browning purposes, potassium metabisulphite (0.4% in water) for anti-browning purposes, and calcium chloride (0.3% in water) for firming property purposes. In brief, for deep-syrup cooked banana, a red colour developed during the final stage of cooking. This could be due partly to the browning reactions and partly to the change of banana pigment during the heat-cooking process. Calcium chloride helped to develop chewiness in the deep-syrup cooked banana. However, in the dried banana, calcium chloride seemed to have a less chewy effect. Vinegar helped to prevent browning reactions in the bananas.

Since banana (GLOUY KAI variety) is normally eaten with GRAYASAHT, the popular traditional Thai snack, it would be suitable to use the ingredients in GRAYASAHT as a part of the ingredients in the product to be developed. GRAYASAHT is a square product made from roasted rice and nuts. Its ingredients are roasted puffed rice, roasted flattened young rice, roasted white sesame seeds, roasted peanuts, palm sugar, coconut cream, and glucose-syrup.

5.3.3.2 Phase 2: The Study on Whole Product Preparation. In phase 2, two types of products were made: the baked square type and the pressed flour mixture type. In this experiment, the emphasis was on the study of the stuffing, while the outside layer of the product was kept similar to the basic recipe previously mentioned (Appendix 4.3Ma) in which wheat flour was used as the main ingredient for the baked square type and glutinous rice flour was used for the pressed flour mixture type. Different stuffings used for the comparison study are shown below.

Baked square Type:

: Stuffed with hot-stirred mungbean (as the original product, recipe in the previous chapter).
: Stuffed with deep-syrup cooked banana.
: Stuffed with deep-syrup cooked banana and roasted nuts.
: Stuffed with dried banana.
: Stuffed with dried banana and roasted nuts.

Pressed flour mixture Type:

: Stuffed with the original mixture of ingredients (glazed gourd, roasted sesame, boiled fatty tissue of pig, fried shallot, salt)
: Stuffed with deep-syrup cooked banana.
: Stuffed with deep-syrup cooked banana and roasted nuts.
: Stuffed with dried banana.
: Stuffed with dried banana and roasted nuts.

The "Best-estimate" technique was applied at this step when considering the ingredient ratio, and an "in-house" evaluation of the products was practised by one Thai graduate student at Massey and the author. It was found from this "best-estimate" experimentation work that-

: It was possible to use dried or deep-syrup cooked banana as the main ingredient of the stuffing for baked square and pressed flour mixture type products.

: Roasted nuts (peanuts and sesame seeds) could be added to the banana stuffing ingredients for processing purposes-- easier to handle the stuffing; nutritional purposes-- high protein and energy; and acceptability purposes-- readily-mixed form of the traditional snacks that are normally eaten together.

: The raw materials to be used would be better in the ready-to-mix form.

Deep-syrup cooked banana (DSC-banana) seemed to be more suitable than dried banana. The reasons were-

: It gave a nice glossy red colour after being cooked. This would be more attractive for children than the dull brownish yellow obtained from the drying process.

: It took a shorter time than the drying process, which could result in a lower cost.

: It had a high concentration of sugar and that was beneficial from the preservation point of view.

: It had less tannin and astringent flavour than the dried banana.

: The flavour of sweet DSC-banana blends better with roasted nuts than that of dried bananas.

: For the pressed roasted flour layers, the stickiness of the deep-syrup cooked bananas can make the product firmer or in other words, can make the product stick together.

5.3.4 The Second Defined Product Concept after an Application of the Findings from the "Best-Estimate" Experiments

The second defined product concept after an application of the above findings is shown in Table 5.2, and in detail in Appendix 5.1M.

Table 5.2: The second defined product concept after an application of the findings from "best-estimate" experiment.

Concept Attributes	Detailed Definition
The Product	A healthy sweet snack in a stuffed form to use as a high protein-calorie supplement. It would contain at least 40% of the bananas as the stuffing and at least 20% of the other stuffing ingredients including puffed rice and nuts.
The Raw Materials	Outer Layer: Flour: rice or wheat flour or mixture of both. Vegetable oil: presence or absence of vegetable oil. Stuffing: Banana: deep-syrup cooked. Sugar: white and/or brown. Nuts: peanuts and/or sesame seeds. Food additives: calcium chloride, nutrients.
The Processing	The stuffing ingredients would be in the cooked form (roasted, puffed, dried, deep-syrup cooked, etc) and ready to be mixed with the vitamin and mineral mixes to form a semi-dried stuffing mixture for the products. The flour mixture, for the pressed flour type product, would be in the roasted form and ready to be mixed with the syrup to form the thin layers for the sandwiching purpose. The flour, for the baked square type product, would be mixed with vegetable oil and other minor ingredients and folded in the way that it would form a flaky type pastry. After stuffing, the pastry would be cut into a square shape.
The Packaging	The product would be packed in a plastic bag, sectioned or unsectioned, with or without cardboard carton. It would be easily made airtight and should be easy for opening.
The Marketing	The product would be sold throughout Bangkok as a consumer product at snack stalls at school, neighbourhood groceries, sweet shops, supermarkets and coop shops. It would be used as a healthy snack for school children. This point of view would be emphasized in any promotion.
The Consumer	The consumers of the product will be mainly school children and possibly some preschool children and adults who like sweet snacks.
The Price	The price would be set at 5 Bahts per packet of the size that would give the overall nutritive values of 25% of daily requirement for school children. Probably, a packet size that would give the overall nutritive value of approx. 13% of the daily requirement, which could be priced at 3 Bahts, would be of some interest.

5.3.5 An Empirical Approach to Appropriate Methods of Ingredient Preparation

A set of experimental trials were carried out to check whether the basic methods for ingredient preparation and the basic formula screened from the literature search and from past experience would be appropriate for the development. Ingredients of both the outer layer and the stuffing and of both types of products were included in these experimental trials. Selected processes tried included: roasting of glutinous-rice flour, sesame seeds, and peanuts; drying and deep-syrup cooking of banana; preparations of a flour mixture type product, a pastry type product, and also their fillings. A summary of the results of all these experimental trials is shown in Table 5.3. Detailed results can be found in Appendix 5.2M.

5.3.6 An Empirical Approach to an Appropriate Combination of the Product Layers (Outside/Inside Ratio)

Experimental trials were conducted to find an appropriate combination of ingredients to form a layered snack product. Since the mixture of the filling, whether from dried or deep-syrup cooked banana, was set constant in structure, the trials were done in groups of product -- flour mixture type and baked square type -- both of which used the deep-syrup cooked banana mixture as the filling. The outer layer and the stuffing used in this experiment were from those selected from the experimental trials in section 5.3.5. Summary results of this experiment are shown in Table 5.4.

5.3.7 Discussion and Conclusion

In this study, preliminary experimentations based on "best-estimate" technique could lead the development process to the step of a systematic formulation development in a short time. Ingredients chosen and methods of ingredient preparation and product layer combination based on this technique were found to be appropriate. At this step of the formulation development, the product concept was also being developed based on the results of "best-estimate" experiments. This was found useful in designing the input constraints and bounds for Linear Programming (LP). In conclusion, "best-estimate" experimentation is necessary for effective formulation development because it indicates a possible short route direction for systematic formulation by LP.

Table 5.3: Summary results of experimental trials for appropriate methods of ingredient preparation.

Ingredient preparation	Possible methods of preparation	Selected characteristics of products
Outer Layer:		
Roasting of glutinous rice flour	Pan roasting; low heat; 15-20 min	Moisture evaporated 4% of original weight
Preparation of flour mixture (for flour mixture type product)	Roasted glutinous rice flour : thickened syrup = 30 : 70 (For thickened syrup, fondant method was used.)	One step below fondant stage was found to be suitable for the mixing.
Preparation of pastry for baked square type	Outer-inner dough method Outer: with cold water added (in addition to oil) Inner: without cold water added One dough method	Flaky pastry by outer-inner dough method
Stuffings:		
Deep-syrup cooking of banana	Pot-cooking; medium heat; initial concentration of syrup 60-65% and final 72% or initial temperature 102-103 C and final 108 C; white or raw sugar; with or without calcium chloride treatment	Storage life > 3 months in room temperature ≈ 20 C Water activity = 0.73
Roasting of sesame seeds	Pan-roasting; low heat; 15-20 min or Oven-roasting 400 C; 2 min bottom heat and 2 min top heat	Moisture evaporated 3% of original weight
Roasting of peanuts	Pan-roasting; low heat; 20 min or Oven-roasting 400 C; 3 min bottom heat and 3 min top heat	Moisture evaporated 4% of original weight Loss through skinning 4% of original weight
Preparation of filling	One mix method DSC-banana : coconut milk : puffed rice : roasted white sesame seeds : roasted peanuts = 65 : 10 : 10 : 5 : 10	Brownish red, chewy, nutty and fruity flavour
Filling trials 1	%ratio of ingredient similar to the above, but one ingredient was dropped at a time	Ingredient caused undesirable effects: Puffed rice: too crunchy Coconut milk: red colour of DSC-banana turned dark purple
Filling trial 2	Possible ratio of banana to the remainder = 60 : 40 or 80 : 20	Organoleptically acceptable.

Note: Coconut cream and puffed rice were bought ready-to-use.

Table 5.4: Summary result of experiment on appropriate combination of product layers (Outside/Inside ratio).

%Ratio Investigated (outside : inside)	Brief Result
Pressed Flour-Mixture Type	
5 : 95	Layering possible
15 : 85	Layering possible but with difficulty
25 : 75	Layering possible with desirable proportion
35 : 65	Layering possible but flour mixture layers too thick
45 : 55	Layering impossible, flour mixture covered filling layer.
Baked Square Type	
15 : 85	Layering possible but with some difficulty in handling and outside layer too thin
25 : 75	Layering possible with desirable proportion
35 : 65	Layering possible with desirable proportion
45 : 55	Layering possible but with thick outside layers

5.4 THE FORMULATION OF NUTRITIONALLY-BALANCED SNACK BY LINEAR PROGRAMMING TECHNIQUE

5.4.1 Introduction

After the more specific product concept was defined and an appropriate combination of the stuffing ingredients and of the product layers were investigated, a systematic screening of formulae was applied using linear programming (SCICONIC LINEAR PROGRAMMING, Scicon Computer Services Limited, 1981) as the optimization technique. Important factors were considered and then incorporated in the linear programming. The linear programming model set up and used by Ngarmsak (1983) was used firstly to select combinations of nine food raw materials with the limits in 5.4.2.2; and secondly the objective function was set to maximise calories.

It was found that in the initial model, there were too many constraints and some of the nutrient constraints were too tight and were not met. Adjustments were made and the relaxed nutrient constraint model was studied. Selected feasible-solution formulae were then organoleptically tested and the more acceptable formulae with higher nutritive values were further developed by LP. In doing this, an addition of other food raw materials was made to the matrix. Also, adjustments were made on the 'minimum-maximum' amount of ingredients in order to keep the total of food raw material constant at 1.00 (or 100%). The addition of other ingredients was based on the nutrients required for the product, the availability and cost of the raw materials, and their compatability with the existing raw materials. For example, mungbean, which was added at a later part of the development, was considered justifiable because it provided the high protein required for the product; it was an economic crop of Thailand, thus it was available and was not too expensive; and it could blend well in flavour with DSC-banana, roasted nuts, and coconut milk.

At the final stage of the formulation experiments, the full constraint model was applied, and the objective function was set to minimise cost.

5.4.2 Factors Concerned

The following factors were considered important in the linear programming, and are summarized as shown in Table 5.5.

Table 5.5: Important factors Considered for LP.

CONSUMER	CHILDREN AGED 7-15 YEARS (target 10-12)
ACCEPTABILITY	TYPE AND CHARACTERISTICS OF SNACK
INPUT FOR LP	NUTRITIVE VALUES AND COST OF RAW MATERIALS
CONSUMPTION QUANTITY	BELOW 160 g FOR 25% RDA BELOW 90 g FOR 13% RDA
NUTRIENT REQUIREMENT	NUTRITIONALLY-BALANCED Type and level as required RDA.

5.4.2.1 Consumer Acceptability. According to the consumer survey, the snack to be developed would be of a sweet-fruit-pastry type. A study of the consumer survey and also of the literature review resulted in the selection of fruits (especially banana), nuts (especially peanuts and sesame seeds), bean (especially mungbean), and sugar, as the ingredients to be used. These ingredients took priority in the selection because they promised long storage life potential and also promised high acceptability.

5.4.2.2 Nutritive Value and Cost of Raw Materials in LP Input. The selection of raw materials for the LP input was principally based on their nutritive values and cost. Those with nutritive values appropriate to the nutritional constraints of the product at a low cost had priority. The minimum (lower limits) and maximum (upper limits) for each of the ingredients were firstly set (shown below) based on "best-estimate" experimentation, formulation of similar products, estimated cost of raw materials, selected nutrients of the raw materials, and also, the technical possibility which was based on literature search and past experience.

Ingredients	Lower Limit %	Upper Limit %
Banana	37.50	67.50
Coconut milk	0.56	3.75
Wheat flour	13.00	15.50
Soybean oil	7.50	10.00
Peanuts	0.56	3.75
Glutinous rice	0.56	3.75
White sesame seeds	0.28	1.88
Brown sugar	0.73	4.88
White sugar	0.00	3.75

For example, for banana, lower and upper limits were set at 37.50% and 67.50% respectively. This was in accordance with the result of the "best-estimate" experiment (see Table 5.3). For coconut milk, the limits were 0.56% and 3.75%. These limits were based not only on the formulation of GRAYASAHT, a similar product to the stuffing of the present product, but they were also based on the cost of the coconut milk which was expensive. Emphasis was put on the center-filling ingredients, the part of the product which is to be innovative. This was to be in accordance with the result of consumer survey that the stuffing was considered the most important attribute of the pastry-type product.

5.4.2.3 Consumption Quantity and Nutrient Requirement. For consumption, the quantity desirable was that it should not be too large a quantity to be consumed at a time for an adequate intake of nutrients. And it should not be too small a quantity that the consumers would feel that they had not eaten enough snack and that the product was too expensive with the result that they might refuse to buy it. Thus, it was considered, based on past experience, that a suitable consumption quantity was 160 grams for 25% RDA and 90 grams for 13% RDA. This quantity was to be assessed for its consumption suitability when the product preparation based on LP formulation was conducted.

Before the nutrient requirement constraints were put in the linear programming model, important considerations were made as follows:

> The snack product was to be nutritionally balanced. The reason was that this product would serve as supplementary food to help solve the problem of malnutrition. Thus, it should be self-supporting, that is, it should be able to provide the nutrients required by the children in a guaranteed quantity. This was to avoid inadequate nutrients for the consumers who missed a meal or a particular food high in certain nutrients on that particular day. The products should be formulated in such a way that they meet all the nutrient requirements for 25% of RDA for 5 Baht packet and for 13% of RDA for 3 Baht packet.

The nutrients required and their levels were based on 100 grams of the product. There were 26 nutrients and 1 ratio nutrient relationship. Inclusion of these nutrients and the ratio was made because of their essential role for growth and physiological functions. The energy and protein were to help solve calorie-protein malnutrition. Normally, Thai food is low in fat; and it was considered necessary to include it. The protein calorie to total calorie ratio was to ensure an adequate quantity of protein intake. For minerals and vitamins, inclusion was emphasized on those whose lack causes nutritional problems in Thailand. However, inclusion was also made for those nutrients the lack of which normally causes nutritional problems amongst poor people in all countries. These included: Ca; P; Fe; Vitamin A, B1, B2, B6, B12; Niacin; Pantothenic acids; Vitamin C; Folate.

An upper limit of dietary fibre was included as the product would consist of banana, sesame seeds, and peanuts, which are high in fibre. An excessive quantity of fibre consumed may cause nutritional failure. The 10 essential amino acids were included to give a standard for the protein quality. Nutrient requirements and the level of each nutrient are shown in Table 5.6. Minimum amino acid requirements were set at 80% of the FAO/WHO (1973) pattern.

5.4.3 Data Collection

5.4.3.1 The Composition and Cost of Raw Materials. 26 nutrients and the costs of food raw materials and chemical nutrients used in the development of the balanced snack bar were collected. These were taken from the works of Anderson (1975), Chittaporn (1977), and Ngarmsak (1983). Those unavailable in the mentioned sources, were from "Food Composition Table For Use In East Asia" (FAO, 1972). The cost of raw materials were taken from Sinthavalai, 1984, and, where unavailable, the costs of similar raw materials were used. Cost adjustment based on the price index was made where costs from earlier years were used.

The list of food raw materials were arranged in alphabetical order. The nutrient composition and cost data were divided into 5 parts as follows: Cost; Energy, Proximate Analysis and Minerals; Vitamins; Essential Amino Acids; and Protein Calorie to Total Calorie Ratio. The nutrient composition and cost of each of the raw materials are given per 100 grams of edible portion in Appendix 5.1.

5.4.3.2 The Consumption Quantity. The quantity of snack to be met by linear programming for the total quantity of food raw material was set at 1.00 (or 100%). The actual quantity of snack consumed by a child at a time was estimated by using the weight of one piece of similar Thai pastry product normally eaten at a time by Thai children. It was found that the weight was approximately 150-180 grams, thus 160 g was taken.

5.4.4 Linear Programming Model

5.4.4.1 Initial Model. The linear programming model was set up to select a combination of food raw materials. The objective function was set firstly to maximise calories; and finally to minimise cost. There

Table 5.6: Nutrient requirement for Thai children aged 10-12 years at different percentages of the total requirement.

Nutrients	100% or daily		25% (= 160 g product) Total 160 g		25% (= 160 g product) per 100 g		13% (= 90 g product)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Calories	2475	none	619	none	387	none	322	none
Protein (g)	32.0	none	8.0	none	5.0	none	5.0	none
Fat (g)	55	96	13	24	9.0	15.0	7.0	12.0
Fibre (g)	12.0	30.0	3.0	7.5	1.9	4.7	1.6	3.9
Calcium (mg)	1000	1850	250	460	156	288	130	240
Phosphorus (mg)	1000	none	250	none	156	none	130	none
Iron (mg)	14.0	none	3.5	none	2.2	none	1.8	none
Vitamin A (IU)	4000	none	1000	none	625	none	520	none
Vitamin B1 (mg)	1.30	none	0.33	none	0.20	none	0.17	none
Vitamin B2 (mg)	1.30	none	0.33	none	0.20	none	0.17	none
Niacin (mg)	17.00	none	4.25	none	2.66	none	2.21	none
Vitamin B6 (mg)	1.4	none	0.35	none	0.22	none	0.18	none
Folate (μg)	350.00	none	87.50	none	54.69	none	45.50	none
Vitamin B12 (μg)	2.50	none	0.63	none	0.39	none	0.33	none
Vitamin C (mg)	45.00	none	11.25	none	7.03	none	5.85	none
Pantothenic acid (mg)	6.00	none	1.50	none	0.94	none	0.78	none
Prot.Cal/Tot.Cal	0.13	none	0.13	none	0.13	none	0.13	none
Unsat.FA/Tot.fats	0.10	none	0.10	none	0.10	none	0.10	none
Amino acids (mg/g Prot.)	Reference Protein Pattern Value							
Isoleucine (Is)	32		32		32		32	
Leucine (Le)	56		56		56		56	
Lysine (Ly)	44		44		44		44	
Phenylalanine (Ph) Tyrosine (Ty)	48		48		48		48	
Cystine (Cy) Methionine (Me)	28		28		28		28	
Threonine (Th)	32		32		32		32	
Tryptophan (Tr)	8		8		8		8	
Valine (Va)	40		40		40		40	

Note: Methods used in other investigations for decisions on nutritional requirements were studied and are summarized in Appendix 5.1M. Though nutrient requirements for Thai children are available, the data is old (1970), and a number of nutrients to be studied are not available. For more recent data and for the purpose of "catching-up growth" for Thai children, it was decided that the nutrient constraints would be based on those with higher figures of Ngarmsak (1983) and Valyasevi (1977).

were 28 sets of constraints to be met; one weight constraint, one cost constraint, twenty-five nutrient constraints, and one nutrient interrelationship constraint. For convenience in sorting out appropriate ways to formula solution, the amino acid and the interrelationship constraints were ignored at this initial stage of the LP experiment. However, their values obtained from the linear programming were calculated manually and the results were observed. No upper limit was set for all vitamins since their values were not so high that they would have detrimental effects to the body. Firstly, nine food raw materials were used. Later, an addition of other ingredients was made based on the nutrients required for the product, availability and cost of raw materials, and their compatability with the existing raw materials.

The model was set as follows:

Maximize: $$\sum_{j=1}^{n} CjXj$$

Subject to: $$\sum_{j=1}^{n} AijXj \geq bi \qquad i = 1,2,....28$$

and: $$Xi \geq 0 \qquad j = 1,2,....9$$

Cj = Calories of raw material j

Xj = Quantity of raw material j selected

Aij = Level of nutrient i in food j

bi = Requirement level of nutrient i

5.4.4.2 Relaxed Nutrient Constraint Model. It was found that in the initial model, there were too many constraints and some of the nutrient constraints were too tight and were not met. Adjustments were made as below and a feasible solution was obtained.

Protein: A protein amount of 5 grams was too low and the ratio of PC/TC of 0.13 could not be met (manually calculated). Thus, the amount of 6 grams was set as the lower limit.

Calories: A calorie level of 387 was too high to be obtained from a limited quantity of snack. The adjustment made was based on the amount that would make the ratio of the protein calorie to the total calorie equal 0.07. Since the new constraint for protein was 6.0 grams or 24 Calories, thus, the total calories should be 24/0.07 or 343.

Fat: There was no upper limit on fat, so that the formulation of maximized calories could be met. This open upper limit would not have detrimental effects since normal Thai food is low in fat and the fat intake could be considered on the daily basis.

PC/TC: The ratio of protein calories to total calories of 0.13 could not be met. Generally, this value is obtained by the addition of a certain amount of calories to the recommended minimum protein calories to ensure its quality. To solve this PC/TC infeasibility problem, ratio values from different sources of recommendation were compared to those obtained by the calculation from the minimum amount of intake protein and calorie recommended by the same sources (Table 5.7). To relax this constraint, it was decided to use the ratio value recommended by McNutt and McNutt (1978) which was 0.07 or that which could be obtained when the daily protein intake was 50 grams. Or in other words, the ratio value was slightly higher than that calculated based on the basic protein recommended.

Table 5.7: Protein-Energy Interrelationship.

Source of information	PC/TC recom.*	PC/TC calc.**
Passmore et.al. 1974.	0.13	0.05
Nutrition Division. 1970.	-	0.06
Valyasevi and Co-workers, 1977.	0.13	0.06
McNutt and McNutt, 1978.***	0.07-0.10	-
Anderson, 1975.	0.13	0.017
Ngarmsak, 1983.	0.13	0.05
Product being developed	0.13	0.04-0.05

*PC/TC recom. = PC/TC recommended
** PC/TC calc. = PC/TC calculated from the recommended amount of protein and calories
***50g protein/day

5.4.4.3 <u>The Final Constraint Model.</u> At the final stage of experimentation, the final constraint model was applied. In the final constraint model, the amino acid and the interrelationship constraints, and the processing and storage loss allowance of nutrients were included in the LP. Also, an allowance was made for costs of raw materials. An assumption was made on the possible devaluation of future money by the time of the production of the developed product. The devaluation of money would result in more money being spent on raw materials. This allowance value was defined in this study as "the devaluation allowance of money" and it would result in an increase in the costs of raw materials.

At this final stage, the objective function of LP was set to minimise cost. A comparison of LP constraints at different steps of formulation development is shown in Table 5.8. This resulted in an infeasible solution, as the requirement of vitamin B2, vitamin A, vitamin C, and folic acids could not be met. This was remedied by the addition of synthetic vitamins into the ingredient data.

Table 5.8: Comparison of prior and final constraints for LP.

Cost & Nutrients per 100 g	Constraints		
	Prior	% Loss Allowance*	Final
Cost (Baht)	1.08	5.00	1.03
Energy (Calories)	343.00	7.50	368.73
Protein, digested (g)	6.00	7.50	6.45
Fat (g)	8.60	-	8.60
Fibre (g)	1.88-4.69	-	1.88-4.69
Calcium (mg)	156-288	1.50	158-292
Phosphorus (mg)	156.25	1.50	158.59
Iron (mg)	2.19	1.50	2.22
Vitamin A (IU)	625.00	20.00	750.00
Vitamin B1 (mg)	0.20	40.00	0.28
Vitamin B2 (mg)	0.20	37.50	0.28
Niacin (mg)	2.66	37.50	3.66
Vitamin B6 (mg)	0.22	20.00	0.26
Vitamin B12 (µg)	0.39	5.00	0.41
Vitamin C (mg)	7.03	50.00	10.55
Folic acids (µg)	54.69	50.00	82.04
Pantothenic acids (mg)	0.94	25.00	1.18
Isoleucine (mg/g PROTD)	32.00	5.00	33.60
Leucine	56.00	5.00	58.80
Lysine	44.00	20.00	52.80
Phenylalanine)		2.50	
Tyrosine)	48.00		49.20
Cystine)			
Methionine)	28.00	5.00	29.40
Threonine	32.00	10.00	35.20
Tryptophane	8.00	7.50	8.60
Valine	40.00	5.00	42.00
PC/TC	0.07	-	0.07

*Nutrient loss allowance was averaged from maximum cooking losses in Harris, 1975; and 5% devaluation of money was assumed for cost.

5.4.5 Linear Programming Input and Output

5.4.5.1 Linear Programming Input. Input data for linear programming were arranged into five sections: ROWS, COLUMNS, RHS, RANGE, and BOUNDS according to the SCICONIC/VM procedure (Scicon Computer Services Limited, 1981) under the PRIME computer system as shown in Table 5.9. An example of the LP INPUT DATA file can be found in Appendix 5.3Ma.

Table 5.9: Arrangement of LP Input.

ROWS	COST AND 28 NUTRITIONAL CONSTRAINTS
COLUMNS	FOOD RAW MATERIALS AND THEIR COMPOSITIONS AND LEVELS
RHS	REQUIREMENT LEVELS OF CONSTRAINTS
RANGE	REQUIREMENT RANGE OF CONSTRAINTS
BOUNDS	QUANTITY ALLOWANCES FOR FOOD RAW MATERIALS TO BE SELECTED

5.4.5.2 Linear Programming Output. The linear programming output was composed of the solution feasibility, levels i.e. the upper and lower bounds of the constraints, the activities or the value of the variables in the solution, and the recipe. An example of the LP OUTPUT file can be found in Appendix 5.3Mb.

5.4.6 The Solution and the Selection of the Best Formulae For Further Development

The selected solutions from different sets of formulae by LP experiments were compared and are shown in Table 5.10. Initial, relaxed, and final constraints were also provided for convenience of comparison purposes.

A previous comparison between baked square and flour mixture type products, both of which have deep-syrup cooked banana as the main part of the centre-filling, suggested that the flour mixture type was superior nutritionally and organoleptically. Although the flour mixture type was chosen because of its higher nutritive value, its unacceptable flour flavour needed to be improved. At this stage, prepared mungbean (skinned, soaked, boiled, and roasted) was used in place of flour in the flour-fondant mixture. In the application of mungbean in the formula, formulated products were prepared in two ways -- a thick filling between mungbean-fondant layers ('pastry type') and a fruit-nut-bean mix ('mix type') -- both of which were high in nutritional (Table 5.10) and organoleptic quality (Table 5.11). The reason that the 'mix type' was included in the experiment in addition to the 'pastry type' (or fondant layer type) was because the latter gave difficulty in preparation. When the mungbean products of the two types were compared, the fruit-nut-bean mix type was preferred because it was superior nutritionally and organoleptically. Thus, it was selected as the suitable formula for further development.

TABLE 5.10: SELECTED SOLUTIONS FROM DIFFERENT SETS OF FORMULAE BY L.P. EXPERIMENTS

Ingredients	LP RECIPES					
	Baked Square Type (BS)			Pressed Flour-Mixture Type (PFM)		
	BS1*	BS2*	BS3*	PFM1*	PFM2*	PFM3*
Wheat flour	0.1300	0.0498	0.0700	-	-	-
Cowpea flour	-	0.0026	-	-	-	-
White sugar	0.0197	0.0068	-	-	-	-
Soybean oils	0.0750	0.0210	0.0300	-	-	-
Water 1	-	0.0198	0.0200	0.0700	-	-
Banana	0.6750	0.3750	0.3000	0.2000	0.2000	0.2000
Brown sugar	0.0488	0.0833	0.0666	0.0444	0.0444	0.0444
Water 2	-	0.0292	0.0234	0.0156	0.0156	0.0156
Mungbean	-	0.1250	0.0750	-	0.2000	-
Water 3	-	0.0440	0.0225	-	0.0600	-
White sesame seeds	0.0028	0.1923	0.2000	0.2000	-	-
Peanuts	0.0056	0.0512	0.1500	0.1900	-	-
Glutinous rice	0.0375	-	-	-	-	-
Pumpkin	-	-	-	-	-	-
Coconut milk	0.0056	-	0.0300	-	0.0600	0.0600
Glucose syrup 1	-	-	0.0075	0.0700	0.0550	-
Beef liver powder	-	-	0.0030	-	-	-
Chicken liver powder	-	-	0.0010	-	-	-
Vitamin mix	-	-	0.000002	-	-	-
Skinned mungbean	-	-	-	0.1400	-	-
Coconut cream	-	-	-	0.0700	-	-
Roasted skinned mungbean	-	-	-	-	-	0.2500
Glucose syrup 2	-	-	-	-	-	0.0500
Roasted white sesame seeds	-	-	-	-	0.2032	0.1998
Skinned roasted peanuts	-	-	-	-	0.1618	0.1801
Ascorbic acid	-	-	0.000998	-	0.000042	0.000039
Riboflavin	-	-	-	-	0.000001	0.000001
Vitamin A	-	-	-	-	0.000012	0.000012
Folic acid	-	-	-	-	0.000001	0.000001

Note: Total formula weight = 1g.

TABLE 5.10: CONTINUED

Weight, Cost, Nutrients	Constraints			Nutrients Obtained					
	Initial	Relaxed	Final	* BS1	BS2	BS3	PFM1	PFM2	PFM3
Weight	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cost (Bahts)	1.08	1.08	1.03	0.59	0.67	0.97	0.87	0.86	0.87
Energy (Calories)	387.00	343.00	350.00	240.00	302.00	351.00	344.00	350.00	360.00
Digested protein (g)	5.00	6.00	6.45	2.00	6.00	8.84	10.49	11.18	11.61
Fat (g)	8.60-15.04	8.60	8.60	8.54	15.04	21.86	22.78	21.51	22.28
Fibre (g)	1.88- 4.69	1.88-4.69	1.88-4.69	1.75	4.28	4.31	4.32	4.69	4.69
Calcium (mg)	156-288	156-288	159-292	21.49	183.52	186.52	193.00	207.00	205.00
Phosphorous (mg)	156.00	156.00	159.00	41.66	201.98	234.85	270.00	284.00	290.00
Iron (mg)	2.19	2.19	2.22	0.99	3.94	3.96	4.17	4.53	4.53
Vitamin A (IU)	625.00	625.00	750.00	365.00	221.68	755.00	135.00	750.00	750.00
Vitamin B1 (mg)	0.20	0.20	0.28	0.05	0.30	0.39	0.47	0.49	0.52
Vitamin B2 (mg)	0.20	0.20	0.28	0.17	0.17	0.28	0.14	0.28	0.28
Niaein (mg)	2.66	2.66	3.66	0.79	2.48	4.26	4.81	4.74	5.07
Vitamin B6 (mg)	0.22	0.22	0.26	0.30	0.47	0.49	0.48	0.52	0.52
Vitamin B12 (μg)	0.39	0.39	0.41	0.00	0.00	0.74	0.00	0.41	0.41
Vitamin C (mg)	7.03	7.03	10.55	8.17	6.32	106.24	6.05	10.55	10.55
Folic acid (μg)	54.69	54.69	82.04	14.00	12.70	94.28	15.72	82.00	82.00
Pantothenic acid (mg)	0.94	0.94	1.18	0.45	0.98	1.33	1.29	1.34	1.38
Isoleucine (mg/g Digested Protein)	32.00	32.00	33.6	39.00	44.00	54.00	54.00	55.00	55.00
Leucine	56.00	56.00	58.80	73.00	73.00	94.00	93.00	94.00	93.00
Lysine	44.00	44.00	52.80	33.00	37.00	53.00	58.00	62.00	62.00
Phenylalanine) Tyrosine)	48.00	48.00	49.20	78.00	84.00	133.00	71) 43) 114.00	72) 41) 113.00	71) 41) 112.00
Cystine) Methionine)	28.00	28.00	29.40	35.00	36.00	41.00	14) 23) 37.00	13) 23) 36.00	13) 23) 36.00
Threonine	32.00	32.00	35.20	33.00	41.00	47.00	46.00	47.00	46.00
Tryptophane	8.00	8.00	8.60	33.00	16.00	17.00	15.00	14.00	14.00
Valine	40.00	40.00	42.00	46.00	52.00	65.00	65.00	66.00	65.00
PC/TC**	0.13	0.13	0.07	0.03	0.08	0.10	0.12	0.13	0.13

*BS1 = Initial formula of baked square type product; that is, the 'basic recipe' base formula developed by the addition of banana. This formula gave no satisfactory result nutritionally and organoleptically; thus, it was dropped.

BS2 = Formula developed from BS1 with the omission of rice, but instead, the addition of mungbean and the increase of sesame seeds, and peanuts. Though nutritive values of the product was much improved, the organoleptic property was not at a desirable level. Also, it degraded in a short period of time. Thus, it was dropped.

BS3 = Formula further-developed from BS2 with nutrients added. Though the product from this formula was improved in nutritional property, its sensory quality was similar to BS2. Thus, it was dropped.

PFM1 = Initial formula of pressed flour-mixture type product; that is, the 'basic recipe' base formula developed by the use of mungbean in place of glutinous rice flour. Though this formula gave the product of high level of organoleptic quality, the nutritional quality was not at a desirable high level. Thus, it was dropped. (Pastry Type and Mix Type)

PFM2 = Formula developed from PFM1 with the use of unskinned mungbean. Though it gave a nutritious and cheaper product, it was not acceptable. Thus, it was dropped. (Mix Type)

PFM3 = Formula developed from PFM1 with nutrients added. Though some improvement was needed for ideal sensory quality, the product from this formula had a high nutritional quality at a desirable level. Thus, this formula was chosen for further study. (Mix Type)

** = Protein calories/Total calories

TABLE 5.11: COMPARISON OF SELECTED ATTRIBUTES OF PRODUCTS FROM SELECTED LP FORMULAE

Attributes	Products					
	BS1	BS2 and BS3	PFM			
			PFM1 (Pastry Type)	PFM1 (Mix Type)	PFM2 (Mix Type)	PFM3 (Mix Type)
Organoleptic Attributes						
Form	Filling-centre pastry	Filling-centre pastry	Filling-centre pastry	Firm mix-product	Firm mix-product	Firm mix-product
Colour	Pastry layer: creamy brown Filling: Creamy brown scattered in purplish red	Pastry layer: golden brown Filling: Mix of red, green, and creamy brown	Outside: golden yellow Inside: Mix of creamy brown and red	Creamy brown and bright yellow scattered in purplish red	'Most-obviously-seen' green and creamy white and least-obviously seen' purplish red	Mix of creamy brown and bright yellow with less distinguished purplish red
Texture	Pastry layer: Tough not tender Filling: Too crunchy; and more crunchy after storage	Pastry layer: Crumbly Filling: Gritty and crumbly; Bean granules turn hard after storage	Pastry layer: Firm but slightly dry Filling layer: Crumbly Not juicy	Firm mix-paste; Chewable, and juicy Withstand to the bite	More crumbly, not juicy, more dry.	Crumbly, not juicy,
Aroma	Sweet smell with caramel aroma	Sweet smell with caramel aroma	Nutty and sweet aroma	Nutty and sweet aroma	Nutty and sweet aroma	Nutty and sweet aroma
Flavour	Pastry layer: bland	Pastry layer: bland, no beany flavour	Just-right sweet strong nutty	Just-right sweet strong nutty	Just right sweet strong nutty	Just right sweet strong nutty
	Filling: sweet too slightly nutty flavour Strong banana flavour	Filling: sweet, nutty, slightly banana flavour	Strong well-cooked bean flavour Very slightly banana flavour	Well-cooked bean flavour Slightly banana flavour	Very strong well-cooked bean flavour Very slightly banana flavour	Slightly well-cooked bean flavour Very slightly banana flavour
Overall	Far from concept organoleptically	Less close to concept organo-leptically	Less close to concept organo-leptically	Most close to concept organo-leptically	Most far from concept organo-leptically	Close to concept
Aw*	-	0.778	0.776	0.793	0.861	0.790

*Aw of DSC-banana used = 0.782; Aw of prepared mungbean used = 0.933

5.4.7 The Interactions During LP Experimentation

In developing formulae by LP, there was no guarantee that the selected raw materials would combine successfully or would make an acceptable snack product; thus, during LP experimentations, product preparation trials based on the "best formula" by LP were conducted and the product was informally organoleptically assessed by one Thai graduate student at Massey and the author. A formula technically unsuitable or a formula not acceptable organoleptically were dropped. However, the result of this preparation experiment would determine the next LP formulation. Therefore, linear programming was used in an interactive way with the preparation trials and the product acceptability test.

5.4.8 The Adjustment of the Raw Material Input Data for Recipe Designing Purposes

Food raw materials were input into the data in the raw state, but for practical purposes, prepared ingredients would be used in the recipe for product preparation. This needed some calculation based on the results from product preparation experimentation. In the later part of the formulation experimentation, for mixing convenience, all the input raw material data were converted into the form that could be directly used in mixing. Calculations were done, for example the moisture loss of sesame seeds during roasting was 4 %, thus converted nutrients of roasted sesame seeds was obtained by multiplying the nutrient values of unroasted sesame seeds by the factor of 100/96. Table 5.12 shows the 'best formula' selected for further development. A converted recipe for mixing purposes is also included, while remarks are given on how the conversion was made.

5.4.9 Acceptability Test of the Selected Formulated Products

The acceptability test of the LP formulated product was carried out by 6 graduate Thai students at Massey, three of whom had already participated in the brainstorming panel. Four of the panelists were females, and two were males. A profile analysis on the ratio basis developed at the Food Technology Research Centre, Massey University, New Zealand (FTRC, 1982) was the method used. The panel procedure, the profile analysis, and the results are detailed in Chapter 6 on "Sensory Analysis Development and Statistics". In brief, the panel were asked to assign the ideal and the sample scores on a 10 cm lines for each sensory attribute (see Section 6.3.2.2). The product ratio profile (Actual : Ideal) is shown numerically in Table 5.13.

Table 5.12: Selected formulae for further development.

Developed formula by LP	%	Recipe for mixing purpose	%
Nut-Fruit-Bean Mix Type			
Bean, skinned and roasted	25.00	Prepared mungbean (method 2)	25.00
Glucose-syrup	5.00)	Coconut milk syrup	11.00
Coconut milk	6.00)		
Banana	20.00)		
Brown sugar	4.44)	Deep-syrup cooked banana	26.00
Water	1.56)		
White sesame seeds, roasted	19.99	Roasted white sesame seeds	19.99
Peanuts, roasted and skinned	18.01	Skinned roasted peanuts	18.01
Ascorbic acid	0.0039)		
Riboflavin	0.0001)	Vitamin Mix	0.0053
Vitamin A	0.0012)		
Folic acid	0.0001)		
	100.0053		100.0053

Remarks:
1. Prepared mungbean = Mungbean which was soaked, boiled, and then roasted.
   (Final weight = 130% original)
2. Final temperature of DSC-banana = 108 C.
3. Moisture evaporation of roasted sesame seeds = 3% by weight.
   Moisture evaporation of roasted peanuts = 4% by weight.

Table 5.13: Product ratio profile from the 1st acceptability test.

Attributes	Product Ratio Profile Mean	S.D.
Odour:		
Sweet aroma	0.9	0.2
Nutty aroma	1.0	0.4
Texture:		
Soft - Hard	1.1	0.7
Crumbly - Cohesive	0.6	0.2
Gritty	1.4	0.4
Dry - Juicy	1.1	0.3
Flavour:		
Nutty flavour	1.0	0.4
Sesame flavour	0.9	0.4
Mellow sweet - Sharp sweet	0.9	0.1
Fruit flavour	1.0	1.5
Mungbean flavour	1.3	0.7
Acceptability score:	0.7	0.1
Colour*:	Creamy brown scattered in dark brown accepted.	
Size**:	In the range of 5-6 cm long, 3-5 cm wide, ≤2.5 cm thick.	

* Description type data.
**Multiple choice data.

It was found that the product was too crumbly (ratio mean 0.6) and gritty (ratio mean 1.4); and that the product was just acceptable for this panel (ratio mean 0.7). The ANOV analysis on selected attributes of ideal and sample scores proved that only the product crumbliness of the two were significantly different (F-ratio calculated = 12.51; $F_{.01}$ (1, 10) = 10.04). The correlation study on the attributes (see Chapter 6 Table 6.1c) suggested that fruit flavour correlated with crumbliness both of which had a trend of dependency on product acceptability.

Since fruit flavour was supposed to be a characteristic of this product and since fruit flavour statistically correlated adversely with crumbliness which had a trend to lower the acceptability of the product (see Chapter 6), an increase of fruit (flavour) seemed to be one of the justifiable ways to decrease crumbliness and increase acceptability. Therefore, it was considered that the LP developed formula should be adjusted so that the product crumbliness might be decreased (or cohesiveness increased) and the fruit ingredient might be increased.

5.4.10 Final Adjustment of LP Developed Formula and Determination of Food Additive Levels

5.4.10.1 Introduction. Cohesiveness of the product was to be increased. This might be done by -

: Increasing existing ingredients that were high in cohesiveness properties i.e. glucose syrup, deep-syrup cooked banana and also the syrup used for banana preparation; and at the same time decreasing ingredients with high crumbliness property i.e. sesame seeds and peanut grits.

: Adding an agent that has a good cohesive-binding property e.g. Gum acacia (Gum arabic), Locust bean gum, Carrageenan, Carboxy Methyl Cellulose (CMC), or a mixture of these agents.

5.4.10.2 Selection of Adjustment Means. Commercial fruit & nut snacks were surveyed and an observation was made on the relation of the thickening/binding ingredients to the texture properties of the products (Appendix 5.4M). In brief, pliable and/or chewable characteristics of the product seemed to be obtained by the use of glucose and/or sugar and/or honey or fruits, especially those high in pectin. Flour seemed to be added for its binding property in one product.

Tests were then conducted on selected thickening/binding ingredients from the survey and on other selected binding agents from a literature search. Firstly they were tested for their thickening property, and then they were tested for their ability to bind the materials in the product. These ingredients included gum arabic, carageenan, cassava flour, and glucose syrup in different amounts. The results of this test can be found in Appendix 5.5M. Glucose and cassava produced the most suitable thickness. However, when cassava flour was added into the recipe at the rate of 2%, problems were found as follows -

: Additional water needed for gelatinization process. This might result in the increase of water activity in the product which is difficult to control.

: Once it gelled, it was hard to mix with other liquid added later. Mixing before the gelatinization process was not justifiable because sugar retards gelatinization. This retardation is due to the fact that sugar takes the water which is needed for the gelatinization process.

: Its stickiness was of a moist type. This resulted, during mixing and pressing, in problems of pan and mould sticking. And moreover, it did not stay firm when pressed, but rather it spread out to some extent after unmoulding.

: After being left in a plastic bag for a few days, the sample containing cassava flour turned out to be firm not sticky and easily cut.

The product from the formula using glucose syrup only was not sticky after moulding; but rather it formed a firm product in which the ingredients were cohesive but not sticky when held in the fingers. Therefore, glucose or other sugar syrups were considered the most suitable binding agents.

The decision based on these findings was that the amount of glucose syrup in the product recipe was to be increased. It was decided that a combined means should be used so that a change in quality could be shared by the existing attributes and thus the change in each attribute would not be obvious.

5.4.10.3 <u>Reformulation of Nutritionally-Balanced Snack Product.</u> In reformulation of the nutritionally-balanced snack product, it was decided that -

: Glucose syrup be increased by not more than 100% of the original.

: Syrup from deep-syrup-cooking process be added in the range of not more than 5 grams. This was the approximate weight of syrup obtained from 26 g of deep-syrup-cooked banana (in the recipe). The use of this syrup had four advantages: avoidance of process residue problem; a decrease in the Aw of the product; an increase in fruit flavour (which is the main character type of the product, and also the weak point of the product in the panel test); and an improvement in the colour intensity (as wanted by the panel).

Bounds for the reformulation of the snack product was similar to what had been done in the former experiment except for those ingredients concerned with the binding property of the product. Formulae chosen for the preparation experimentation, which were to be selected later for the taste panel retest, are shown in Table 5.14.

Table 5.14: Formulae chosen for preparation experimentation.

	1*	2	3	4	5	6**
Prepared mungbean	25	25	25	25	25	25
Prepared banana	26	26	26	26	26	26
Prepared sesame seeds	20	20	13.3	20	20	20
Prepared peanuts	18	11.3	17.7	11.4	14	14
Coconut milk	6	6	4	2.6	-	-
Glucose syrup	5	8	10	10	10	10
Banana Syrup	-	3.7	4	5	5	5
Aw	0.865	0.803	0.821	0.792	0.775	0.748
Cost (Bahts)	0.87	0.85	0.88	0.86	0.87	>0.87
Energy (Calories)	360	358	360	361	370	370
Digested Protein (g)	11.6	9.9	10.5	9.8	10.4	10.4

* Former formula from former panel test experimentation.
**Similar to formula 5, but 0.04 cc of coconut essence were added.

5.4.10.4 <u>Selection of Formula for the Taste Panel Retest.</u> Formula 1, 2, 5, and 6 (from Table 5.14) were chosen for the taste panel retest. Formula 1 which was the original formula from the first panel test was included to check the performance and/or consistency of the panelists and also for use as the measurement of the characteristic change (better or worse) of the product. Formula 5 was chosen since it gave the highest calorie value (370 calories), lowest water activity value (0.748), and was also easier to prepare (less pan and mould stickiness). Formula 6, which was similar to Formula 5 except that it contained immitation coconut essence, was included to see whether the coconut flavour was needed in this product. One of the formulae having coconut milk was still retained for the experiment. In this case, Formula 2 was chosen, because its water activity was near the constraint (0.803; constraint $\leq$ 0.80) and also it had the lowest cost (0.85 Bahts).

Formula 3 was rejected because its Aw was too high (0.821). Formula 4 was also rejected, even though its Aw was acceptable (0.792), because its formula was very similar to Formulae 5 and 6, while its nutritive values were quite different (Calories 360, Protein 9.8; compared to Calories 370, Protein 10.4). 2.6 g of coconut milk could be prepared by adding 1.3 g water to 1.3 g of coconut cream. Much effort was needed for the preparation of this small amount of coconut cream, while the cost for this formula was higher than formula 1 (.86 Bahts vs .85 Bahts).

5.4.10.5 <u>Preparation of Samples for the Panel Retest.</u> Samples of Formula 1 product from the former panel test were used as Formula 1 (F1) for this experiment. This had been stored for two weeks at room temperature and one week in a refrigerator. The sample was reformed into the same mould-shape as the other newly-prepared samples (round shape of about 6 cm diameter, 2 - 2.5 cm thick; approximately 90 g). Other samples were freshly prepared the day before the panel test using the previous formula 2, 5 and 6 and were regarded as formula 2 (F2), formula 3 (F3) and formula 4 (F4) respectively in this panel retest experiment. Only half of the round piece sample (approximately 45 g) was served for evaluation. At this stage of sample preparation, the Aw values of ingredients and of the product samples were reexamined. The result is shown below.

Ingredients/Samples	Water Activity Value	
Prepared mungbean	0.933	
Prepared banana	0.73	
Prepared sesame seeds	<0.40*	(~0.35)
Prepared peanuts	0.453	
Coconut milk	-	
Glucose syrup	0.724	
Banana syrup	0.804	
Imitation coconut essence	-	
Sample: Formula 1 (F1)	0.972**	
Sample: Formula 2 (F2)	0.831	
Sample: Formula 3 (F3)	0.769	
Sample: Formula 4 (F4)	0.749	

* Aw lower than 0.4 which is the lowest scale for the Aw-value analyser used.
** Formula 1: Aw value of the previous freshly prepared sample = 0.865

5.4.10.6 Method and Procedure for the Taste Panel Retest. The taste panel form from the first panel test was adapted by including the mean ideal scores from the former test on each attribute line (see Chapter 6). The panel were asked to evaluate for all attributes of the 4 samples against the ideal scores. Three digit numbers were used for coding the samples. The panel procedure was similar to the former panel test except that 4 samples, of 45 g each, were evaluated against the fixed ideal scores and the questions on colour and size were excluded. The method of profile analysis used in the former panel test was also applied to this test experiment.

5.4.10.7 Results of the Final Adjustment of the LP Developed Formula. Detailed results of the final adjustment of the LP developed formulae are shown in Chapter 6. In brief, the four samples were similar in most sensory attributes. The exception was for the 'crumbly - cohesive', 'mungbean flavour', 'soft - hard', and 'sweet aroma' characteristics, in which only Formula 1 (F1) was significantly different from the others; while Formulae 2, 3, 4 (F2, F3, F4) were not significantly different from each other (Table 5.15). In general, Formula 1 (F1) was inferior in the four sensory characteristics mentioned to the other three formulae, which were similar in sensory quality; thus, it was dropped. Since Formula 2 (F2) had a similar 'mungbean flavour', 'soft - hard', and 'sweet aroma' characteristics to Formula 1 (F1), it was also dropped. Formula 4 (F4) was later dropped because it gave a slightly over strong nutty aroma and flavour (Ratio mean = 1.2 and 1.1, while ratio mean of Formula 3 (F3), with no coconut essence added, = 1.0 for both aroma and flavour). Therefore, Formula 3 (F3) was selected for process development. The ratio profile of the product from Formula 3 (F3) is shown in Table 5.16.

TABLE 5.15: MEANS AND LEVELS OF SIGNIFICANCE FOR SENSORY ATTRIBUTES OF PRODUCTS FROM FORMULAE 1,2,3 AND 4

Attributes	F1 Mean	F2 Mean	F3 Mean	F4 Mean	Level of Significance
Sweet aroma	0.57^{a}	0.78^{ab}	0.88^{ab}	1.13^{b}	95%
Nutty aroma	1.02	0.89	0.99	1.19	n.s.
Soft-Hard	0.70^{a}	0.83^{ab}	1.13^{ab}	1.32^{b}	95%
Crumbly-Cohesive	0.34^{a}	0.73^{b}	0.97^{b}	1.05^{b}	99%
Gritty	1.38	1.13	1.19	1.61	n.s.
Dry-Juicy	0.69	0.94	0.91	0.88	n.s.
Nutty aroma	0.88	0.93	1.04	1.06	n.s.
Sesame flavour	0.62	0.79	1.07	0.20	n.s.
Mellow-Sharp sweet	0.78	0.99	0.99	1.02	n.s.
Fruit flavour	1.02	0.71	0.82	0.88	n.s.
Mungbean flavour	1.20^{a}	1.00^{ab}	0.66^{b}	0.56^{b}	99%
Acceptability scores	0.36^{a}	0.71^{b}	0.76^{b}	0.79^{b}	99%

F1, F2, F3, F4 = Formula 1, Formula 2, Formula 3, Formula 4
Means having different superscript are significantly different according to Duncan's multiple range test, that is 'a' is not significantly different from 'ab' but is significantly different from 'b'.
n.s. = not significantly different.

Table 5.16 : Ratio profile of product selected for process development.

Attributes	Ratio Mean	S.D.
Odour:		
Sweet aroma	0.9	0.4
Nutty aroma	1.0	0.2
Texture:		
Soft - Hard	1.1	0.2
Crumbly - Cohesive	1.0	0.1
Gritty	1.2	0.1
Dry - Juicy	0.9	0.1
Flavour:		
Nutty flavour	1.0	0.2
Sesame flavour	1.1	0.2
Mellow sweet - Sharp sweet	1.0	0.2
Fruit flavour	0.8	0.5
Mungbean flavour	0.7	0.3
Acceptability score	0.8	0.1

5.4.10.8 <u>LP Developed Formula Selected for Process Development.</u> The adjusted formula selected for process development is shown below; and a comparison between the properties of this formula and the constraints is shown in Table 5.17.

LP FORMULA	%	RECIPE FOR MIXING PURPOSE	%
BEAN, boiled & roasted	25.0000	PREPARED MUNGBEAN (soaked, boiled and roasted)	25.00
SYRUP, glucose	10.0000	GLUCOSE SYRUP	10.00
SYRUP, banana	5.0000	BANANA SYRUP	5.00
BANANA SUGAR, brown WATER	20.0000 4.4400 1.5600	DEEP-SYRUP COOKED BANANA	26.00
SESAME, roasted	20.0000	ROASTED WHITE SESAME SEEDS	20.00
PEANUT, roasted & skinned	13.9941	SKINNED ROASTED PEANUTS	14.00
ASCORBIC ACID	0.0045	ASCORBIC ACID	0.0045
RIBOFLAVIN	0.0001	RIBOFLAVIN	0.0001
VITAMIN A	0.0012	VITAMIN A	0.0012
FOLIC ACID	0.0001	FOLIC ACID	0.0001

Table 5.17: A comparison between properties of selected formula and constraints.

Cost/Nutrients	Output	Constraints
Cost (Bahts)	0.87	1.03
Energy (Calories)	370	369
Protein, digested (g)	10.40	6.45
Fat (g)	18.53	8.60
Fibre (g)	4.59	1.88 - 4.69
Calcium (mg)	209.22	158 - 292
Phosphorus (mg)	268.80	158.59
Iron (mg)	4.61	2.22
Vitamin A (IU)	750	750
Vitamin B1 (mg)	0.46	0.28
Vitamin B2 (mg)	0.28	0.28
Niacin (mg)	4.30	3.66
Vitamin B6 (mg)	0.50	0.26
Vitamin B12 (μg)	0.41	0.41
Vitamin C (mg)	10.55	10.55
Folic Acids (μg)	82.00	82.00
Pantothenic Acids (mg)	1.26	1.18
Isoleucine (mg/g digested protein)	56	34
Leucine	94	59
Lysine	63	53
Phenylalanine) Tyrosine)	112	49
Cystine) Methionine)	37	29
Threonine	47	35
Tryptophane	14	9
Valine	66	42
PC/TC	0.10	0.08

5.4.11 Discussion and Conclusion

Linear programming was found useful for the formulation of a high calorie-low cost snack product with the necessary nutrient requirements, cost limitation, and of an adequate amount. It was found from this study that although the formulation and process development did overlap, a systematic and planned experimental design technique for process development was started only after the formulation was considered acceptable.

In this study, a profile test on the ratio basis was found to be effective for testing the product's acceptability because it could identify the weak points of the product from the ideal. The ANOV and Correlation analyses were found necessary for selecting the weak point which needed remedying. In this case, the selected product needed an adjustment in order to get rid of the crumbliness of the product. In making the adjustment, a combined change of ingredients was used in order that there would only be a small change of quality in the existing product attributes and any change would not be obvious.

In conclusion, a formulation system for nutritional product development was set, and was applied in the development of a nutritionally-balanced snack product for urban school-age Thais. The effective and reliable method developed in this study was as follows. Firstly, start with the 'best-estimate' experimentation to define the detailed product concept. Secondly, conduct experimental trials to find the appropriate methods of ingredient preparation, and to find their appropriate combination. Thirdly, formulate the products by LP techniques to get the optimized products. Select suitable formulae/formula and prepare the product(s). Conduct acceptability test with laboratory trained panel by using profile test technique. Fourthly, make adjustment(s), where necessary, and use LP technique to reformulate, until an acceptable formula is obtained.

This was considered an effective formulation system because: it could give the optimum feasible formula in a short time; it gave a satisfactory result, or in other words, it gave an acceptable formula oganoleptically and it gave reliable results. However, this effectiveness could be reached only if it was used interactively with careful experimental trials and with the profile test technique for acceptability testing.

5.5 AN APPROACH TO PROCESS DEVELOPMENT

5.5.1 Introduction

Food process development can be defined as an activity which results in the obtaining of the data and experience necessary to design, build, and operate plants for production of foods for sale at a profit. Although the overall activity may include a wide range of different activities, from kitchen-scale food preparation to the production of food for market evaluation, this part of the study was limited to the pilot-plant development.

In general, the aim of the process development is to design an optimal system comprised of individual processing steps arranged in an ordered sequence to convert given raw materials into a specified product. Process development can be classified under 2 categories: the development of a new process for an old product, and the development of a new process for a new product. In this project, the objective of the process development was to find the conditions under which a cheap and nutritious snack formulation could be produced as an acceptable and profitable product. This could be regarded as the development of a new process for a new product. However, it was the purpose of this project that adaptation from an existing process and adjustment from the traditional product would be made where possible.

In this part of the study, a systematic quantitative process model was designed for the nutritional snack product formulated in 5.4. The following discussion is to illustrate how an approach was made, step by step, on the application of the designed model to process the selected formulated product as an acceptable product by the shortest route. The main systematic steps used had similar principles to what was applied for formulation development (Figure 5.1). These included -- objective setting, planning and data preparation, testing and validation, and marketing research.

The process for the nutritionally-balanced snack was designed using, firstly, experimental trials on the processes from a literature search and past experience, and finally, using a planned stepwise experimentation in which critical evaluation was made basically on the 4 main interacting factors -- economics, consumer acceptability, formulation, and process. Screening for important process variables was carried out, where possible, and then the process was optimized. During the step of optimizing the process, experimental preparations of the product from the final linear programming formula using the optimized process were done and the result obtained was used for a process suitability judgement.

In developing the process, constraints were set that: the process should use equipment existing in biscuit or snack factories in Thailand; the process should produce minimal wastage; and the process should be capable of producing a product to the required standard and of consistent quality. The aims of the process development were -

: To design the process for a nutritionally-balanced snack for urban school-age Thais.

: To study factors influencing DSC-banana (deep-syrup cooked banana), BSE-mungbean ('boiled - hot stirred - evaporated' mungbean), and MP-snack ('mixed-pressed' snack).

: To test the process in a Thai snack factory.

: To select methods and techniques of experimental design, statistical analysis, and sensory testing suitable for nutritionally-balanced snack process development.

5.5.2 <u>Literature Review on Raw Materials and Processes</u>

5.5.2.1 Raw Materials. Articles on banana (NAMWA variety), mungbean, peanuts, and white sesame seeds, grown in the Thailand, can be found in Thai literature, but mostly from the agriculture point of view. For banana, Chomchalao et al.(1967) found that both the percentage of soluble solids and sweetness of bananas increased with time after harvesting. However, the percentage of soluble solids was constant at 26% after 16 days of storage. Bananas were also found to have a different rate of respiration, the average of which was 1.64 g/day. Although the density of bananas was found to decrease gradually, the decrease was extreme after 12 days of storage.

Chaitragoolsap (1982), in her study on chilling damage in bananas (including NAMWA), found that bananas stored at low temperatures were firmer than those ripened without being subjected to low temperature storage. There was much variation of firmness among the different temperatures. Total soluble solids of ripened NAMWA bananas were substantially higher than those of mature green bananas of the same variety for every storage temperature.

Personal communication with banana growers suggested that NAMWA bananas, harvested at the fully mature stage, are sweeter than those harvested too green. Also, NAMWA from different geographical sources are different in colour, sweetness, and firmness.

The varieties and availability of mungbean were investigated by the Deparment of Agricultural Extension (1983) and Srinives (1984). Among all the Thai articles available, the study of Narkrugsa (1983) seemed to be most directly applicable to the selection of mungbean for product development work. The chemical and physical properties of 20 varieties of mungbean grown in Thailand were studied for their most suitable uses. Although OOTONG 1, which is a variety being promoted by the Ministry of Agriculture, had a higher protein content than mungbean available in the market (21.68% for OOTONG 1 compared to 18.23% for mungbean in the market), its availability in the market was low. This might be a weak point of the marketing system in Thailand in that the food commodities are not labelled and varieties are not specified.

Varieties of peanuts grown in Thailand can be found in Varanyoowat (1982). Of all the varieties available, Valencia and Spanish Varieties are popular for roasting. Examples of these are TAINAN 9 and LAMPANG. The recommended storage condition for peanuts is at temperatures below 5 C and 70% relative humidity.

Two types of sesame seeds -- white and black, have been grown in Thailand for a long time (Gaweeta, 1984). 'Local race' variety is the most popular for growing. Lighter-coloured sesame seeds were found to have a higher fat content than the black ones.

5.5.2.2 Process. A deep-syrup cooking process has been used in the preparation of fruits (peel or pulp), roots, and egg-yolk for a long time for Thai snacks for the purpose of varying the product flavour and preserving the product (Sinthavalai, 1979). Briefly, for fruits, they are cooked in syrup, the initial concentration of which depends mainly on the maturity and texture of the raw materials. During cooking, while the concentration of the syrup is increasing, the water in the fruits decreases due to its replacement by syrup in an osmosis process. The final concentration of syrup used designates the storage life and sensory characteristics of the product. However, the process is limited in its application for the snack production at the vendoring level.

For the preparation of an intermediate-product (which is 'DSC-banana-like') of a new banana product, Palmer (1979) proposed the use of 'Osmo-Vac Process'. In this process, the pulp of fully-ripe banana was cut into 6 mm thick slices. The slices were submerged in a 67-70 Brix sugar syrup for 8 to 10 hours to remove about 50% of the water by osmosis. The osmo-dried slices were subjected to further steps -- removing from syrup, draining excess syrup, vacuum drying, puffing, cooling -- and a puffed, porous product was obtained.

A hot-stirring process has also been used for a long time in the preparation of fruits, roots, and cereals/flours for Thai snacks. Briefly, for the hot-stirring of mungbean, the mungbean is cooked, at a medium heat, in plenty of liquid (normally, a syrup and coconut milk mixture) until the starch granules firstly gelatinize and later burst. Then the excess water is further evaporated by low heat hot-stirrring (Sinthavalai, 1979). However, the hot-stirred mungbean obtained has a limited shelf-life period; and also, this process is limited in its application to vendoring and home-factory levels.

5.5.3 Outlining of Process and Raw Materials for the Developmental Experimentation

Unit processes of the nutritionally-balanced snack process were firstly identified and the processes were described (Appendix 5.2a) for the deep-syrup cooking of bananas, boiling and roasting of mungbeans, roasting of peanuts and sesame seeds, and preparation of coconut milk. Four process trials were experimentally carried out in order to find suitable methods for development, using the described processes as a guide, as follows:

: A trial on the DSC-banana process using a steam jacketed pan.
: A trial on the nut-roasting process using an oven.
: A trial on the mix-mould operation using an electric mincer.
: A trial on the mix-mould operation using a KENWOOD, bakery roller, and TASTI moulder.

The summary result of the above trials is shown in Table 5.18 and the detailed result in Appendix 5.6M.

5.5.4 Screening of Process alternatives

Since the individual processing steps, including the steps of mixing and moulding operations in this project, would affect the optimal system designed for the product, it was decided that process alternatives should be studied at this stage. The method of the "Combination Approach" suggested by Earle (1971) was used in generating process alternatives systematically. Alternative methods for achieving the key operations were listed, and then compared on the basis of their potential for improving the process.

TABLE 5.18: SUMMARY RESULTS OF EXPERIMENTAL TRIALS ON PROCESSES

Experimental Trial	Methods and Procedures of Processing/Operating	Selected Main Findings
DSC - banana process	Steam jacketed pan Peeled banana: sugar: water = 1.3 : 1.5 : 1 Initial temperature of syrup = 102-103°C Initial concentration of syrup = 60-65% Final temperature of syrup = 108°C Final concentration of syrup = 72% Cooking time ≃ 2 hr Steam control valve : at medium	Ratio of banana/syrup = 1:2 by weight Banana : at well mature stage (yellowish-green; just noticable banana flavour) Cooking syrup: boiled but not vigorously (rate of temperature increase should be controlled) : Circulation of syrup needed.
Roasting process for white sesame seeds	Oven roasting Temperature: 260°C Time: 2 min bottom heat; 2 min top heat Crushing: by rolling the cooled seeds in plastic bag	Yield : 96.8% Loss through evaporation = 3.2%
Roasting process for peanuts	Oven roasting Temperature: 260°C Time: 3 min bottom heat; 3 min top heat Skinning and winnowing: manually	Yield: 92% Loss through evaporation 3.7% Loss through skinning 4.3$ Total loss 8%.
Mix and mould operation 1	Using adapted electric mincer (bar-shape mould attached to the outer screw ring) Formula: Selected LP reformulated formula (or Formula 6 in Table 5.14) Input weight: 0.5 kg	Input weight needed: 1 kg at least Loss (input through part): 350g Size of bar considered suitable: 8.2 x 3.5 x 0.75 cm^3 which weighed 30 g Bar characteristics: Colour: brown for 1st mince, grey for 2nd mince Texture: soft, readily break, not cohesive Mouthfeel: paste-like Flavour: Normal banana-nut-mungbean bar flavour Decision: For better colour and texture cutter should be removed.
Mix and mould operation 2	Using KENWOOD for mixing and bakery roller (break roller) for moulding Formula: Formula 6 in Table 5.14	The mixture was too sticky and impossible to roll. Moisture of the mixture: 17.1% when freshly prepared 17.7% after 24 hr open on bench
Mix and mould Operation 3	Using KENWOOD for mixing and Tasti Mould for moulding Formula: Formula 6 in Table 5.14 Method 1: Roasted mungbean (15% moisture content) and hot mix. Method 2: 'Further roasted mungbean and ground' mungbean (9.5% moisture content) and cold mix.	Method 1: The mixture was considered too sticky and impossible to mould by Tasti moulder. Moisture content: 17.1% fresh, 17.7% one day old. Method 2: The mixture was possible to mould but difficult to knock out from the mould and afterwards there was breakage. The bar was crumbly; the mungbean are unacceptably hard gritty. Moisture content: 13.4% fresh, 11.2% one day old

After the obviously illogical alternatives had been eliminated, the remaining options were evaluated using a sequential screening technique. The screening criteria included: technical feasibility, economic feasibility, and availability of necessary equipment. For judgment convenience, the situation of snack food factories in Thailand was used as the basis of the criteria.

Assumptions were made that the following facilities would be available in snack food factories (or baking factories) in Bangkok: Platform weighing machines, boilers, steam jacketed pans, continuous tunnel ovens, cooling system connected to the continuous oven, and form-fill-seal packaging machines. The availability of an agitated drying pan or movable agitator and gyratory sifters were in doubt.

The process alternatives for the individual processes of nutritionally-balanced snack bars is shown in Appendix 5.7M. As an example, the process alternatives for hot-stirred mungbean is shown in Figure 5.2.

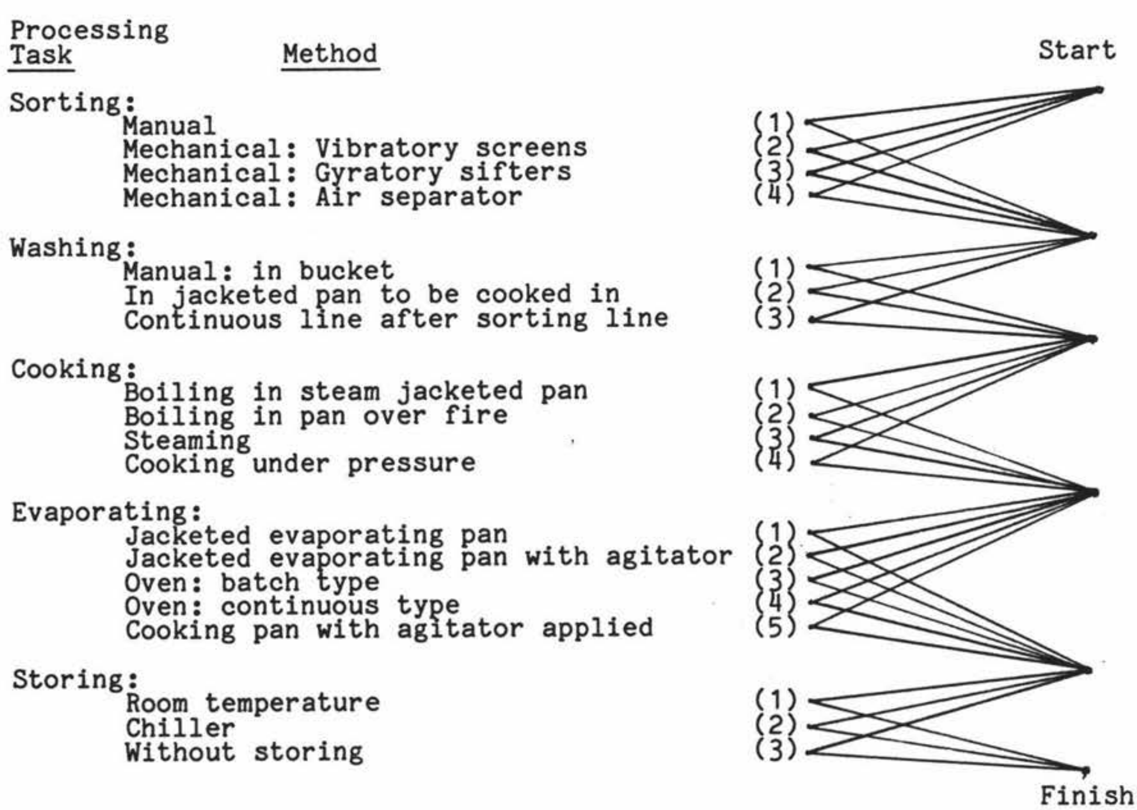


Figure 5.2: Process Alternatives for Hot-Stirred Mungbean.

5.5.5 Selected Key Operations

Of the five processes, three were chosen for further study while the other two, for which the prepared ingredients were readily available, were dropped. The key operations of each process chosen for detailed study were as follows -

Deep-syrup cooking of bananas
: The selection of bananas at the right maturity or ripeness stage
: The correct initial temperature of the syrup for banana cooking.
: The use of the right type of sugar for syrup making.

Boiling and roasting of mungbeans
: The boiling of the mungbeans.
: The evaporating of the cooked mungbeans.

The mix-mould-cut operation of the product
: The mixing of the ingredients.
: The moulding of the mixed ingredients.
: The cutting of the moulded product.

5.5.6 Actual Unit Operations Used in Pilot Plant Experiments

Although the processes and the operations carried out in phase 1 and phase 2, during the process development stage, were theoretically similar, some differences were unavoidable because of the different raw materials and equipment used. Therefore, where a difference was found, processes and operations in phase 1 and phase 2 are discussed in isolation.

5.5.6.1 DSC-Banana Process. In phase 1, the steam jacketed pan used for the DSC-banana process experiment was a pilot plant model with a one-inch steam valve to control the steam pressure (2.11×10^4 Kg/m^2). The sugar and water was boiled until the desired temperature was reached after which the peeled whole banana was added. It should be noted that the boiling pattern (or the rate of temperature increase) could not be strictly controlled. However, this was roughly controlled by using the steam valve to maintain the boiling pattern at a rolling boil. The undesirable foam was spooned out. At the later part of the cooking, a perforated round plate was applied to keep the banana submerged in the boiling syrup.

In phase 2, the round bottom stainless steel pan used for the deep-syrup cooking process was a pilot plant model for Thai snack cooking, and was 53.8 cm diameter at the top and 17.0 cm deep. The pan was heated directly by a gas stove. The gas stove used had 2 round burner hole sets with diameters of 8.5 cm and 17.5 cm. The burners were controlled by a knob attached to a gas cylinder. Half of the water required in the recipe was boiled and the peeled bananas were added. After half an hour of boiling, the other half of the water was added, and after the mixture returned to the boil, the sugar was added. Boiling was continued for another period of time depending on the experiment designed. The bananas were kept under the boiling syrup while cooking by a technique of controlling the bubbling of the cooked syrup. The DSC-banana process is shown in Appendix 5.2b.

5.5.6.2 BSE-Mungbean Process. Prior to phase 1, a steam jacketed pan was used for the boiling and evaporation of the mungbean. The soaked mungbean was boiled until the seeds burst and most of the water had evaporated. The steam pressure was lowered from time to time to avoid loss through over-foaming. The boiled mungbean was then spread on to a baking pan and was roasted in an air oven. Half way through the roasting time, the mungbean was turned over to achieve an even dryness. Unfortunately, this was considered an unsuitable method because of the large loss through sticking-to-pan and because hard lumps which occurred during the roasting stage would be of a great disadvantage to the mixing of the final product. Lower temperatures could be used for roasting but the much longer time required made this unsuitable.

In phase 1, a hot-stirring process for mungbean was experimentally tried in a steam-heated stirring pan (C & H Variable Drive, Australian No D2V/1123, HP 1/4, Fast 405, Slow 67) which was normally used for liquid products. This pan was chosen for use because no transfer of cooking container was needed in spite of the 3-stage nature of the hot-stirring process, namely, boiling, hot-stirring, and evaporating. Measured mungbean and water were firstly boiled (Steam control $\simeq$ 1 KPa x 100; Variable drive No 0; Time: depending on the experiment designed), then hot-stirred and evaporated (Steam control $\simeq$ 1 KPa x 100; Variable drive No 1; Time: depending on the experiment designed).

In phase 2, a mechanical hot-stirring machine (Figure 5.3), which was developed at the Department of Product Development, Kasetsart University, Bangkok, was used. The stirrer was rotated by a motor. The 3 speeds -- 1 (slow), 2 (fast), and 4 (back turn) -- were controlled by a gear and these could be turned on or off by a switch. Gas was used to heat the mungbean. A gas stove had 4 rounds of flame hole sets, 2 of which could be controlled by the same valve, and another 2 by another valve. There was an accelerator for gas flow at the head of the gas cylinder.

A stainless steel round bottomed pan was 53.8 cm diameter at the top and 17.0 cm deep. A brass round bottomed pan of the same size was also available. The stainless steel stirrer was in a double-paddle form so that it could stir and sweep the mungbean from the bottom and the side of the pan. The stirrer was attached to a floating axle so that it could be lifted up or lowered down as desired by a controlled

Figure 5.3: Mechanical Hot-Stirring Equipment

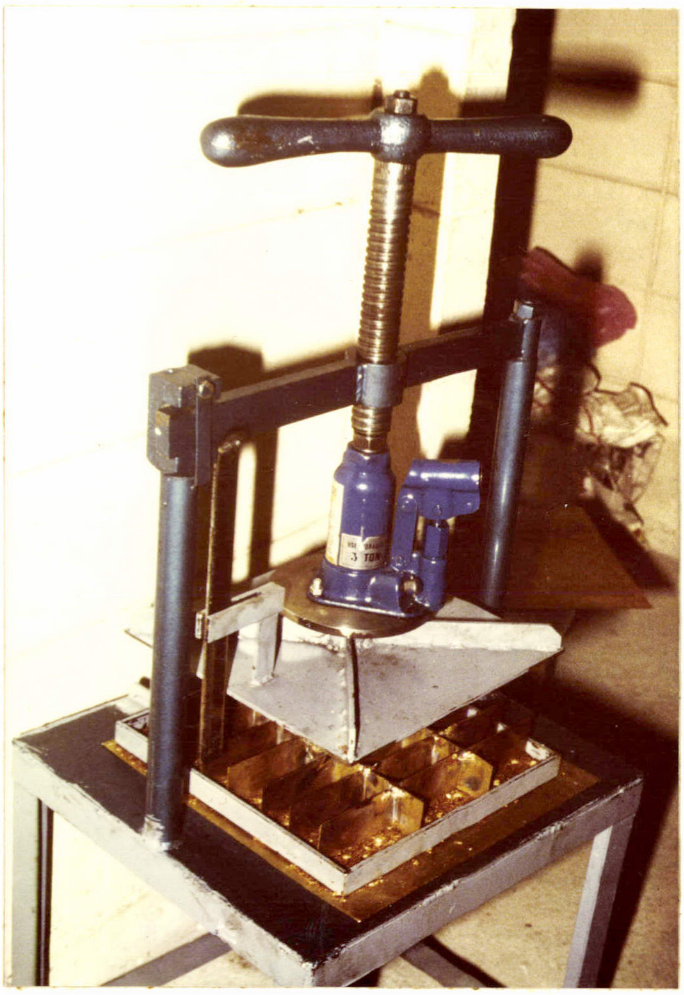


Figure 5.4: Mechanical Pressing and Cutting Equipment

wheel. The stirrer was held loosely so that when one blade of the double paddle touched the bottom of the pan, the other side of the paddle would be raised up, and vice versa.

Since this mechanical hot-stirring equipment was previously developed for a fluid (thick or thin) product while the final hot-stirred mungbean desired was a semi-dried product, an adaptation of equipment and/or processing steps was found to be necessary. In this case, manual evaporation was applied in the final stage.

For all process experiments on mungbean, the BSE-mungbean process used comprised of 3 stages -- boiling, hot-stirring, and evaporating. Although the mechanical hot-stirring machine could be used for all 3 stages of the process, the evaporating stage was done on another gas stove. This was to save time for the experiment, that is, while evaporating, another batch could be started on the boiling and hot-stirring stages.

5.5.6.3 MP-Snack Operation. In phase 1 of the experimental trial on the MP-snack operation, different mixing and pressing and/or moulding machines were used. These included: a KENWOOD mixer (Kenwood Manufacturing Company Ltd., England), two ribbon horizontal mixer (developed by the Food Technology Department, Massey University, N.Z.), a Bakery roller, a TASTI mould (Tasti Snack Food Factory, Auckland, N.Z.), a heavy duty vertical K type mixer (spitting-shield adapted by the Sanitarium Health Food Factory, Palmerston North, N.Z.), a Z-arm mixer (spitting-shield adapted by the Sanitarium Health Food Factory, Palmerston North, N.Z.), a manual moulder (ordinary cookie moulder), a manual presser and cutter (adapted from a baking pan with a rectangular segmented cutter provided), an extruder (adapted from Mincer Bauknecht type AL 2-1 by Food Technology Department, Massey University, N.Z.), and a NID bar-forming machine (Australia). Among these, the Z-arm mixer and the NID bar-forming machine were used for the critical experimental trial in phase 1. Detailed descriptions of two of these machines are shown in Appendix 5.3.

In phase 2 of the experiment on the MP-snack operation, because of the delay in the developed press-cut equipment, mixing and pressing experiments to optimise the operation conditions were conducted using KENWOOD (MAJOR MODELS; Kenwood Manufacturing Company Ltd., England) for mixing, and using CARVER Hydraulic Equipment (FRED S. CARVER, Wis. 53051) for pressing. However, the optimised conditions obtained were proved related to the conditions applied in the developed press-cut equipment.

The ingredients were mixed at speed 1 at the start for approximately half a minute and then speed 3 for a period of time according to the experiment designed. For pressing, 10 g of the mixture was placed in a cylinder mould and then pressed down by the CARVER plunger fitted with the cylinder mould. The pressing force used was controlled by the gauge attached to the equipment. After pressing, the moulded product was punched out and kept for quality tests.

For the MP-Snack operation, mechanical pressing & cutting equipment (Figure 5.4) for an intermediate moisture food was developed by the Department of Product Development, Kasetsart University. This was adapted from a hand screw squeezing machine commonly used for the preparation of coconut cream from shredded coconut meat, flour cake from ground tubers or grains, and bean-residue cake from ground bean. The main parts of the equipment included: two square brass plates as product containers (35.6 x 35.6 centimetres); an iron frame of 30.5 x 30.5 x 2.22 centimetres that could contain 1 - 1.1 Kg of product to be pressed at a time; a pressing iron plate, attached to the end of the screw press the size of which could fit into the iron frame, held straight by an iron flat rod, so that the plate could be moved straight down into the frame below; a segmented brass cutter which could cut the pressed product into twenty-four bars 10.2 x 3.8 centimetre size.

The mix-product was placed onto the brass plate in the frame and manually spread. A wooden roller was applied for a better arrangement of the mixture. The spread mixture was then pressed until the desired thickness was obtained. Then, after the brass cutter was placed into the frame, the pressed product was cut, by the use of the hand screw press on the cutter, and the product bars were obtained.

At a later stage in the MP-Snack Bar experiment, for labour-saving in winding the hand screw press onto the cohesive mixture of the snack product, a hydraulic jack was attached between the screw and the press plate. The jack was in use only after the plate was manually wound down and touched the spread product. This made it possible for this machine to be operated by one worker instead of two.

5.5.7 Identification of Input and Output Variables

In designing the experiments, firstly, important input and output variables were identified and levels of input variables studied were set (Table 5.19). Though some output variables could not be investigated in certain phases of the process experimentation because

Table 5.19: Input-output variables and levels of input variables for process development.

Input Variables	Input Variable Levels	Output Variables
DSC-Banana Process		Physical Property:
Ingredients:		Weights (DSC - banana, Loss through foam)
%SS of raw banana	17.5 - 23; 15 - 17.5; 23 - 29	
		%SS (DSC-banana, banana syrup)
Sugar type	White-Raw	Aw (DSC-banana, banana syrup)
		pH (DSC-banana, banana syrup)
Process Variables:		Tristimulus Values (DSC-banana, banana syrup)
Initial temperature of syrup (C)	102-106; and 100 (Fixed)	Compression & extrusion force (Raw banana, DSC-banana)
%SS of initial syrup	60-65; 68; 10; 50 (Fixed)	Sensory Property:
Final temperature of syrup	108; 120 (Fixed)	Colour
%SS of final syrup	72; 78; 85 (Fixed)	Texture
Cooking time (hrs)	2-3	Flavour
		Microbiological Property:
		Susceptible to mould growth score
BSE-Mungbean Process		Physical Property:
Process Variables:		Weight (BSE-mungbean, Loss through scorching)
Water/Mung ratio	2.3-2.8	Specific volume (BSE-mungbean)
Boil time (min)	20-40	Moisture content (BSE-mungbean)
Hot-stir time (min)	20-30	Sensory Property by Taste Panel:
Hot-stir speed (rpm)	38-66	Colour
Evaporation time (min)	20-30	Texture
Batch size (Kg)	1-2; 2-3	Sensory Property by Subjective Inspection:
Pan type	Stainless Steel-Brass	Evaporation score
		Evaporation time
MP-Snack Operation		Physical Property:
Process Variables:		%SS
Mixing time (min)	1-7	Sensory Property by Taste Panel:
Pressing force (Kg/m^2)	1.41×10^6 - 7.03×10^6	Colour
		Texture
		Flavour
		Sensory Property by Subjective Inspection:
		Handling score
		Stickiness score

of the unavailability of equipment, suitable output variables were used as substitutes. For example, the water activity value of the product was not measured in phase 2 of the experiment in Thailand; instead, the percentage of soluble solids and the moisture content were determined. Though these were not absolutely related to the water activity value, they could portray certain qualities of the product/intermediate product. Also, in phase 2, modification was made in the selection of input and output variables for the mungbean process to make it suit the circumstance. For example in the optimization process for mungbeans, the hot-stir time and evaporation time were not controlled, but instead, they were considered as response variables to be studied, while their end-points were controlled by the weight of the product.

5.5.8 Methods and Techniques for Process Development

5.5.8.1 Introduction. Systematic and planned techniques for process development were used in order to obtain detailed and inclusive information at a low cost. Experimental designs and techniques chosen for use were based on their relative ease in processing and analysis, and their effectiveness in giving reliable results. The systematic approach to the experimental design in the process development for this project followed the steps suggested by Anderson (1981) as follows: problem definition, setting objectives, experimental planning, execution, analysis of results, drawing conclusions, and then 'action', or in this case, application in the production step.

It should be noted here that because of the constraints of the Study Program, the process development of this project was divided into two phases: phase 1 conducted in New Zealand, and phase 2 in Thailand. There were some difficulties in the acquisition of certain specified raw material and equipment at phase 1 of the process development, and substitutions were made on the banana variety (NAMWA variety substituted by GLUOY HOM variety), hot-stirring equipment (pan with stirrer for paste-type product substituted by pan with stirrer for liquid product), and pressing machine (press-cut machine substituted by moulder of different types).

5.5.8.2 Methods and Techniques Used. Table 5.20 shows a summary of methods and techniques used for process development, methods used for statistical analysis, and methods and techniques used for quality tests. More than one method was applied for each item for the purposes of comparison.

Table 5.20: Summary of methods and techniques used in the process development stage.

Process/Operation	Methods/Techniques
DSC-Banana Process	
Phase 1:	
Experimental design	Full factorial (2^2) with a centre point
Statistical analysis	Stepwise regression, Yates'
Quality test	Sensory test, Objective test (texture, colour, pH, % SS, Aw, Moisture content)
Phase 2:	
Experimental design	Full factorial (2^2) with a centre point
Statistical analysis	Stepwise regression, Yates'
Quality test	In-product test, Sensory test, Objective test (% SS), Visual storage test
BSE-Mungbean Process	
Phase 1:	
Experimental design	Experimental trial
Statistical analysis	-
Quality test	Objective test (Aw, Moisture content, In-product test)
Phase 2:	
Experimental design	Plackett and Burman Screening Experiment, Full factorial (2^2) with a centre point
Statistical analysis	Plackett and Burman analysis, Stepwise regression, Yates'
Quality test	In-product test, Moisture content
MP-Snack Operation	
Phase 1:	
Experimental design	Experimental trial
Statistical analysis	-
Quality test	Sensory Test (product profile) Objective test (Aw, Moisture content, Texture)
Phase 2:	
Experimental design	Full factorial (2^2) with a centre point
Statistical analysis	Stepwise regression, Yates'
Quality test	Sensory test (product profile) Objective test (Moisture content) Nutritional test (Proximate analysis, EAA pattern, Selected vitamins) Storage Test (ASLT*; 7 conditions, 2 packages)

* Accelerated Shelf Life Test

5.5.8.3 Experimental Designs. In this study, 'Plackett and Burman' (Stowe and Mayer, 1966) and 'Factorial Experiment' were the experimental designs chosen for use. The former was for the purpose of screening input variables while the latter was for optimizing the process conditions.

Factorial Experiment. A full '2 level, 2 factor' factorial experiment was applied. All combinations of the input variables were run at both the low and high levels. In each experiment, a centre point of the low and high levels was also included for the purpose of regression analysis. Therefore, the total number of runs were $2^2 + 1 =$ 5 runs (Table 5.21). The presence of a lower case letter in the treatment code indicates that the corresponding variable was at the high level for that run while another was at the low level. For example, in run 2 the treatment code is 'a' indicating that variable A was at the high level and B at the low level.

Table 5.21: Factorial experiment for a 2 factor, 2 level experiment.

Run	Treatment Code	Variable A	Variable B
1	1	low (-)	low (-)
2	a	high (+)	low (-)
3	b	low (-)	high (+)
4	ab	high (+)	high (+)

* For the purpose of regression analysis, the run of the middle point was also investigated i.e. 1/2 a, 1/2 b.

After each run, the output variables were measured. Systematic errors, which could occur due to some inherent pattern in the experimental design, were reduced by randomization of the experimental conditions. Random errors, which could occur due to some uncontrolled variables in the system were reduced by carefully and precisely setting and controlling the input variables. Where possible and justifiable, replication was carried out for the estimation of the experimental errors.

Plackett and Burman. The Plackett and Burman experimental design was used mainly for screening a number of variables in the BSE-mungbean process experiment. This design, principally, can screen N-1 variables in N experiments, and the important variables can be isolated. In this experiment, a matrix of 12 runs of 7 variables was applied according to the matrix provided by Stowe and Mayer (1966), the first row of which included: + + - + + + - - - + - , where + signified the high level of the variable and - the low level. The remainder of the design matrix was generated by shifting the first row one space to the left N-2 times, where N equalled the number of experiments. A row of minus signs i.e. low levels was added to the last row of the matrix. For the Plackett and Burman Experimental Design, dummy runs were included for experimental error investigation.

5.5.8.4 The Statistical Analyses. Statistical analyses used in the process development stage in this project were varied depending on the nature of the individual experiment designed. More than one method was used on the same process/operation experiment for the purpose of a comparison study.

Stepwise Multiple Regression. All the data from factorial experiment were subjected to stepwise multiple regression analysis as an approach to process condition optimisation. By using this technique, the relationship between each dependent variable and the independent variables could be investigated (Gunst and Mason, 1980). The significance of the coefficients for each of the terms in the mathematical equations (e.g. $Y = b_0 + b_1X_1 + b_2X_2 + b_{12}X_1X_2$) designated which of the independent variables had a significant effect on the dependent variables.

Stepwise multiple regressions were conducted using a standard computer program (MINITAB for phase 1, SPSS for phase 2). In this analysis, the independent variables that contributed most to the prediction of a dependent variable were selected first. New variables were added to the regression equation in order of their contribution to the prediction of the dependent variables, providing that they contributed at a 95% level of significance. This level of significance was practised in both adding and removing the variables from the equation. From this analysis, the multiple correlation coefficients (R) obtained were squared, and the percentages of the variance obtained were used to consider whether the next stage of developing the optimization model was appropriate.

Yates' Analysis. The results of all factorial experiments were also subjected to Yates' analysis which could be calculated quickly and simply by hand. This was done in order to compare its effectiveness with that of the stepwise multiple regression analysis which was time consuming, more complex and more expensive. The Yates' analysis procedure for a two-factor experiment followed Box et al.(1978) or Anderson (1981).

The significance of effects were tested by relating their levels to the experimental error which was based on a t-test (Anderson, 1981). The experimental errors were calculated from repeat runs of the same treatment. The standard errors were calculated from the variance of results. Where no replications of runs were conducted, the effect significances were roughly estimated by comparing the effects. Those with effect values around 10 or more times different than the others, were considered to have trends of significance.

Plackett and Burman. The results from the Plackett and Burman experiments were analysed by calculating the effect of each input variable, and also a dummy variable, by subtracting the average result at the low level of that variable from that at the high level. The calculated dummy variables were used to test the significance of the real effects. The dummy variable effect values were pooled, and the pooled estimate of the standard error was obtained by using the following expression: $S.E.(\text{effects}) = \sqrt{\frac{\Sigma(E)^2 d}{n}}$; where E = dummy effects, and n = number of dummy effects. By using this standard error obtained, the real effects were subjected to a t-test to see if they were non-zero through the application of the following expression: t = effect/S.E.(effect). The t values calculated were compared to the table value of which the number of degrees of freedom was equal to the number of dummy effects making up the error term. A 80% level of significance was applied to reduce the risk of overlooking an important factor.

5.5.8.5 The Quality Tests. After each run of the experiment, measurements were objectively and subjectively taken on one or more of the following qualities: Physical quality: weight, specific volume, compression & extrusion force, colour (CIE tristimulus values), in-pan test; Chemical quality: moisture content; Physico-chemical quality: percentage of soluble solids, pH value, water activity value; Sensory quality: sensory property scores by tasting the product (colour, texture, flavour, acceptability), visible sensory property scores by observation during the preparation stage (handling scores, stick-to-mould scores); and Microbiological quality: days taken for visible mould growth by observation. Details of quality test procedure can be found in Chapter 7 under "Product Evaluation and Statistics".

5.5.9 Process Development Experimentation

Systematic experiments for the development of selected unit processes under a nutritionally-balanced snack bar process were conducted. Firstly the problem for each process was defined; then, the objective for the experiment was set (Table 5.22). The experiments were conducted on the three processes as follows: DSC-banana process, BSE-mungbean process, and MP-snack bar operation. The result of each experiment determined the direction for the next experiment.

There were three factorial experiments in the development of the DSC-banana process.

Experiment 1:

Temperature of syrup: 102 C, 104 C, 106 C
Percentage of solids in banana: 17.5%, 20.2%, 23%

Experiment 2:

Percentage of solids in banana: 15.0%, 17.5%
Sugar type: white, raw

Table 5.22: Problem definitions and experimental objectives for process development.

Experiment	Problem Definitions	Experiment Objectives
1	A deep syrup cooked banana would be used as a differentiative ingredient in a new snack product; and processing conditions are required	To study the effects of the initial-temperature of the syrup and the stage of ripeness of the banana for deep-syrup cooking.
2	It was found from the first experiment that 102 C was the better initial temperature for banana cooking than those of 104 and 106 C. The percent soluble solids of banana used at level below 17.5% was expected to improve the quality of the cooked banana, especially those that were considered to be critical for this product. These included the percent banana yield, the water activity and the texture of the cooked banana. The disadvantages in the masking property of the brown sugar was obviously found on the important sensory attributes (colour and flavour) of the cooked banana. Also, the use of brown sugar seemed to cause much more foam residue (self judgment based on experience). Therefore, investigations on the optimal %SS and on the type of sugar suitable for deep-syrup cooking of banana are required.	To study the effects of percent soluble solids of banana in the range below and at 17.5% and of the type of sugar for the deep-syrup cooking of banana.
3	NAMWA banana (GLUOYSUON BANPAW) would be used as an ingredient in the snack product instead of GLUOY HOM, the only variety available in New Zealand, and processing conditions are required.	To study the effects of the percent soluble solids (or stage of ripeness) of NAMWA banana and the boiling time for DSC-banana.
4	The BSE-mungbean would be used as a source of protein in a new nutritionally-balanced snack product. The formulation of the product has been finalised. Now the important process variables are required before the processing conditions for the BSE-mungbean are to be investigated.	To define the important processing variables for boiling and evaporating the mungbean to be used in the nutritionally-balanced snack product.
5	Cooked mungbean with tender fluffy texture with approx. 20% moisture content is going to be used as a source of protein in the nutritionally-balanced snack bars. The previous study showed that two input variables -- batch size and hot-stirring speed -- were justified for further experimental evaluation. Now processing conditions of these two important input variables are required.	To study the effects of the batch size of mungbean and the hot-stirring speed of the the hot-stirring equipment for BSE-mungbean.
6	Pressing force would be applied on the nutritionally-balanced snack product. The formulation of the product and the preparation of each ingredient has been finalised. The preliminary trials on mixing and pressing has been done on KENWOOD and CARVER respectively. Now the optimisation of the operations is required.	To optimise the process conditions at mixing and pressing stages of the process for a nutritionally-balanced snack bar.

Experiment 3:

Percentage of solids in banana: 23%, 26%, 29%
Cooking time: 2, 2.5, 3 h

For development of the MSE mungbean process, a Plackett and Burman experiment was used to screen the process variables of water/mungbean ratio, boiling time, hot stirring time, hot stirring speed, evaporating time, batch size, type of pan. The variables were tested at the levels detailed in Table 5.19. This was Experiment 4 in the process development and was followed by a factorial experiment to optimise the conditions.

Experiment 5:

Batch size: 2, 3 Kg
Hot-stir speed: 38, 66 r.p.m.

With the optimising of the DSC-banana process and the MSE-mungbean process, the MP-snack preparation was studied. A factorial experiment was used.

Experiment 6:

Mixing time: 1, 4, 7 min
Pressing force: 1000, 3000, 5000 lbs/0.5 sq in

5.5.10 Results of Process Development Experimentation

In this section, the results of analysis by the Yates' and by the Plackett and Burman methods are shown and interpreted. Those obtained from the Stepwise Regression Analysis are shown in Section 5.10 under the heading of Comparison of Methods. A summary of the results of process development experimentation is shown in Table 5.23a-f; while the detailed results are in Appendix 5.4a-f.

TABLE 5.23a: SUMMARY OF RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION (PDE SUMMARY RESULTS) ON DSC BANANAS, EXP. 1.

Experiment and Input Variables	Output Variables	Mean Effect	Output Variables	Mean Effect	Output Variables	Mean Effect
Exp. 1						
DSC-Banana	% DSC-banana obtained	33.90	% of B-syrup left	53.400	% Loss through foam	6.500
		-0.30		0.800		2.700(*)
Initial temperature of syrup (102-106°C)		-12.20(*)		15.600(*)		-0.300
		- 0.30		1.000		0.000
% SS of HOM-Banana (17.5-23)	% of SS of DSC-banana/syrup	77.50	Aw of DSC-banana	0.840	Aw of B-syrup	0.798
		0.00		0.033(*)		-0.006
		1.00(*)		0.055(*)		0.024(*)
		0.00		0.012		0.026(*)
	pH of DSC-banana	4.84	pH of B-syrup	4.830	Force for 1st chew	8.900
		0.00		0.000		-0.100
		-0.05		-0.030		0.000
		0.07		0.070		1.100(*)
	Force for 2nd chew	6.40	Ratio-mean: Red	0.700	Ratio-mean: chewy	0.900
		0.50		-0.400(*)		0.000
		1.70(*)		-0.400(*)		-0.400(*)
		1.00		-0.200		0.200
	Ratio-mean: Banana flavour	0.80	y-value: DSC-banana	0.323	x-value: DSC-banana	0.275
		0.10		0.005		0.010
		0.50(*)		0.005		0.020(*)
		0.10		0.005		0.000
	y-value:	0.310	x-value: B-syrup	0.253		
		0.000		0.015		
		0.000		0.025(*)		
		0.000		0.015		

NOTE:

Four figures in 'Mean Effect' column of each output, variable show the effects of run (1), a, b, and ab respectively. For example, for % DSC-banana obtained, mean effect for 'run (1)' = 33.9, 'run a' = -0.3, 'run b' = -12.2(*), and 'run ab' = -0.3 Symbol (*) over 'run b' designates that its mean effect has trend of significance (significantly different by examination not statistics because no replication and no standard error was done for statistical purpose), or in other words % SS of banana used has trend to cause negative effect on % DSC-banana obtained. The higher is the % SS of banana used, the lower is the % DSC-banana obtained. Where no symbol was applied, the effect was not found. In this case, neither initial temperature of syrup not interaction of temperature and % SS has effect on % DSC-banana obtained.

TABLE 5.23b: PDE SUMMARY RESULTS ON DSC-BANANA, EXP. 2.

Experiment and Input Variables	Output Variables	t-ratio	Output Variables	t-ratio	Output Variables	t-ratio
EXP 2						
DSC-Banana	% DSC-banana obtained	14.98	% B-syrup left	6.01	% SS of DSC-banana/syrup	148.81
		-1.66(*)		0.98		1.44(*)
% SS of HOM-Banana (15.0-17.5)		1.71(*)		1.55		0.00
		0.29		0.30		0.96
Sugar type (white-raw)	Aw of DSC-banana	21.75	Aw of B-syrup	41.25	pH of DSC-banana/syrup	19.84
		0.70(*)		0.65		0.08
		-2.03(*)		-0.80		-2.44(*)
		0.08		-0.07		-0.08
	Ratio-mean: Red	5.27	Ratio-mean: chewy	2.45	Ratio-mean Banana-flavour	4.25
		1.33(*)		-0.29		0.31
		1.60(*)		2.29(*)		2.19(*)
		-0.67		-0.25		0.50
	Y-value: DSC-banana	34.00	X-value: DSC-banana	20.95	Y-value: B-syrup	37.40
		0.30		-0.65		1.80(*)
		-1.50(*)		1.90(*)		-0.80
		0.30		-0.65		0.30
	X-value: B-syrup	12.40				
		2.58(*)				
		0.33				
		0.08				

(*) has trend of significantly different.

TABLE 5.23c: PDE SUMMARY RESULTS ON DSC-BANANA, EXP. 3

Experiment and Input Variables	Output Variables	Mean Effect or t-ratio	Output Variables	Mean Effect or t-ratio	Output Variables	Mean Effect or t-ratio
EXP 3;						
DSC-Banana						
Cooking time (2-3 hrs)	Weight of DSC-Banana	331.2 -0.8 5.8** 22.5**	Weight of B-syrup	159.4 -50.0** -66.3** 10.0**	% SS of DSC-Banana at Day 0	107.5 3.0* 17.0** 5.0**
% SS of NAMWA-banana (23-29)	% SS of DSC-Banana at Day 1	102.0 0.0 16.0** 4.0*	% SS of DSC-Banana at Day 5	104.0 16.0** 16.0** 4.0*	% SS of B-syrup at Day 0	160.0 0.0 0.0 0.0
	% SS of B-syrup at Day 1	150.5 9.0** 5.0** 1.0	% SS of B-syrup at Day 5	63.8 0.5 4.5* 1.5	% SS of DSC-banana left in syrup at Day 0	108.0 2.0 18.0** 4.0*
	% SS of DSC-banana left in syrup at Day 1	111.0 9.0** 11.0** 1.0	% SS of DSC-banana left in syrup at Day 5	118.0 22.0** 12.0** 2.0	% SS of B-syrup left in fridge at Day 0	160.0 0.0 0.0 0.0
	% SS of B-syrup left in fridge at Day 1	49.2 3.0* 0.3 1.0	% SS of B-syrup left in fridge at Day 15	70.3 1.5 -0.5 0.5	% SS of DSC-banana left in fridge at Day 15	97.5 15.0** 9.0** 5.0**
	MG-scores of DSC-banana	10.5 9.0** 5.0** 5.0**	MG-scores of DSC-banana left in syrup	14.0 8.0** 3.0* 3.0*	Colour scores of DSC-banana	9.7 2.0 11.7** 4.6**
	Aroma scores of DSC-banana	16.4 14.3** 12.3** 8.8**	Flavour scores of DSC-banana	8.2 5.1** 6.1** 8.9**	Texture scores of DSC-banana	19.4 9.6** -1.2 14.4**
	Accept scores of DSC-banana	16.8 4.0* 13.6** 12.0**				

* statistically significant at 95% level

** statistically significant at 99% level

TABLE 5.23d: PDE SUMMARY RESULTS ON MSE-MUNGBEAN, EXP. 4. (Plackett and Burman Screening Experiment)

Variable		Levels		Loss			Specific Volume			Moisture Content		
Code	Name	Low (-)	High (+)	Effect(-) to (+)	Relative Significance t-test		Effect(-) to(+)	Relative Significance t-test		Effect	Relative Significance	(t-test)
A	Water/Mung ratio	2.3	2.8	1.41	1.01	60%	-0.29	-3.91	97%**	4.59	2.67	94%**
B	Boiling time (min)	20.0	40.0	-3.58	-2.56	94%**	0.07	0.93	60%	-1.70	-0.99	60%
C	Hot-Stirring time (min)	20.0	30.0	1.92	1.37	70%	0.51	6.80	99%**	-2.15	-1.25	70%
D	Hot-Stirring speed (rpm)	38.0(sp.1)	66.0(sp.2)	3.25	2.32	92%**	0.17	2.27	91%**	0.52	0.30	<50%
E	Evaporating time (min)	20.0	30.0	-1.58	-1.13	65%	0.06	0.80	50%	-1.52	-0.88	55%
F	Batch size (kg)	1.0	2.0	4.25	3.04	95%**	-0.78	-10.40	99%**	13.81	8.03	>99%**
G	Type of pan	SS	B_1a SS	1.75	1.25	70%	0.12	1.60	60%	-2.74	-1.59	80%*
H	Dummy			-2.58			0.07			-2.43		
I	Dummy			0.75			-0.05			0.68		
J	Dummy			-0.25			-0.02			-0.46		
K	Dummy			-0.75			-0.12			2.30		

	Handling Score			Texture Score			% Yield		
Code	Effect	Relative Significance	(t-test)	Effect	Relative Significance	(t-test)	Effect	Relative Significance	(t-test)
A	-0.34	-1.17	65%	-0.34	-2.00	88%*	-0.09	-0.05	<50%
B	0.34	1.17	65%	1.00	5.88	99%**	-0.18	-0.10	<50%
C	0.34	1.17	65%	0.00	0.00		-6.27	-3.65	97%**
D	0.00	0.00		0.34	2.00	88%*	0.41	0.24	<50%
E	-0.34	-1.17	65%	-0.66	-3.88	98%**	-2.85	-1.66	80%*
F	-1.34	-4.62	99%*	0.66	3.88	98%**	13.71	7.97	99%**
G	0.34	1.17	65%	0.34	2.00	88%*	-5.81	3.38	97%**
H	0.00			0.00			0.08		
I	-0.34			0.00			2.57		
J	-0.34			0.00			1.39		
K	-0.34			-0.34			1.81		

TABLE 5.23e: PDE SUMMARY RESULTS ON MUNGBEAN, EXP. 5

Experiment and Input Variables	Output Variables	t-ratio	Output Variables	t-ratio	Output Variables	t-ratio
EXP 5 :						
BSE-Mungbean	Hot-stir time	6.84	% Yield	13.54	% Loss	8.83
	(scores)	5.00**		-0.96		3.38*
Batch size		1.68		-0.36		4.57*
(2-3 kg)		2.08		-1.50		1.79
Hot-stir speed	Specific volume	23.75	% Moisture	14.43	Evaporate	3.59
(38-66 rpm)		-1.75	Content	1.75	time	2.72(*)
		-0.25		0.79		0.00
		-0.25		-1.06		-0.11
	Evaporate scores	25.00	Texture	40.33	Colour scores	67.00
		-12.00**	scores	-25.33**		-38.00**
		0.00		2.67(*)		8.00**
		2.00		8.67**		16.00**

* statistically different at 95% level

** statistically different at 99% level

(*) has trend of significance

TABLE 5.23f : PDE SUMMARY RESULTS ON MP-SNACK, EXP. 6

Experiment and Input Variables	Output Variables	Mean Effect	Output Variables	Mean Effect	Output Variables	Mean Effect
EXP 6:						
MP-Snack	Colour scores	-5.45	Cohesive scores	5.30	Grit scores	4.85
		1.50(*)		0.40(*)		-0.10
Mix-time		-0.50		0.00		-0.10
(1-7 min)		0.50		0.20		0.10
Press force $(1.4 - 7.0 \times 10^6 \; kg/m^2)$	Sweet scores	3.08	Handling scores	7.75	Sticken-to-mould	9.00
		-0.45(*)		2.50*)	scores	1.00*
		-0.85(*)		-0.50		0.00
		-0.05		-1.50		-1.00*
	% SS before	80.80	% SS after press	81.30		
	press	0.50		1.50(*)		
		0.00		0.00		
		0.00		0.00		

* Statistically different at 95% level

** statistically different at 99% level

(*) has trend of significance

5.6 EFFECTS OF INPUT VARIABLES ON DSC-BANANA

5.6.1 Introduction

In general, the desirable deep-syrup cooked banana (NAMWA variety) was known to the Thais to be red in color, firm and chewy in texture, and banana-sweet in flavour. From self past experience in experimental cookery work, these characteristics of DSC-banana depend on many variables, for example, its texture depends on the banana variety, maturity or ripeness, postharvest storage, syrup formula or in other words the initial temperature of the syrup for the banana cooking, cooking time, final temperature of the syrup for the banana cooking, proportion of syrup to banana, the circulation of the syrup while cooking, and the application of lime or calcium chloride before cooking.

The influences that certain factors had on the cooked banana were experimentally investigated and evaluated, subjectively and objectively. Not only the characteristics of the product were determined but also the relationship between each of these processing variables and the final product characteristics. Knowing these relationships, the establishment of control limits on each processing variable as well as methods of compensating for a variable which must be allowed to exceed limits, would be possible. The significant effects from the three experiments are shown in Table 5.24a,b,c.

5.6.2 Effects of Initial Temperature of Syrup for Cooking

From self past experience, suitable initial temperatures of the syrup for cooking banana depend on the variety and ripeness of the banana. From the present study, when the initial temperature of the syrup ranged from 102 to 106 C for deep-syrup cooking of banana of the HOM variety, the higher temperature resulted in not only more loss through foam residue but also in a greater quantity of syrup being left which, in turn, lowered the DSC-banana yield (Table 5.23a). The water activity value of DSC-banana, which was related to its keepability, was found to depend partly on the initial temperature of the syrup. The higher initial temperature resulted in an undesirable higher water activity of DSC-banana (Appendix 5.4a).

TABLE 5.24a: SUMMARY OF SIGNIFICANT EFFECTS FOR DSC-HOM BANANA FROM EXP. 1

Output Variables	Significant Effects		
	IT	SS	INT
EXP 1: DSC-HOM BANANA			
1. % DSC-banana obtained		(*)	
2. % B-syrup left		(*)	
3. % Loss through foam	(*)		
4. % SS of DSC-banana/syrup		(*)	
5. Aw of DSC-banana	(*)	(*)	
6. Aw of B-syrup		(*)	(*)
7. pH of DSC-banana	-		
8. pH of B-syrup	-		
9. Force for 1st chew			(*)
10. Force for 2nd chew	-	(*)	
11. Ratio-mean: Red	(*)	(*)	
12. Ratio-mean: Chewy		(*)	
13. Ratio-mean: Banana flavour		(*)	
14. Y-value: DSC-banana	-		
15. X-value: DSC-banana		(*)	
16. Y-value: B-syrup	-		
17. X-value: B-syrup		(*)	

IT = Initial temperature of syrup

SS = % SS of banana

INT = Interaction

(*) = has trend of singificantly difference

TABLE 5.24b: SUMMARY OF SIGNIFICANT EFFECTS FOR DSC-HOM BANANA FROM EXP 2

Output Variables	Significant Effects		
	SS	ST	INT
EXP 2: DSC-HOM BANANA			
1. % DSC-banana obtained	-		
2. % B-syrup left	-		
3. % SS of DSC-banana/syrup	(*)		
4. Aw of DSC-banana	(*)	(*)	
5. Aw of B-syrup	-		
6. pH of DSC-banana syrup		(*)	
7. Ratio-mean: Red	(*)	(*)	
8. Ratio-mean: Chewy		(*)	
9. Ratio-mean: Banana flavour		(*)	
10. Y-value: DSC-banana		(*)	
11. X-value: DSC-banana		(*)	
12. Y-value: B-syrup	(*)		
13. X-value: B-syrup	(*)		

SS = % SS of banana

ST = sugar type

INT = Interaction

(*) = has trend of significantly different

TABLE 5.24c: SUMMARY OF SIGNIFICANT EFFECTS OF DSC-NAHWA BANANA FROM EXP 3

Output Variables	Significant Effects		
	BT	SS	INT
EXP 3: DSC-NAM WA BANANA			
1. Weight of DSC-banana		**	**
2. Weight of B-syrup	**	**	**
3. % SS of DSC-banana: Day 0	*	**	**
4. % SS of DSC-banana: Day 1		**	*
5. % SS of DSC-banana: Day 5	**	**	*
6. % SS of B-syrup: Day 0			
7. Day 1	**	**	
8. Day 5		**	
9. % SS of DSC-banana left in syrup: Day 0		**	*
10. Day 1	**	**	
11. Day 5	**	**	
12. % SS of B-syrup left in fridge: Day 0			
13. Day 1	*		
14. Day 15			
15. % SS of DSC-banana left in fridge: day 15	**	**	**
16. MG-scores of DSC-banana	**	**	**
17. MG-scores of DSC-banana left in syrup	**	*	*
18. Colour scores of DSC-banana		**	**
19. Aroma scores of DSC-banana	**	**	**
20. Flavour scores of DSC-banana	**	**	**
21. Texture scores of DSC-banana	**		**
22. Acceptability scores of DSC-banana	*	**	**

BT = Boiling time; SS = % SS of banana; INT = Interactions

* = statistically different at 95% level

** = statistically different at 99% level

Although the use of the higher initial temperature for cooking had a beneficial effect in accelerating the development of the characteristic flavour of DSC-banana, it resulted in a shorter cooking time which might, in turn, cause detrimental effects e.g. a decrease in the intensity of the red colour and in the chewiness of DSC-banana. The initial temperature was found to have no effect on the banana syrup or the force needed for the first and second chews of the cooked banana.

5.6.3 Effects of Ripeness of Banana Used

The ripeness of the banana was scientifically identified by using its percent soluble solids (%SS). In this study, for the HOM variety of banana (Philippine banana), it was found that in the range of 17.5-23

%SS of banana used, the lower %SS (greener banana) resulted in a higher DSC-banana yield which, in turn, lowered the amount of banana-syrup left (Table 5.23a, Appendix 5.4a). However, when banana with 15% SS was used (Appendix 5.4b), the DSC-banana obtained was low in quality because the cooking syrup could not penetrate well into the green banana which was high in density.

The higher %SS of banana used had a beneficial effect on DSC-banana because of the high %SS it produced in the product (Appendix 5.4a). In this experiment, and also another experiment using banana with 15-17.5 %SS, the lower the %SS the lower the water activity. This was unexpected and may have been caused by the short cooking time in these experiments. The high %SS of banana used also had a beneficial effect on the red colour of the DSC-banana as identified in both the red ratio mean (subjective measurement) and the 'x' chromaticity coordinate value (objective measurement which was roughly equivalent to hue and intensity of the colour subjectively measured).

Chewiness of the cooked banana was lowered if the banana used was higher in %SS (Appendix 5.4a). This detrimental effect could be reduced by using a higher initial temperature for cooking. This result disagreed with that of the force for the first chew. The banana-sweet flavour of the DSC-banana was found to depend on the %SS of the banana used. The higher %SS was found to be the better. The %SS of banana used was found to have no effects on the pH of the product.

When an experiment was designed including sugar types as input variables in addition to %SS of banana used, no statistically significant effect on DSC-banana characteristics was found. The low final temperature of the cooking syrup which caused improperly cooked DSC-banana might cause an error in this finding. For this reason, trends of significance were roughly estimated. Those with a t-ratio around 10 times or more greater than the others, were considered to have trends of significance (Table 5.23b). This was for the benefit of the designing of further experiments.

Although the high %SS of banana used tended to have the detrimental effect of raising the Aw value of the product (Table 5.23b, Appendix 5.4b), the short cooking time was responsible for this effect. By using bananas of a higher %SS, the ratio mean of the red colour was closer to the ideal; and the value and hue (as identified by 'y' and 'x' chromaticity coordinate values) of the syrup was increased.

For the NAMWA variety of banana, the pre-experimental trials suggested that of the three different varieties of bananas, namely, GLUOY SUON NONTHABURI (GS-N), GLUOY SUON BANPAO (GS-BP), and GLUOY RAI (GR), GS-BP was considered the most suitable to be used in the product to be developed because it was lighter in colour, had a banana-sweet flavour and was less sour and less astringent, was chewy but tender enough to be mixed, and it was cheaper than any other type of bananas bought from the Marketing Organization for Farmers (MOF) in Bangkok. (GS-N) was the next most suitable. The pre-experimental trial also suggested that with a longer cooking time, the DSC-banana could be kept free from mould growth longer; and if riper bananas (designated by the measurement of its %SS) were used, the banana tissues were easier for the syrup to penetrate, so that the DSC-bananas were well-saturated with syrup after cooking.

When (GS-BP) variety was studied in a factorial experiment in which the %SS of banana ranged from 23-29, and the cooking time from 2-3 hours, it was found that %SS of banana used (or ripeness of banana) had significant effects on almost all the response variables studied. The main exception was for the texture score for the DSC-banana. The use of NAMWA-banana of a higher %SS gave a lower weight of DSC-banana obtained ([illegible] Appendix 5.4c). This result coincided with that obtained when the HOM variety was used (Appendix 5.4a,b).

Under constant cooking time, the %SS of DSC-banana -- freshly cooked or after storage -- was directly related to the ripeness of the banana used. Thus, DSC-banana with high %SS was desirable. For sensory properties, the riper banana was found to give the cooked banana that was more "DSC-banana sweet" in flavour and aroma, though more tender in texture, instead of "tender chewy". This was beneficial to the finished bar-product because of its specific flavour characteristic and its easiness to be manipulated during mixing stage.

An examination into the interaction between %SS of banana used and its cooking time suggested that the final product characteristics did partly depend directly on this interaction. Those directly affected characteristics included: the weights of DSC-banana and banana-syrup obtained, MGS-scores of DSC-banana, and all sensory scores studied -- colour, texture, flavour, and acceptability.

5.6.4 Effects of Sugar-Type

From experiments on other cooking variables of the DSC-banana process, the disadvantages of raw sugar in masking the colour and flavour of DSC-banana was observed. When the sugar type -- white and raw -- was subjected to a factorial experiment with the %SS of banana used at 15-17.5%, the initial temperature of the syrup controlled at 102 C and the final temperature at 106 C, the sugar type had no statistically significant influence on the DSC-banana obtained. Therefore, a low final temperature (or short cooking time) was responsible for the results in the initial experiments. An investigation on the trends of significance suggested that the sugar type had effects on Aw and pH values of DSC-banana, sensory properties of the product (red, chewy, and DSC-banana flavour), and on the value and hue ('y' and 'x' chromaticity coordinate values) of DSC-banana.

The use of raw sugar resulted in lower Aw and pH values of the DSC-banana (Table 5.23b, Appendix 5.4b) which was considered beneficial to the keepability of the product. However, this resulted in a darker red colour which was identified by the higher ratio mean of red, lower 'y-value' of DSC-banana and higher 'x-value' of DSC-banana (Appendix 5.4b). Although the ratio mean of chewiness and banana flavour of DSC-banana seemed to be increased by the use of raw sugar (Appendix 5.4b), its chewiness was an undesirable hard-chewy type.

5.6.5 Effects of Cooking Time

From past experience, a short cooking time tended to give a less intense red colour for the DSC-NAMWA banana. When GS-BP, NAMWA banana, was subjected to a factorial experiment with a cooking time of 2-3 hours using bananas of 23-29 %SS and controlling the initial temperature of the cooking-syrup at 102 C and the final temperature at 112 C, it was found that while the cooking time itself had certain effects on DSC-banana characteristics, it also interacted with %SS of banana used and gave results in both a positive and a negative way to the main effects.

Although the longer cooking time decreased the weight of the DSC-banana yield and the banana syrup left, the %SS of the product obtained, freshly prepared or after storage, whether in a refrigerator or at room temperature and under or without syrup, depended strongly and directly on the length of cooking. %SS of banana used had a direct interaction effect on this property.

The most important finding from this experiment seemed to be the mould growth susceptibility of the product. DSC-banana which had been cooked longer could be kept for a longer period of time. The interaction of this effect with that of the %SS of banana used could have a positive result for increased shelf life.

Though the effects of the cooking time on the sensory qualities of DSC-banana were negative for almost all attributes studied (Table 5.23c, Appendix 5.4c), its interaction with the high %SS of banana used was strongly positive. The long cooking time by itself resulted in too intense a red colour, too sweet a flavour, and finally lower scores of its acceptability. This effect of the cooking time on DSC-banana characteristics was more strongly positive when riper bananas were used. The product was found to be more tender-chewy for these interacting effects as well.

The results of the experimental trial on ripe bananas (27-29%SS) cooked for different periods of time, 1-2 hours longer than the 3 hour optimum of the previous experiment, proved that the longer the cooking time the longer the shelf life of the product.

5.6.6 Summary and Conclusion

5.6.6.1 Summary and Conclusion Based on Experimental Designs. For optimum quality of DSC-HOM banana, 102 C was suggested for the initial temperature because it gave a higher DSC-banana yield, a smaller amount of syrup remaining, less foam residue, and a lower water activity value in the DSC-banana than did the higher temperature. The use of this initial temperature has an advantage in reducing the detrimental effect of the riper banana on the chewiness of DSC-banana. An initial temperature for the banana cooking below 102 C seemed to be possible; however, this was not suggested since it would result in a longer cooking time and therefore, the use of more fuel, and possibly, the break down of the banana tissue.

For the HOM variety, the riper banana that had a greenish yellow peel and more than 17.5 %SS in the pulp gave a DSC-banana with a high %SS, a high intensity of red colour, and a more desirable "DSC-banana sweet" flavour. However, to obtain an optimum banana yield, a lower quantity of syrup left, and higher chewy scores, the final temperature, or in other words, the cooking time needed to be optimised. The use of white sugar was considered suitable because it gave a DSC-banana with desirable sensory properties -- 'bright red' in colour, 'tender-chewy' in texture, and 'DSC-banana sweet' in flavour.

For the NAMWA variety, to gain the optimum quality of DSC-NAMWA banana, for the mix to be pressed into a snack product, a longer cooking time and a higher %SS of banana (riper banana) was needed for a DSC-banana of a higher %SS and with a longer shelf life free from mould growth. The final suitable %SS of DSC-banana was considered to be 85%, which after storage would reduce to 78-80%. The final %SS of 85% could be obtained by using very ripe NAMWA bananas (29% SS) and cooking them for as long as five hours, if they were prepared in approximately a five kilogram batch (banana weight) over medium heat.

5.6.6.2 Summary and Conclusion Based on Experimental Procedures. In the preparation of DSC-NAMWA banana to be further used in the mixing for snack-bars, a simple but effective method for anti-browning purposes was to keep the peeled bananas under plain water. It was considered that no treatment was necessary for firming purposes. Controlling the bubbling of the syrup (through the control of the heat supplied) while cooking was taking place, was suggested as a simple technique for keeping the cooking banana under the cooking syrup.

For a longer shelf life of DSC-banana, the suggestion was that the cooked banana be kept under the banana-syrup left after the process. In this way, a greater penetration of the syrup into the banana cells or tissues would further increase the %SS of the DSC-banana. Crytallization of the sugar from the syrup could, however, lower its %SS. This could be avoided by protecting the syrup from disturbance. Sliced banana was not suggested for DSC-banana for snack bars because it was sensitive to crystallization and it was difficult to separate from the syrup.

5.7 EFFECTS OF INPUT VARIABLES ON BSE-MUNGBEAN

5.7.1 Introduction

The effects of selected input variables on BSE-mungbean were investigated in 2 phases. In the first phase in New Zealand, because of the unavailability of suitable hot-stirring equipment for a paste type product, split peeled mungbean was subjected to only experimental trials by using an available stirring machine normally used for liquid products. However, its findings were worthwhile of being combined and discussed in association with those of phase 2 which were obtained from planned experimentation.

The experimental trial on the hot-stirring of mungbean suggested that during hot-stirring, the cooking mungbean would progressively change from a dispersed state to a paste, to a dough, and finally to a fluffy moist powder (Table 5.25). Crumbly characteristics of the hot-stirred mungbean and its moisture content was used as a guide for the BSE-mungbean to be used for the final product. A summary of the significant effects in the Plackett and Burman Experiment 4 are shown in Table 5.26a and in the factorial experiment 5 in Table 5.26b.

5.7.2 Effects of Soaking Temperature and Time

A preliminary experiment on the cooking of mungbean suggested that no soaking was necessary for mungbean to be hot-stirred. It was easy to thoroughly cook mungbean. Soaking might lead to microbiological problems. A previous experimental trial suggested that an almost equal time would be taken for the cooking of soaked or unsoaked mungbean.

Table 5.25: Stages for hot-stirring of mungbean.

Hot-Stirring Stages of Mungbean	Cooking Time approx. min	In-Pan Characteristics	Moisture approx. %
Mung* Boiled	10	Mung vigorously boiled and impregnated with water.	n.m.
Mung-At-Side Pulled	40	Mung in a fine thick batter form and parts of mung-at-side starts being pulled.	n.m.
Mung-At-Bottom Pulled	50	Mung in a coarse thick batter form and parts of mung-at-bottom starts being pulled.	n.m.
All Mung Pulled	60	All parts of mung pulled. Mung in a wet coarse dough form. Wet smooth dough can be formed.	33.6
Moist Mung Dough	70	Coarse dough still moist. Moist smooth dough can be formed.	31.3
Dry Mung Dough	80	Coarse dough rather dry. Dry smooth dough can be formed.	26.3
Very Dry Mung Dough	90	Coarse dough very dry. Dry crumbly dough can be formed.	22.0
Crumbly Mung	>100	Dry crumbs.	15.0

*Mung = Mungbean
Mung-At-Side = Mungbean at the side of the pan.
Mung-At-Bottom = Mungbean at the bottom of the pan.
n.m. = not measured

5.7.3 Effects of Water/Mungbean Ratio

A pre-experimental trial suggested that water/mungbean ratio of above 2 seemed to be justifiable because it would provide enough water for impregnation of the seeds. When this variable was subjected to a Plackett and Burman experiment with a water/mungbean ratio of 2.3 as a low level and 2.8 as a high level, it was found that, in a controlled condition, the water/mungbean ratio had effects on the specific volume, moisture content, and texture score of the BSE-mungbean (Table 5.26a). The high level of water to mungbean gave a product that was high in moisture content, and in turn, high in specific volume, but low in texture score because of its sogginess.

A low level of water had a negative effect on the texture of the product because of the incomplete water-impregnation of the mungbean seeds, while a high level took more time for the extra water to be evaporated before the hot-stirring stage started. Thus, the ratio of 2.5 was considered suitable. When this ratio was applied in the factorial experiment, the BSE-mungbean obtained was desirable because the water quantity was just right for the water-impregnation of the

TABLE 5.26a: SUMMARY OF SIGNIFICANT EFFECTS OF A BSE-MUNGBEAN FROM EXP 4 (Plackett and Burman Experiment)

Output Variables		Significant Effects						
EXP 4: BSE-MUNGBEAN (Plackett and Burman)								
		W/M	BT	HST	HSS	ET	BS	PT
1.	% Yield			**		*	**	**
2.	% Loss		**		**		**	
3.	Specific Volume	**		**	**		**	*
4.	Moisture content	**					**	*
5.	Handling Scores						**	
6.	Texture scores	*	**		*	**	**	*

W/M = Water/mungbean ratio
BT = Boil time.
HST = Hot-stir time
HSS = Hot stir speed
ET = Evaporate time
BS = Batch size
PT = Pan type
* = Statistically significant at 80% level
** = Statistically significant at 90% level

TABLE 5.26b: SUMMARY OF SIGNIFICANT EFFECTS FOR BSE-MUNGBEAN FROM EXP 5

Output Variables		Significant Effects		
		BS	HSS	INT
EXP 5: BSE-MUNGBEAN (Factorial Experiment)				
1.	Hot-stir time	**		
2.	% Yield			
3.	% Loss	*	*	
4.	Specific volume			
5.	% Moisture content			
6.	Evaporate time	(*)		
7.	Evaporate scores	**		
8.	Texture scores	**	(*)	**
9.	Colour scores	**	**	**

BS = Batch size; HSS = Hot stir speed; INT = Interaction
* = Statistically significant at 95% level
** = Statistically significant at 99% level

mungbean seeds which was beneficial to the hot-stirring and evaporating process.

5.7.4 Effects of Boiling Temperature and Time

Because the gas-type stove used in the experimentation stage had no temperature control, it was difficult to control the temperature during the boiling of the mungbean. Therefore, the boiling appearance was used as the identifier for a good cooking temperature. However, the pre-experimental trial on mungbean suggested that too high a temperature would cause over-high foam bubbles which, in turn, would cause a loss through over foaming out of the pan.

The boiling time is related to the boiling away of the water. There should be just enough water left to prevent burnt scorching before the hot-stirring stage is started. Too much water left would lead to a soggy mushy mixture which would not evaporate well. In the case of the Plackett and Burman experiment, the heat was controlled by the accelerator of the gas flow at the head of the gas cylinder, by the outward/inward flame sets, by the valves for the gas flow which were wound to the 45 degree position and also by visual observation of the gas flame. The boiling time was found to have effects on the %loss and texture score (Table 5.26a). A long boiling time caused a great loss of water, and in turn, great scorching before the hot-stirring stage could be started (Appendix 5.4d). This burnt part acted as a nuclei for further burning and moreover it would break down during the hot-stirring stage and cause grittiness to the texture of the final product. Self-observation also suggested that this burnt part had a detrimental effect on the aroma and flavour of the final product.

5.7.5 Effects of Hot-Stirring Temperature and Time

For the same reason as in Section 5.7.4, the hot-stirring temperature was controlled by an accelerator for the gas flow, by the outward/inward flame sets, and by the valves for the gas flow, and by visual observation of gas flame. However, the pre-experimental trial suggested that medium heat was suitable for the hot-stirring of mungbean. Too high a heat caused burnt parts during hot-stirring, while too low a heat took a much longer time to evaporate the undesired water.

Also, the trial suggested that the hot-stirring time was important because it was directly related to the moisture content and other characteristics of the intermediate-product. It seemed that the hot-stirred mungbean would have desirable characteristics for a further evaporating step, if the final weight was two times the original weight of mungbean used.

The Plackett and Burman experiment proved that hot-stirring time could influence the %yield and specific volume of the final product. Unfortunately, in this case, the high %yield obtained, or in other words, the high weight of BSE-mungbean obtained was considered undesirable because of its high moisture content which, in turn, caused an undesirable low specific volume, or in other words, caused an undesirably soggy product.

5.7.6 Effects of Hot-Stirring Speed and Revolution-Type

The pre-experimental trial suggested that the hot-stirring speed was related to both cooking time and durability of the equipment. The hot-stirring speed was 38 rpm for speed 1 and 66 rpm for speed 2. When the hot-stir equipment was loaded with mungbean, the speeds remained the same except when the mungbean mixture was so thick it formed a dough.

When this variable was subjected in the Plackett and Burman experiment, the hot-stir speed was found to have effects on %loss, specific volume, and texture score (Table 5.26a). With too high a speed, the mungbean mixture was soggily mushy even at the top part, and it was difficult for evaporation to take place. In turn, water from the bottom part could not evaporate. This resulted in both a loss through sticking-to-pan, and also the necessity for a longer hot-stirring time (Appendix 5.4d).

When investigating the optimum hot-stirring speed for this hot-stir equipment in the BSE-mungbean process, this input variable (i.e. speed) was subjected to a factorial experiment together with the batch size. There was a trend that at a higher speed, the hot-stirring time would be longer, and the %loss would be increased (Table 5.26b). The reason for the higher loss was because the mungbean burst easily at a high speed. This resulted in a mushy texture and, in turn, the scorching of the bottom of the pan. The stirrer blades could not scrape it off the pan and it was not cohesive enough to be pulled by its cohesiveness. The high speed of the scraping blades resulted in removing the mungbean paste from the heat and thus it was hard for the water to evaporate.

An experimental trial proved that not only the hot-stirring speed is important, but that the starting point for hot-stirring had an effect on the stick-to-pan character. If the stirring of mungbean mixture was started during the boiling stage (Table 5.25), chain disadvantages might occur as follows: the bursting of seeds caused mushiness; this, in turn, caused sticking to the pan; and, in turn, coagulation of the protein part together with the burnt gel of the starch part; and, finally, in turn, this blocked the heat transfer to the mungbean in the pan. The soggy mushiness and the burning of the mungbean mixture would result in an undesirably low specific volume and a low texture score of the BSE-mungbean.

For the revolving type of stirrer, from past experience in experimental cookery work on hot-stirred products, the application of both clockwise and anticlockwise revolution alternatively would result in longer periods of hot-stirring times. Therefore, it was suggested that only clockwise revolutions should be used which was similar to other Thai hot-stirred products.

5.7.7 Effects of Gap between Stirrer and Bottom of Pan

For the gap between the stirrer and the bottom of the pan, the pre-experimental trial suggested that the stirrer blades should be lowered to such a position that the blades could sweep off the mungbean from the bottom of the pan. One wheel turn-up was also suggested after the stirrer was at the lowest position in order that the blades would not scrape out the pan itself.

5.7.8 Effects of Evaporating Temperature and Time

In the same manner as that for the boiling and hot-stirring temperature, the evaporating temperature was controlled and an experimental trial was carried out. Lower medium heat was suggested for use at the beginning of the evaporating stage to accelerate the evaporating rate; then a low heat would be applied to prevent the gritty texture caused by the over evaporation of certain parts.

The time for evaporation was directly related to the characteristics of the final mungbean product. When this variable was subjected to a Plackett and Burman experiment, it was found to have significant effects on the %yield and texture score (Table 5.26a). For a 2-3 Kg batch (raw mungbean weight), thirty minutes of evaporating time would give an optimum yield and texture score. Too short an evaporating time, resulted in a higher yield, but the texture of BSE-mungbean was mushy caused by the high moisture content, while too long a time would result in too dry a BSE-mungbean with a lower weight and a gritty texture because of the over-loss of the moisture content (Appendix 5.4d).

5.7.9 Effects of Batch-Size

In general, a larger batch size needs a longer cooking time. The Plackett and Burman experiment proved that an appropriate batch size was needed for an optimum result. A larger batch-size was found to increase the %loss because of a greater sticking-to-pan, to increase the specific volume and moisture content because of the greater difficulty in evaporation, to increase the difficulty of handling because of the larger size of the input, and to cause the BSE-mungbean to be more soggy because of the higher water retention (Table 5.26a).

For operating-time saving and for a suitable loading of the equipment, the batch size was subjected as one variable in a factorial experiment with the hot-stirring speed. The result proved that the batch size had direct effects on the hot-stirring time, the evaporating time and the %loss; and it had strong negative effects on the evaporation score, the texture score, and the colour score (Table 5.26b). A larger batch-size needed a longer time for hot-stirring and evaporating in the same ratio of the difference in size. This longer cooking time resulted in a greater sticking-to-pan, and in turn, to a higher loss (Appendix 5.4e)

A larger batch-size was hard to evaporate manually and the cooked mungbean was agglutinated into lumps. Also, with a large batch-size the mungbean could not be properly manually separated and it was not evenly powdered. This would cause moisture problems when it was being mixed with syrup, and would be susceptible to mould growth. The long cooking time for large batch-size resulted in a darker yellow colour of the BSE-mungbean. Although the use of the high speed was found to help decrease the dark color intensity, this was not suggested because of higher loss as previously mentioned.

5.7.10 Effects of Pan-Type

The Plackett and Burman experiment suggested that there was no difference in loss between the use of stainless steel or brass pans, although the bottom-curvedness was slightly different and it was thought that this would affect the scraping motion of the equipment. However, the copper in the brass was considered to affect the colour of BSE-mungbean obtained which was greenish-yellow in a brass pan.

Thus, it was suggested that a stainless steel pan should be used.

5.7.11 Summary and Conclusion

The Plackett and Burman screening experiment indicated that seven original process variables: water/mungbean ratio, boiling time, hot-stirring time, hot-stirring speed, evaporating time, batch-size, and pan-type, had some effects on one or more of the response variables: %yield, %loss, specific volume, moisture content, handling score, and texture score. Two input variables, batch-size and hot-stirring speed, were screened and subjected to factorial experiment for optimization of the BSE-mungbean process conditions.

The latter experiment indicated that there was no real advantage in using high speeds to improve the texture quality (not gritty) of the BSE-mungbean because the mushy texture of the mungbean during the hot-stirring process led to a greater loss of mungbean through scorching. Also, it tended to lengthen the hot-stirring time. However, a high hot-stirring speed reduced the dark (dull) colour of mungbean in a larger batch which was cooked for a longer time during the hot-stirring and evaporating stages. Scraping of the mixture during the process was better at a low speed.

A larger batch-size resulted in a longer stirring and evaporating time. The rate of increase for both seemed to be parallel, that was when the batch-size was increased from 2 to 4 Kg, the stirring and evaporating time was increased from 1 to 2 hours. Thus, the larger batch did not save stirring and evaporating time at all, although it did save boiling time (40 min could be used for both cases). Moreover, the larger batch had significant detrimental effects on the %loss (more loss through scorching), on the evaporation score (difficult to manually stir), on the texture score (more grainy), and on the colour score (dark and dull yellow colour). In fact, it also had a detrimental effect on the aroma of the obtained mungbean (burnt grassy aroma caused by longer evaporating time of larger batch-size of mungbean).

It was therefore recommended that for the preparation of mungbean for the snack bars (moisture content 20 $\pm$ 2%), freshly harvested (1 month skinned split mungbean) could be prepared by the Boil-Hot Stir-Evaporate Process using hot-stirring equipment. A low speed (speed 1; 38 rpm) should be used and batch-size of 2 - 2.5 Kg is suggested.

Using the conditions suggested above, 1 hour hot-stirring time and evaporating time was predicted. %loss could be approximately 1.5%, manual stirring of the hot-stirred mungbean would not be too difficult and the mungbean thus obtained would be bright yellow and rather fluffy in texture with no hard grits.

5.8 EFFECTS OF INPUT VARIABLES ON MP-SNACK

5.8.1 Introduction

Previous trials on the preparation of the bars during the formula and process development suggested that methods for mixing, pressing, and cutting (or moulding) might have some effects on product characteristics especially those that could be measured by the sensory method. Thus, those methods for product preparation were considered to be some of the important steps worthy of a thorough investigation.

For this product, ingredients should be not only mixed in a good proportion, but also in such a way that the syrup should penetrate into the prepared mungbean which was the most susceptible to microbiological growth. Since no oil would be added into this high syrup product, a small amount of extracted oil from its own nut ingredients during the process seemed to be justifiable for anti-sticking purpose. The equipment to be used for the above purpose should exist at cottage snack factories where experiments would be held or at least it should be possible to procure it. Therefore, warm syrup was expected to be added into the freshly evaporated mungbean and the mixture should immediately be mixed well in a simple mixer and then the DSC-banana should be added and mixed well before the addition of the other roasted ingredients.

In optimising the conditions for mixing and pressing the snack bar, a nutritionally-balanced mixture with moisture content of approximately 10% or approximately 83% soluble solids was used. Although it was planned to develop a presser and cutter for this purpose, it could not be developed in time for the experiment which had to be done before the fixed date for the next experiment. Thus, a CARVER Hydraulic Machine (CARVER LABORATORY PRESS MODEL-C 12 TON CAPACITY, A Subsidiary of 'Sterlco' Sterling Inc., Milwaukee, Wisconsin) was used, and the result obtained was later related to that from the presser & cutter developed, which was used in the production test. For mixing of the ingredients at this step, a KENWOOD (MAJOR MODEL; Kenwood Manufacturing Company Ltd., Havant, Hants PO92NH, England) was used. A summary of the significant effects in the factorial experiment 6 are shown in Table 5.26c.

TABLE 5.26c: SUMMARY OF SIGNIFICANT EFFECTS FOR MP-SNACK FROM EXP 6

Output Variables	Significant Effects		
	MT	PF	INT
EXP 6: MP-SNACK (Factorial Experiment)			
1. Colour scores	(*)		
2. Cohesive scores	(*)		(*)
3. Grit scores			
4. Sweet scores	(*)	(*)	
5. Handling scores	(*)		(*)
6. Sticking-to-mould scores	(*)		(*)
7. % SS before press			
8. % SS after press	(*)		

MT = mixing time
PF = pressing force
INT = Interaction
(*) = has trend of significance

5.8.2 Effects of Mixing Time

The pre-experimental trial on the mixing of the ingredients suggested that the ingredients could be initially mixed at speed 1 for 30 seconds and then speed 3 for a period of time according to the experiment. The lower limit could be set at 1 min and the upper limit at 7 min. The mixtures obtained were expected to range from 'soggy, sticking to the bowl and hand' for the lower limit, and 'not sticking to the hand or bowl, not too crumbly, not too many broken nuts, and drier after leaving overnight' for the upper limit.

When the mixing time (1-7 min) was subjected to the factorial experiment together with pressing force (1.41×10^6 - 7.03×10^6 Kg/m^2), it was found that the mixing time had direct effects on the intensity of the colour, cohesiveness of the texture, % soluble solids of the pressed product, and on the handling scores of the mixture, while it had an adverse effect on the product sharp sweet flavour (Table 5.26c). When this variable interacted with the pressing force, the influences on those response variables were affected.

The longer mixing time intensified the colour and the mellowness (less sharp sweet) of the bar. This effect was stronger if the pressing force was increased. It was thought that moisture content loss during the longer mixing was responsible for this colour intensity. The higher % SS of the product (which means a lower moisture content) with a longer mixing time supported this statement. Also, this drying effect could be felt (designated by easier handling) during the handling of the dough mixture before pressing.

With a longer mixing time, because of its breaking-effects on the nut ingredients, the oil was extracted. The nutty flavour from this extracted oil, when well-mixed with the sweetness of the DSC-banana and the banana-syrup, reduced the sharp-sweetness of the product (Appendix 5.4f). The reduction of the moisture content during mixing was thought also to be responsible for the reduction of the product sweetness, since the human tongue is more sensitive to sweet ingredients in solution form.

The longer mixing time would also reduce the stickiness characteristic of the ingredient mixture. The longer the mixing time, the easier was the handling of the product during the pressing stage and also the smaller the incidence of sticking-to-mould of the product. Thus, it was easy to mould. However, its optimum desirable effect was preventing the loss of the extracted oil during the later pressing operation.

Although the mixing time by itself had no effect on the texture of the product, the long mixing time interacted with the high pressing force and tended to increase the cohesiveness of the product texture. The mixing time was found to have no effect on the product grittiness.

5.8.3 Effects of Pressing Force

The pre-experimental trial on pressing the bar mixture indicated that: the higher the pressing force used, the lower the product thickness but the greater the quantity of oil extracted during pressing; too much oil extracted resulted in too dry a product and in difficulty of product removal from the mould; a low moisture mixture resulted in a crumbly mixture which had an advantage for the product appearance after pressing because the nuts would be scattered here and there on the product surface (not sunk into the paste); among the amounts subjected to the hydraulic presser mould (10, 15, and 20 g), 10 g gave the most suitable product size and was chosen to be further used in a factorial experiment.

The factorial experiment using mixing time (1-7 min) and pressing force ($1.41 \times 10^6 - 7.03 \times 10^6$ Kg/m^2) as input variables indicated that the pressing force itself had adverse effects on the handling score. Too high a pressing force would cause the mixture to stick to the mould and caused difficulty in removing the mixture from the mould (Appendix 5.4f). A higher pressing force could increase the colour intensity and cohesiveness effects of the mixing time. With a high level of these two variables, the product would be intensely browny-red, of good cohesiveness and would have less mellow-sweetness. Though the pressing force and the mixing time showed no effect on the product grittiness, the product was considered by the special panel to be slightly more gritty than the ideal. However, the T-test result (Appendix 5.7) proved that the difference was nonsignificant.

5.8.4 The Relation of Effects Obtained from Hydraulic Presser and Developed Presser & Cutter

The result of the prediction of sensory attribute scores at various mixing times and pressing forces (Appendix 5.5) suggested that the optimum sensory scores (which was the ideal scores of SATIT KASET panel) and the optimum handling score would be obtained by using a mixing time of four minutes and 2.81 x 10^6 Kg/m^2 force.

When the pressing force applied to the nutritionally-balanced snack bars, using the developed presser & cutter was experimentally measured and compared with that when using the hydraulic presser (see procedure in Appendix 5.6), it was found that the bars were applied with exactly the same force which applied in the optimization experiment (2.81 x 10^6 Kg/m^2). This finding indicated that the optimum condition of pressing obtained by the hydraulic presser could be obtained using the developed presser & cutter.

5.8.5 Summary and Conclusion

For the preparation of the nutritionally-balanced snack bar, the optimum conditions for mixing and pressing operations using the developed presser & cutter could be set at four minutes for the ingredient mixing and 2.81 x 10^6 Kg/m^2 for the pressing force.

5.9 THE COMPLETE PROCESS DEVELOPED

The optimisation experiments for each process produced the conditions for each process step and then the process steps were combined in the total process. An outline of the total process is shown in Chapter 8 Figure 8.6. The process consisted of two parts, firstly preparation of ingredients and secondly mixing the ingredients to form the final bar. The BSE-mungbean was prepared by adding water (2.5 of the weight of mungbean), boiling, hot-stirring and then evaporating to approximately 20% moisture content. The DSC-banana was prepared by firstly boiling the peeled whole banana in water until soft then sugar was added and the syrup boiled for approximately 5 hours and the temperature rose to 120 C or the %SS was at 85%. The banana were cooled overnight in the syrup. Before the final mixing, the syrup was separated from the banana and mixed with the glucose syrup. The sesame seeds and the peanuts were roasted in the pan firstly over medium heat and then over low heat for approximately 30 minutes.

All the ingredients were then mixed and formed into bars as described below.

Formula	Kg
Boiled - Hot Stirred - Evaporated Mungbean (BSE-Mungbean)	1.250
Banana-Syrup (B-Syrup)	0.375
Glucose-Syrup	0.375
Deep-Syrup Cooked Banana (DSC-Banana)	1.300
Roasted Sesame Seeds	1.000
Roasted Peanuts	0.700
(Vitamin Mix)*	(0.29 g)
Total	5.000

Procedure

1. Warm B-syrup and glucose syrup in boiling water until the temperature of the syrup mixture is approximately 90 C.
2. Mix vitamin mix into approximately 500 g of BSE-mungbean, then mix into the BSE-mungbean.
3. Warm the BSE-mungbean mix in a round bottom pan until the temperature is approximately 90 C.
4. Add warmed syrup-mix, stir until the mixture is rather dry or until the %SS of the excess syrup is 79%.
5. Mix BSE-mungbean mix and DSC-banana in a three speed type mixer as follows:
   : Use slow speed (speed 1) and mix for 1 min; then, add half of roasted nuts.
   : Increase the speed (speed 2) and mix for 2 min; then, add another half of nuts.
   : At slow speed, mix for 1 min to complete mixing.
6. Divide mix into 1.1 Kg lots; cover.
7. Place 1.1 Kg mix into a mechanical presser. Press mix using a force of 2.81×10^6 Kg/m^2.
8. Cut the pressed dough using the same mechanical presser but with the segmented cutter applied before pressing (bar shape: 10.2 cm x 3.8 cm or bar weight: 44 g).
9. Pack each bar in the polypropylene packet (size: 11.4 cm x 8.9 cm x 0.1 mm). Then, seal and label.

* The vitamin mix consists of 0.220 g Ascorbic, 0.005 g Riboflavin, 0.060 g Vitamin A, 0.005 g Folic Acid.

When larger quantities of product/intermediate products are to be prepared, larger sizes of DSC-banana equipment can be designed using the same principles as that which was used in this experiment. For the BSE-mungbean equipment, an adaptation is necessary for the evaporating stage so that the boiled & hot stirred mungbean can be scraped properly out of the bottom of the pan. This might be done by the use of two stirrer-like blades, one of which, will 'scrape out' the hot-stirred mungbean at one side of the pan, while another one with a fork-like shape will 'scrape up' the hot-stirred mungbean at the other side of the pan. With this type of scraping motion, the BSE-mungbean should be fluffy in texture which will be beneficial for the absorption of syrup in the next stage. For the preparation of larger quantities, a round-bottomed cylinder-shape pan would be more suitable.

For the MP-snack bar equipment (moulding & cutting equipment), after the hydraulic jack was applied, some minor adaptations were still needed as follows: the brass plate needed to be fixed and the presser needed to be controlled for straight winding down into the frame; indentations around the inside of the frame were needed for the cutter blades, to give evenly cut segments; hard plastic needed to be substituted for iron in the frame and presser; a gauge was needed for measuring the pressing force applied.

5.10 TESTING THE PROCESS

The total developed process was tried out by the factory owner and the factory medium-skilled staff at RIN, a small-scale GRAYASAHT factory in Thailand, which was considered to be suitable for the developed process. (Details, concerning the process used in this factory and how its key operations were screened for the improvement applied in this project, can be found in Appendix 5.8M). The procedure for each process was written down for the staff to follow. Most ingredients and equipment were already available at the factory; the exceptions were bananas, a thermometer and hand refractometer, and a mechanical presser & cutter.

Since it was believed that the sensory weak point of the product as mentioned by the child consumers could be improved by a production development technique like EVOP (Evolutionary Operations) which is the form of experimentation used right on the production line, this testing of the process included the minor change of scattering one tenth of the peanuts in the recipe on the top of the bar to lighten its colour intensity. Sensory evaluation of the factory product by four trained Lab panelists (Appendix 5.7) using a category scale profile test (scores 9,7,5,3,1) on four important product attributes -- colour, grittiness, cohesiveness, and sweetness, proved that all attributes including its colour were not statistically significantly different from those of the ideal (Ideal = 5). The exception was for its lower cohesiveness than the ideal (4 compared to 5). The high moisture content of the factory product was considered responsible for its low cohesiveness. This could be prevented by carefully controlling the end-point of the mixture while mixing over heat.

It was found from the transferal of the information obtained from nutritionally-balanced snack bar process development that the developed process could be used for commercial production at a small scale factory. However, the factory product had some difference in characteristics compared organoleptically, microbiologically, and nutritionally, with those of the consumer-test products (Table 5.27). The factory product had an obviously higher protein, fibre, and moisture content, but a lower fat content. The factory nuts used might be responsible for the difference in the nutritional properties of the snack bar. Its higher moisture content was responsible for the higher microbiological count. In sensory characteristics, the factory product profile was closer to the ideal. The exception was for its cohesiveness. With the higher moisture content, the factory product was more crumbly. An improvment in process control was needed. A discussion with the factory owner concerning the possibility of applying the total developed process for nutritionally-balanced snack bars in this level of factory gave a positive result. The details of the final process developed is given in Section 8.4.

Table 5.27: Comparison between consumer-test and factory products.

Characteristics	Consumer-test Product	Factory Product
Nutritional Characteristics		
Fat	18.27	22.45
Protein	13.33	16.00
Ash	1.93	2.09
Fibre	1.28	5.27
Carbohydrate (by difference)	57.36	46.86
Total solids	90.89	87.40
Calories	447.19	453.49
Moisture content	9.11	12.60
Microbiological Characteristics		
Total plate count	1.4×10^3	3.8×10^3
Yeast and mould	None	1.8×10^3
Sensory Characteristics*	By Consumer Taste Panel	By Lab Panel
	S.D.	S.D.
Colour	5.8 (1.4)	4.5 (1.0)
Gritty	5.5 (1.3)	5.5 (1.0)
Cohesive	5.0 (1.2)	4.0 (1.2)
Sweet	4.7 (1.5)	5.0 (1.6)

* Mean from category profile test: 9, 7, 5, 3, 1
Figures in parentheses are standard deviation values.

5.11 COMPARISON OF STATISTICAL ANALYSIS METHODS

5.11.1 Introduction

Different methods of statistical analysis were used with the different experimental designs used in the process development study. For the experiments in which the goal was to express the response variable as a function of the predictor variables, factorial design was used accompanied by regression analysis. For quicker calculation of the effects, Yates's Algorithm were applied to the observations after they have been rearranged in what is called "standard order".

In this present pilot plant process development study for a nutritionally-balanced snack product, 2^2 factorial experiments were used and Yates' Algorithm was applied for the calculation of the main effects and of the estimated response variable values (predicted 'Y') in the prediction equation. It was the purpose of this study to compare the effectiveness of Yates' method, in evaluating the main effects and in estimating the response variable values in a 2^2 factorial experiment, with that of regression analysis. Stepwise regression procedure, which is a selection technique that sequentially adds or deletes single predictor variables to the prediction equation, was chosen for use; and the data at the centre point of the 2^2 factorial design was collected and included in this analysis method.

The stepwise multiple regressions were conducted using a standard computer program, MINITAB for phase 1 and SPSS for phase 2. Examples of command for MINITAB and SPSS Programs for regression analysis are shown in Appendix 5.9Ma and 5.9Mb respectively.

5.11.2 Comparison of Selected Results of Process Development Experimentation by Two Statistical Analysis Methods

The selected results from two process development experiments were chosen for comparison. These included -- Experiment 1 (EXP 1) on DSC-Banana in phase 1 and Experiment 6 (EXP 6) on MP-Snack in phase 2. A comparison was made of selected output variables of process experiments on the basis of their main effects and estimated output variable values (Table 5.28). The prediction equations, coded and uncoded, of both methods are shown in Appendix 5.8a, and the calculations for selected estimated output variable values in Appendix 5.8b. The effectiveness of the method was based on its accuracy of the predicted values compared to those obtained in the real application in consumer test products.

The comparison on the 'main effect' results of EXP 1 suggested that the Yates' method and the Regression method expressed them in a similar way. The exception was for the Aw value of B-syrup in which no main effect was found by the Stepwise Regression method. The 'interaction effects' which were found only by the Stepwise Regression method suggested the sensitivity of this technique to the interaction of the effects. This sensitivity of the regression method was responsible for the lower estimated output variable values under the regression method. Similar predicted values of %DSC-banana obtained and Aw value of DSC-banana proved that where main effect results of the two methods were the same, the predicted values were similar. And vice versa, where the main effect results were different, the predicted values were also different. However, the results were in the same direction.

Since in this estimation, %SS of banana was set at 15% which was outside the range of the %SS used in EXP 1 (%SS = 17.5, 23), there might be some error in the predictions. And this was thought to be responsible for the minus value of flavour ratio mean (-0.4) obtained by the stepwise regression method.

TABLE 5.28: COMPARISON OF SELECTED RESULTS ON PROCESS DEVELOPMENT EXPERIMENTATION BY TWO STATISTICAL ANALYSIS METHODS

Output variables	Main Effects		Estimated Output Variables**	
	Yates'*	Stepwise Regression	Yates'	Stepwise Regression
EXP 1 DSC-Banana Process (No Rep)				
1. % DSC-banana obtained	S	S	45.800	45.700
2. % B-syrup left	S	S,I	38.100	35.100
3. % Loss through foam	T	T,I	5.500	3.000
4. % SS: DSC-banana/ syrup	S	S,I	76.500	70.800
5. Aw: DSC-banana	T,S	T,S	0.768	0.760
6. Aw: B-syrup	S,I	-	0.710	-
7. Force: 1st chew	(I)	-	-	-
8. Force: 2nd chew	(S)	-	-	-
9. Red R. mean	(T),(S)	-	1.200	-
10. Chewy R. mean	S	S,I	1.300	1.00
11. Flavour R. mean	S	S,I	0.400	-0.400
EXP 6 MP-Snack Operation (with Rep)				
1. Colour scores	M	(M)	5.46	(4.56)
2. Cohesive score	(M)	-		
3. Gritty score	-	-		
4. Mellow-sweet score	M,P	M,P	3.29	3.98
5. Handling score	M,(I)	-		
6. Sticking-to-mould score	M,I	-		
7. % SS of mixture before press	-	-		
8. % SS of snack after press	(M)	M	81.29	80.20

* For EXP 1: T = initial temperature of syrup; S = % SS banana used; I = Interaction
For EXP 6: M = mixing time; P = pressing force; I = Interaction
Character in parenthesis = trend of being mean effect

** For EXP 1: T = 102°C; S = 15%
For EXP 6: M = 4 min; P = 2.81×10^6 $kg.m^{-2}$

The comparison in EXP 6 on the MP-snack operation experiment also suggested that both statistical methods gave similar patterns of results. The 'main effects' found were not exactly the same because of the subjective judgment by the 'estimation technique' used (see 5.5.8.3). However, where 'trends of being main effects' were found by Yates' method, they were found by the stepwise regression as well and vice versa. This was designated by the high F-value close to the critical value of significance or at least by being the highest F-value compared to those of the 'not main effects'. For example, by 'estimation technique' on Yates' method, mixing time was found to be the 'main effect'; whereas this variable was found to have 'trend of being main effect' by the stepwise regression method (as shown in Table 5.27 by using parenthesis).

Also, the similar predicted values of this experiment (Mellow-sweet score = 3.29 by Yates' and 3.98 by stepwise regression; %SS of snack after press = 81.29 by Yates' and 80.20 by stepwise regression) proved that both methods gave similar results. The exception was for the colour score, where no 'main effect' was found by the regression method, and prediction equation was taken from that considered to have a 'trend of being a main effect'.

The comparison of the above three predicted values with those obtained on the 'consumer test product' proved that both Yates' and the Stepwise Regression methods were similar in effectiveness because they gave predicted values that were similar and in some cases close to what would be obtained as shown below.

	Predicted Values		Consumer Test
	Yates'	Regression	Product
Colour score	5.5	(4.7)	5.8
Mellow-sweet score	3.3	4.0	4.7
%SS of snack after press	81.3	80.2	83.0

5.11.3 Conclusion

Based on this experiment, Stepwise Regression and Yates' methods of statistical analysis gave similar results for the 'main effect' and 'estimated output variable value' studied. The results on predicted values obtained, compared to those obtained from the application in the consumer test product, though they were not exactly the same, were similar. The two methods were considered as similar in their effectiveness.

5.12 DISCUSSION AND CONCLUSION

A model of formulation and process development for a nutritionally-balanced snack product to be used for the intervention programme in Thailand was designed (See Figure 8.1 and 8.2 in Chapter 8) using systematic methods and planned techniques. One of the best methods and techniques recommended, based on this investigation, was to use optimization techniques. Linear programming was suggested for the formulation and factorial for the process development. A profile test was suggested for the sensory property test of the developed product and water activity value analysis, refractometer, or moisture analysis for the critical physical property -- the available moisture in the product. For statistical analysis, profile analysis on the ratio basis was recommended for the product`s profile, and stepwise regression or Yate's analysis for data of process development experimentation. A t-test and Analysis of Variance techniques could be used whenever a difference between/among treatments was to be known, and the correlation technique whenever the relation among attributes was to be identified.

Between Stepwise Regression and Yates' analysis methods, the latter was recommended for full factorial experiments where a computer facility is not available and the budget is limited. The advantages of using Yates' method are: ease of use (with hand calculation possible); less time and money necessary; effectiveness (with 'rather accurate' prediction).

In conclusion, for a nutritional snack development project with limited time and budget, it was possible to use only simple but nevertheless effective techniques after the formulation by LP was done. That is a factorial design with Yates' analysis used for process optimisation, a refractometer for critical "water-available" test, and a small taste panel for sensory profile testing. However, careful subjective judgment should be included in the interpretation of the statistical analysis.

CHAPTER 6

SENSORY ANALYSIS DEVELOPMENT AND STATISTICS

6.1 INTRODUCTION

Product development in the food industry may vary in aims and objectives, depending on the policy of individual companies. However, one aim of all product development projects is that the final product should meet the acceptance criteria of the consumer expected to be the target market. Food acceptance and preference or degree of liking depend mainly on consumer sensory response; thus, sensory tests using human subjects are imperative. For this reason, the sensory analysis of food plays an important role in the PD system.

At the 'development' and 'testing' stages in the PD process, sensory analysis activities are needed. The developed products from the formulation and process development steps need sensory analysis techniques that can lead to products with the characteristics desired by the consumers, that is the ideal product profile; whereas those from the production, storage, and consumer trial steps need techniques that can portray the profile changes caused by the trials. For optimum results, these sensory analysis techniques need not only different panel types with different sensory analysis capabilities but also different statistical techniques for data analysis.

Since the ultimate consumers are untrained and not selected, and are therefore lower in discrimination, sensitivity, and consistency in measurement, sensory analysis techniques selected for use for this group are generally simple but effective. And since the ultimate consumers are the goal for the product developed, it is considered necessary to relate any types of panel and any methods and techniques used for sensory analysis at each step to ones that are used for the ultimate consumers. This resulted in an overlapping of the sensory analysis methods and techniques used in certain steps in the PD process of this project.

For the nutritionally-balanced snack bar developed in this project, a suitable method was required to determine the whole sensory profile change at each step of the development. A change towards the ideal product sensory profile of the consumer panelists was considered positive. The descriptive sensory profiling technique, because it is not quantitative, is difficult to analyse and interpret (Cairncross and Sjostrom, 1950 as quoted by Anderson, 1982). Therefore, scaling methods were chosen for the sensory profiles of the products developed in this project. Linear scaling was chosen for use at the beginning of the product development process especially for the trained laboratory panel, while category scaling was used at the later part especially for the untrained panel and the consumer survey.

It was the purpose of this study to investigate the appropriateness of linear scaling and category scaling techniques for use in the sensory profile of products developed at various stages in the PD process. Also statistical analysis techniques were compared in order to choose the most appropriate one(s). The effectiveness of different methods and techniques was investigated as follows: the effectiveness of the ratio profile analysis technique by comparison with other methods of profile analysis; the effectiveness of laboratory and consumer panels by a comparison of the predicted results with those obtained in the consumer survey; the effectiveness of the sensory methods by a comparison of the sensory analysis results with those obtained from instrumental methods.

The final aim of the study was to design a sensory analysis development model to be used for nutritional product development projects in Thailand. Also this study was to set up reference C.V. (Coefficient of Variation) values for the judgment of the standard deviation size for sensory analysis of a developed product using the profiling technique.

6.2 METHODS AND TECHNIQUES IN SENSORY ANALYSIS OF FOODS INCLUDING STATISTICS

6.2.1 Introduction

According to Amerine et al.(1965), sound methodology for the sensory analysis of foods rests on a thorough knowledge of sensory physiology and an understanding of the psychology of perception. In addition, careful statistical design and analysis of the data is essential, and finally, new understanding of the sensory judgment is to be sought through correlation with physical and chemical data.

6.2.2 Methods and Techniques for Sensory Analysis and Statistics in General

Different methods and techniques for the sensory analysis of food and the statistics associated with them can be found in the literature (Amerine et al., 1965; Kramer and Twigg, 1970; Larmond, 1970; Birch et al., 1977; Cooper, 1981; Gatchalian, 1981; Anderson, 1982; Food Technology Research Centre (FTRC), 1982; Moskowitz, 1983; Williams and Atkin, 1983; and Piggott, 1984). The correlation of subjective-objective methods in the study of food were discussed in detail in Amerine et al.(1965), Kramer and Twigg (1970), Cooper (1981), Moskowitz (1983), and Williams and Atkin (1983). ASTM (1968) discussed the correlation of subjective-objective methods in the study of odours and taste, and Martens and Russwurm (1982) discussed in detail data analysis in food research. Amerine et al.(1965) categorized the most important types of sensory tests to provide information that can lead to product improvement, quality maintenance, the development of a new product, or analysis of the market.

6.2.3 Methods and Techniques for Sensory Analysis and Statistics in PD System

A number of types of scaling have been used to quantify sensory attributes of developed food products. For product profile development in the PD system, a linear scaling method was used effectively and successfully by Cooper (1981) and FTRC (1982). Recently, a ratio profile technique was developed by FTRC as a promising method for profile data analysis.

For the consumer panel studies, Calvin and Sather (1959) as cited by Amerine et al.(1965) used a hedonic scale of nine descriptive terms to establish the degree of liking for various food products by using a student laboratory panel and also a household consumer panel. Agreement in results between the two panels was found to be very good. A hedonic scale as used above can be classified under the category scaling method.

6.3 METHODS AND TECHNIQUES IN THE PRESENT PRODUCT DEVELOPMENT PROJECT

6.3.1 Introduction

In this study, two different scales were used to quantify sensory attributes in the developed snack-bar: linear scaling and category scaling, both of which could portray the sensory profile and the acceptability attributes of the product. For sensory profile analysis using a linear scale, two methods were used to analyse the data. Firstly, the ratio of the panelist score to the ideal score and secondly, the linear distance of the sample score from the ideal score. Where justifiable, the actual scores were included in the comparison. Three factors were used to judge the effectiveness of the two scaling techniques: simplicity, quickness, and difference-sensitivity. During the different steps of the PD process, four types of panels were used -- a laboratory panel, a special panel, a consumer panel, and a consumer survey.

6.3.2 Definition of Selected Sensory Analysis Terms Used in This Study

6.3.2.1 Panel Terms. The four panel types used for analysing the developed snack-bar were the laboratory panel (lab panel), the special panel, the consumer panel, and the consumer survey. The meanings of these four terms for this project are given below.

Lab Panel. A small group of respondents who were interviewed on the same sensory topic throughout the project. Though they were not representative of the consumer, they were semi-trained in evaluating the sensory attributes of the product based on consumer preferences.

Special Panel. A semi-trained panel formed for special analysis of certain intermediate products in this project. Panelists might or might not be technical personnel, but they were semi-trained in discriminating samples on the basis of the sensory properties of the product samples, rather than on their individual preference.

Consumer Panel. A sample of typical consumers who were interviewed several times on the same sensory topic. In this project, a static panel or in other words a permanent or a constant panel was preferred, since 'before and after data' was required.

Consumer Survey. Respondents who were only interviewed one time on one topic, sensory or non-sensory. In this project, the consumer survey not only included more respondents than the consumer panel but also included a more demographically representative sample.

6.3.2.2 Sensory Scaling Methods. Two sensory scaling methods used for the sensory testing of the developed snack bars were linear scaling and category scaling.

Linear Scaling. The scale was represented by an unnumbered line. The line had verbal anchors at each end and was 10 cm long. The panelist was instructed to mark the line at the point appropriate to the extent of his/her perception. An example of the 'verbal anchor' line for colour is shown below.

light -- dark

Category Scaling. The category scales used in this study were of two types: Unipolar scales for the level of the degree to which an attribute was present, and bipolar scales for the level of the acceptance/preference/degree of liking. Numbers were assigned for each category level. For example, for category scaling on the liking of the snack bar, '1' was assigned for 'like very much', '3' for 'neither like nor dislike', and '5' for 'dislike very much'. This type of scaling was used for the untrained panel.

For the stored product evaluation, a category segmented-scale was used. This was represented by 5 segments of a broken line, each end of which had verbal anchors (see below). The scales were for the strength of each attribute of each sample, compared to the reference. The scale was from 'not present' (equalled score 1) and 'strong' (equalled score 5). The sample codes were to be placed somewhere along the scale by the panelists, who would also include their reference score.

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not present strong

6.3.2.3 Score Terms. Two score terms were used as the basis for profiling analysis.

Sample Score. The sample score was the length in centimetres from the zero end to the point marked for the strength of the product sample attribute on the linear scale by the panelist. For category and segmented scales, a verbal score was assigned by the panelists. The verbal scores were previously assigned numerical scores by the researcher.

Ideal Score. The ideal score had a similar definition to the sample score but it was assigned for the strength of the ideal characteristics of the product instead of the sample.

6.3.2.4 Data Analysis Terms. Two data analysis terms were used for sensory data analysis in this part of the study.

Analysis of Profile Data. Analysis of the profile data from the linear scaling method was carried out in a number of steps. To begin with, the distance along the sample line was measured and the ratio with the ideal line length was used to calculate the ratio mean. For a sample marked at the zero end of the line, the assumption was made that the sample score was 0.1. This was done to solve the 'zero problem' with ratios (i.e. 0/5 = 0). The data obtained were plotted in a spider-web form. The data obtained were also analysed by an analysis of variance or the student's t test (ANOV/T-test) for the difference among attributes. Correlation techniques were used to study the relations among attributes.

For the data from the category scaling method, the ratio was obtained by a division of the sample score by the 'just right' or 'middle segment' score (which was '3' for both types of scaling); and the product obtained was analysed by statistical techniques in the same manner.

Chi-Square Distribution Analysis. Chi-square distribution analysis was applied to the consumer panel data which consisted of counts, or frequencies by comparison of 'expected frequencies' against 'observed frequencies'. Such a comparison could lead to useful conclusions on the questions of 'whether or not the discrepancies between observed and expected frequencies are so large that doubt is cast on the assumptions that gave rise to the expected frequencies' and 'whether the observed data present sufficient evidence to cause rejection of the hypothesis'.

For the consumer survey test data, the chi-square analysis was used to test the null hypothesis that two criteria of classification, when applied to a population of subjects, were independent. The two criteria of classification in this project were firstly either sex, age or education level attained, and secondly an attribute intensity score. Thus, "the tests of independence" was considered to be the type of chi-square distribution to be used.

6.3.2.5 Other Associated Terms.

Score Mean. The score mean was the mean of the raw scores obtained by either linear or category scaling methods of the sensory analysis of the product profile.

Ratio Mean. The ratio mean was the mean of the ratios obtained by dividing the sample score of each attribute for each panelist by its ideal score. For the ratio method of profile analysis, when the ratio mean was equal to 1.0, the sample was considered the same as the ideal. At a value less than 1.0, the sample had less of the attribute, and at a value greater than 1.0, the sample had more of the attribute. At the preliminary stages of development, a small standard deviation (assumed when S.D. $\leq$ 0.5) indicated panel agreement about the intensity of the attribute, whereas a large standard deviation (assumed when S.D. > 0.5) showed that the panelists could not agree on the sample's attributes.

Interval Mean. The interval mean was the mean of the intervals obtained by subtracting the sample score of each attribute for each panelist from its ideal score. For the interval method, at an interval mean equal to 0.0, the sample was considered the same as the ideal. If a negative score resulted, the sample had less of the attribute, whereas if a positive score resulted, the sample had more of the attribute. The description for the standard deviation above also applied for the interval mean.

1st Panel. Panel formed in phase 1 in New Zealand.

2nd Panel. Panel formed in phase 2 in Thailand.

1st Consumer Test Product. Product produced in phase 1 in New Zealand for the consumer panel test purpose.

2nd Consumer Test Product. Product produced in phase 2 in Thailand for the consumer panel test or consumer survey purpose.

6.4 GENERATION AND USES OF IDEAL PRODUCT PROFILES

6.4.1 Introduction

In the PD system, a sensory ideal product profile is needed for use as a standard against which the products developed can be compared. In this study, because of the two phases of the "Study Program", two ideal product profiles were generated. The 1st sensory ideal product profile was generated in phase 1 in New Zealand by the 1st lab panel (6 Thai graduate students at Massey); and the 2nd sensory product profile was generated in phase 2 in Thailand by the 2nd consumer panel (36 school-children at SATIT KASET).

In generating the sensory ideal product profile, a product was needed for use as a guide for the judgment. It was considered important that panelists were presented with a product and did not develop an ideal profile with no reference product as guidance. The product can be a commercial product that is available or an experimental product from an early development stage. In this project, an experimental product was used for the ideal product profile generation. This was done by presenting a prototype product to the panelists as an 'imaginary anchor'. The 1st product developed at the LP formulation stage (LP formulated product) was used for phase 1 generation; and the product produced in the production run in a New Zealand factory was used for phase 2 generation. Thus in this project, the sensory product profile was generated at the same time as the first product (the prototype product) was tested by the panel.

Undoubtedly, each panelist generated a different ideal product profile in magnitude; and their ideal profiles obtained were defined as "moving ideal" profiles. These were in contrast with the "fixed ideal" profile which was obtained when the ideal profile, against which the product was to be compared, was fixed on the line.

6.4.2 Selection of Sensory Attributes and the Taste Panel Forms

In phase 1, before conducting the panel test, a temporary panel of three was formed consisting of two technical personnel from the Food Technology Research Centre and the researcher. Each tasted a piece of the nutritionally balanced snack product, and selected and evaluated the important attributes for appearance, odour, texture, and flavour. The panelists discussed the attributes and agreed on common vocabularies, and also developed the form. An example of the taste panel form is shown in Appendix 6.1a. Thus, in this study the selection of sensory attributes and the development of the panel form was carried out by the technologists not the panelists.

In phase 2, the questionnaire in the form of a profile test type, used for the lab panel and consumer panel tests in New Zealand, was translated into Thai and used for the consumer panel test in Thailand (Appendix 6.1b). In brief, the taste panel form included a linear scale for the following product attributes: appearance (colour and size), odour (sweet and nutty), texture (soft-hard, crumbly-cohesive, gritty, dry-juicy), flavour (nutty, sesame, mellow-sharp sweet, fruity, and mungbean flavour), and acceptability score.

6.4.3 The Panelists

In phase 1, because it was impossible to have a taste panel of school-age Thais at Massey University, a group of 6 Thai graduate students aged from 25 to 35 were accepted for participation in the initial taste panel. Four of the panelists were females, and two were males.

In phase 2, the panelists, aged from 7 to 15, i.e. school children of levels 1-9, were volunteers who did not mind eating nuts, who did not have a cold and who had not eaten other snacks before the testing time. Two boys and two girls from each level were chosen by the teacher of each level. These, when collated to cover the whole range of levels studied, made up 36 respondents, 18 males and 18 females.

6.4.4 The Preparation for the Panel Tests

The necessary materials were prepared the day before the test date as follows:

Phase 1:

6 pieces of sample
6 plastic cups
6 white plates
6 questionnaires and pencils
And tissue, candy as a gift.

Phase 2:

50 packets of samples
1 box of tissue
40 plastic cups
4 plastic trays
4 plastic jugs
1 big bottle of drinking water
40 questionnaires
40 good quality pencils with rubber.
(To be kept as a gift after the test)

6.4.5 Panel Orientation/Training

Before the test, the panelists were given orientation on the tasting method. The meaning of each attribute term was explained to the panel to avoid any error in panel interpretation. Examples were given where necessary.

6.4.6 Panel Procedure

In phase 1, samples prepared in advance and kept at room temperature were used. The bar served for tasting was approximately 6 x 5 x 2.5 cm in size and weighed 80 g. This was half the size of a 5 Baht packet and was slightly smaller than the size of a 3 Baht packet. Only one sample was used for the initial profile test. Water was available to cleanse the panelist's mouth. Three sample sizes were also provided for evaluation.

160 g measuring 11 x 5.5 x 2.5 cm (5 Baht size)

90 g measuring 6 x 5.5 x 2.5 cm (3 Baht size)

50 g measuring 5 x 3 x 2.5 cm (app. 1/3 of 5 B size or 1/2 of 3 B size).

The panel test was done in a taste panel room with white fluorescent lighting and an air conditioning system.

In phase 2, permission for a consumer test in SATIT KASET SCHOOL was asked for two weeks in advance. Four graduate students from the Home Economics Department, Kasetsart University were used as the interviewers. Orientation on the consumer test method for the interviewers was done the day before the test date. The importance of communication was explained to the interviewers, who were also thoroughly trained in the use of profile test forms.

The test was conducted after school hours, at 3:45 - 4:45 p.m., in an air conditioned room where there was no interference (Figure 6.1). A profile test form, a pencil, a glass of water, a tissue and a packet of the sample (4 weeks old) were distributed to each child and then the author explained to the children how the profile test form should be completed and gave the meanings of all the terms at intervals. The interviewers had all been taught to give the same explanation for each term. After the profile test forms were filled in they were firstly checked by the interviewers.

6.4.7 Method of Profile Analysis

The method of ratio profile analysis developed at The Food Technology Research Centre (1982) Massey University, New Zealand, was used. An unnumbered line of 10 cm in length, with verbal anchors at each end, was prepared for the panelist to indicate the intensity of each attribute compared to its individual ideal.

Each sample score allocated for the intensity of each attribute by each panelist, was divided by its corresponding ideal score. The ratios obtained were then averaged (x) and the standard deviation (S.D.) calculated to see the distribution of the data. Correlation among selected attributes and between selected individual attributes and acceptability were calculated. The difference between treatments (in this case, Sample vs Ideal) was investigated.

Figure 6.1: Product Acceptability Test by 2nd Consumer Panel (Child Consumer Panel in Thailand)

6.4.8 Data Processing and Analysis

Before the processing of the data, the test forms were checked by the author. The primary data obtained from the sensory tests was processed by computer. The programmes, MINITAB (Ryan et al., 1976) for phase 1 and SPSS (Nie et al., 1975 and Nie, 1983) for phase 2, were used for the calculation of means, standard deviations, ratios to the ideals, correlations of the attributes, and statistical difference by ANOV/T-Test. The significance of difference was tested with a level of probability of 0.05.

6.4.9 Results and Discussion of the 1st Ideal Product Profile Generation

6.4.9.1 Profiles of Product Ideal and Product Sample. Score mean profiles of the ideal and the sample and the sample's ratio profile are shown numerically in Table 6.1a, and graphically in Figure 6.2. Their standard deviations are also included so that the variability of the data can be examined. The mean ideal profile was fixed and was used for comparison in further experimentation during phase 1 of this project.

Table 6.1a: Score means of ideal and sample and ratio mean profile of LP formulated product sample by 1st lab panel.

Attributes	Ideal		Sample		Ratio	
	x	S.D.	x	S.D.	x	S.D.
Odour:						
Sweet aroma	5.2	1.2	4.5	1.5	0.9	0.3
Nutty aroma	5.1	1.4	5.1	1.8	1.0	0.4
Texture:						
Soft-Hard	4.9	1.5	4.5	2.2	1.1	0.7
Crumbly - Cohesive	6.1	1.4	3.5	1.2	0.6	0.2
Gritty	4.1	1.2	5.8	1.9	1.4	0.4
Dry - Juicy	5.8	1.9	6.1	1.3	1.1	0.3
Flavour:						
Nutty flavour	6.3	2.0	5.8	2.9	1.0	0.4
Sesame flavour	5.6	0.9	5.0	2.5	0.9	0.4
Mellow sweet - sharp sweet	4.4	1.4	4.1	1.5	0.9	0.1
Fruit flavour	3.6	1.7	1.6	1.6	1.0	1.5
Mungbean flavour	5.2	1.7	6.6	2.8	1.3	0.7
Acceptability score	7.0	0.0	5.2	0.8	0.7	0.1

Notes:
1. x = sample score mean.
2. S.D. = sample standard deviation mean.
3. Color: Descriptive type of data; thus, it was excluded.
4. Size: Multiple choice data; thus, it was excluded.
5. Acceptability: Top of hedonic scale provided was assumed for ideal.
6. The ratio mean was 1.0 on fruit flavour although the ideal mean score was 3.6 and its sample mean score was 1.6. This was because individual panelists used different parts of the line. The comments on the taste panel form suggested that fruit was not really a well defined flavour. It was difficult to define what fruit was. 'Banana flavour' seemed to be a better term in this case.

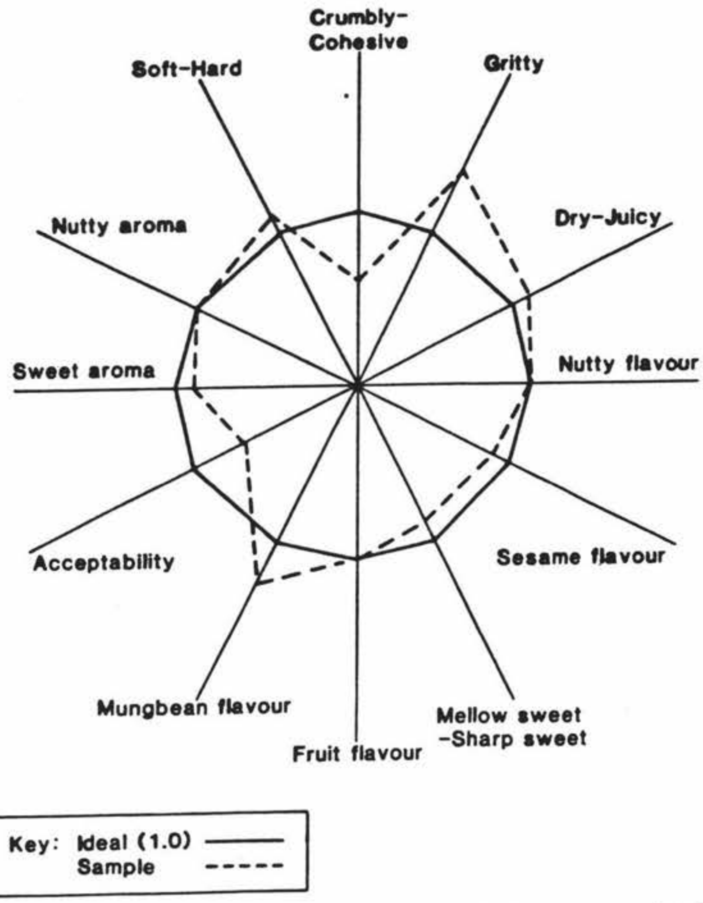


Figure 6.2: Ratio Mean Profile Using Linear Scales: LP Formulated Product by 1st Lab Panel

Primary investigation was made to find out the weak points of the sample. It was found (according to the distance away from the ideal point) that the sample was rather crumbly, gritty, not fruity enough, and was liked slightly (average 5.17 out of 7) by this panel. However, the result from the ANOV technique indicated that among those attributes mentioned, only crumbliness and acceptability of the sample were statistically significantly different from the ideal (Table 6.1b). Thus, though certain attributes were further statistically investigated, crumbliness and acceptability were emphasized.

Table 6.1b: Means and levels of difference of selected attributes of 1st sensory product ideal and 1st LP formulated product.

Attributes	Ideal Mean	LP Sample Mean	Level of Significance
Crumbly	6.13	3.47	99%
Gritty	4.13	5.80	n.s.
Fruit flavour	3.62	1.63	n.s.
Mungbean flavour	5.22	6.58	n.s.
Acceptability score	7.00	5.17	99%

n.s. = not significantly different

It was found from the ratio profile that crumbliness and grittiness were the weak points (too crumbly and too gritty) of the product sample; and that the product was just-acceptable for this panel. However, the high standard deviation (1.52) for fruit flavour by the ratio method indicated that the panel did not agree on this attribute of the sample.

It was, therefore, considered that crumbliness, grittiness, fruit flavour, and acceptability of the product should be statistically studied in detail. The improvement of product profile was based on these findings. The improved profile is shown in Appendix 6.2a.

6.4.9.2 Correlation of Selected Attributes Using Ratio Means. Four main attributes - crumbly, gritty, fruity, and acceptability, and related texture and flavour attributes - soft, dry and mungbean flavour were used as the key attributes for the study of correlation. The results obtained are shown in Table 6.1c. Although no attribute could solely statistically affect the acceptability of the product sample, the highest correlations were with fruit flavour and crumbliness (by highest r values). The fruit flavour was found to be inversely correlated with the crumbly-cohesive attribute.

Table 6.1c: Correlation values among selected attributes using ratio means of LP formulated product.

	Crumbly-Cohesive	Gritty	Dry	Soft - Hard	Fruit flavour	Mungbean flavour
Gritty	0.655					
Dry	-0.180	-0.276				
Soft - Hard	0.714	0.827*	-0.576			
Fruit flavour	-0.974**	-0.625	0.301	-0.671		
Mungbean flavour	0.223	0.121	0.223	0.275	-0.038	
Acceptability	0.627	0.381	-0.500	0.576	-0.698	-0.433

* Significant at 5% level (r >0.7545; df = 4)
**Significant at 1% level (r $\geq$0.8745; df = 4)

6.4.10 Results and Discussion of the 2nd Ideal product Profile Generation

6.4.10.1 Profiles of Product Ideal and Product Sample. Profiles, using the actual mean of the scores from the ideal and the sample product and using the mean of the ratio of the sample score to the ideal, are shown numerically in Table 6.2a and graphically in Appendix 6.2b. Their standard deviations are also included in the table so that the variability of the data can be examined. The ideal mean profile was fixed and was used for comparison in further profile experimentation in phase 2 of this project.

TABLE 6.2a: NUMERICAL SCORE MEANS OF IDEAL AND SAMPLE AND RATIO MEAN PROFILE OF SAMPLE BY 2ND CONSUMER PANEL

Product Attributes	Numerical Profiles					
	Ideal		Sample		Ratio mean	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Colour	4.4	1.7	5.7	1.8	1.6**	0.8
Size	5.1	1.6	5.1	1.3	1.1	0.5
Sweet aroma	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.
Nutty aroma	4.5	1.8	5.5	2.1	1.4**	0.9
Soft-Hard	4.5	1.6	4.9	1.4	1.2	0.7
Crumbly-Cohesive	5.1	1.5	4.9	1.7	1.0	0.3
Gritty	4.4	1.9	6.2	2.3	1.5**	0.6
Dry-Juicy	5.2	2.0	5.1	2.4	1.2	1.0
Nutty flavour	4.5	1.2	4.6	1.9	1.1	0.6
Sesame flavour	4.3	1.5	4.4	1.8	1.1	0.5
Mellow sweet-Sharp sweet	3.7	2.1	3.1	2.2	1.1	1.1
Fruit flavour	4.3	2.2	3.0	2.4	0.8	0.7
Mungbean flavour	4.3	1.5	4.6	2.2	1.1	0.5
Acceptability	7.0	-	5.5	1.1	0.8	0.2

Notes: n.t. = not tested

** = ratio mean from sample data significantly different from the ideal at 99% level of T-test

* = ratio mean from sample data significantly different from the ideal at 95% level by T-test

The test product was significantly different ($P \leq .01$) from the ideals of the child panel in colour, nutty aroma and grittiness. The product was identified as too intense in colour, too strong in nutty aroma, and too gritty. In a further development experiment, these three attributes seemed to have priority. However, the panel had different opinions on these three attributes. Thus, careful consideration based on other subjective judgments was included before a decision on the readjustment was made.

6.4.10.2 Correlation of Selected Attributes. Correlation values among selected attributes using the ratio means are shown in Table 6.2b. Of all the attributes studied, 'nutty flavour' was the only attribute that had some correlation directly with the acceptability of the product. Second to 'nutty flavour', though not significantly correlated, was 'mellow sweet - sharp sweet'. Other main findings in this study were that there was some correlation between grittiness and nut aroma and flavour, between nutty flavour and cohesiveness, and between mellow - sharp sweet and fruit flavour. Thus, these attributes were considered to be important for further study. Possible methods of attribute readjustment of the product in further development is shown in Appendix 6.3.

TABLE 6.2b: CORRELATION VALUES AMONG ATTRIBUTES BY USING RATIO MEANS OF THE 1ST CONSUMER TEST PRODUCT BY THE 2ND CONSUMER PANEL

	COL	SIZE	ARO	SOFT	COH	GRIT	JUI	NUT	SES	MS	FRUIT	HUNG
SIZE	-0.147											
ARO	0.284	-0.053										
SOFT	-0.164	0.060	0.331									
COH	-0.024	0.180	0.271	0.492**								
GRIT	0.395*	0.345	0.568	0.191	0.179							
JUI	0.100	0.519**	-0.114	-0.046	-0.106	0.230						
NUT	0.308	0.395*	0.139	0.258	0.480**	0.408*	0.340					
SES	-0.211	0.423*	0.083	0.456	0.212	0.423*	0.243	0.472**				
MS	-0.200	0.049	-0.115	0.097	-0.008	0.129	0.103	0.073	0.536**			
FRUIT	-0.325	0.373	-0.273	0.113	0.043	0.010	0.411*	0.162	0.544**	0.605**		
HUNG	-0.110	0.127	-0.141	-0.030	0.293	0.050	0.217	0.305	0.374*	0.352	0.401*	
ACC	0.306	-0.026	0.090	-0.045	0.056	0.299	-0.200	0.395*	0.259	0.346	0.205	0.225

r. table .05 = 0.361
.01 - 0.463

For translation of coded names see Table 6.2a.

6.4.11 Other Ideal Product Profile Generated

In phase 2, an ideal product profile was also generated by 2nd lab panel using the same method and procedure as that generated by the 2nd consumer panel. The result of the generation experiment was used for and is shown in a comparison study in Section 6.6.

6.4.12 Summary Of The Profiles of Developed Products

1st Product Profile:

: Ideal product profile was fixed (Table 1) for further use.

: Of all the attributes, crumbliness and acceptability of the sample were significantly different from the ideal (P< 0.01, using score means; Crumbliness ratio mean = 0.58; and acceptability ratio mean = 0.74); thus, they were considered critical attributes for this product. Since the grittiness value of the sample was high

(1.44 for ratio method), though not statistically different from the ideal, it was also considered as important.

: Crumbliness statistically correlated inversely with fruit flavour. Since fruit related to banana, increasing the banana was a possibility for decreasing crumbliness.

: Acceptability did not correlate significantly with any other attribute, or in other words, the acceptability of the product by this panel did not depend solely on any single attribute. However, crumbliness showed the greatest effect on the acceptability of the product.

: For further formulation development, the fruit might be increased, the weight of which would be limited by cost and nutritional constraints.

2nd Product Profile:

The main findings suggested that for a higher acceptability of the product by the child panel, improvements were considered to be through the reduction of nutty aroma, colour, and grittiness, and the increase of fruit flavour.

6.5 SENSORY PROFILE ANALYSIS DEVELOPMENT

6.5.1 Introduction

In this project of nutritional product development, the development of sensory analysis was made through the improvements of the profiles of the products developed at continuous stages of the product development process. Important stages needing product profile development in this study included-

: LP formulation of the product
: LP reformulation of the product
:*Process development for each selected unit operation
:*Lab panel test of the developed product
:*Consumer panel test of the developed product
: Consumer test of the developed product
: Lab panel test of the stored product
: Lab panel test of the final improved product

For this project, because there were two phases of process development, the product profile development at the stages of the process development (marked with * on the stages shown above) were conducted in both phases in a similar way but by different groups of panelists.

6.5.2 Experimentation and Aims

Sensory analysis development experimentation included twenty experiments as shown in Table 6.3a. Different experiments had different objectives, and used different product samples, panel groups, and sensory ideal product profiles. The differences depended not only on the objectives of the experiments, but also on the different conditions in the two phases of this project.

Table 6.3a: Sensory analysis development experimentation.

Experiment (EXP)	Aim of Experiment (Test on:)	Product Sample*	Panel**	Sensory Ideal Product Profile Applied as an Anchor/Reference
Phase 1 in New Zealand:				
EXP 1	product acceptability	LP formulated product	1st lab panel	1st lab panel ideal profile
EXP 2	product acceptability	LP reformulated product	1st lab panel	1st lab panel ideal profile
EXP 3	DSC-banana sensory quality (GLUOY HOM)	DSC-banana from process development	1st special trained panel	Literature and self judgment based on final bar requirement
EXP 4	DSC-banana sensory quality (GLUOY HOM)	DSC-bananas from process development	1st special trained panel	Literature and self judgment based on final bar requirement
EXP 5	product acceptability	1st consumer test product	1st lab panel	1st lab panel ideal profile
EXP 6	product acceptability	1st consumer test product	1st consumer panel	1st lab panel ideal profile
Phase 2 in Thailand:				
EXP 7	product acceptability	1st consumer test product	2nd lab panel	2nd lab panel ideal profile
EXP 8	product acceptability	1st consumer test product	2nd consumer panel	2nd consumer panel ideal profile
EXP 9	product acceptability	1st consumer test product	2nd lab panel	2nd consumer panel ideal profile
EXP 10a-e	product profile change	1st storage test product	2nd lab panel	Profiles by lab panel at Day 1
EXP 11	DSC-banana sensory quality (GLUOY NAMWA)	DSC-banana from process development	2nd special trained panel 2nd special trained panel	Literature and self judgment based on final bar requirement
EXP 12	BSE-mungbean sensory quality	BSE-mungbean from process development	process operator panel	Self judgment based on final bar requirement and handling convenience
EXP 13	BSE-mung sensory quality	BSE-mungbean from process development	process operator panel	Self judgment based on final bar requirement and handling convenience
EXP 14	MP-snack sensory quality	MP-snack from process development	2nd special trained panel	2nd consumer panel ideal profile
EXP 15	product acceptability	2nd consumer test product	2nd lab panel	modified 2nd consumer ideal profile***
EXP 16	product acceptability	2nd consumer test product	2nd consumer panel	modified 2nd consumer ideal profile
EXP 17	product acceptability	2nd consumer test product	consumer survey	modified 2nd consumer ideal profile
EXP 18a-e	product profile change	2nd storage test product	2nd lab panel	2nd lab panel profile (on selected attributes only)
EXP 19	descriptive product profile change	2nd storage test product	One member of the 2nd special trained panel	-
EXP 20	product acceptability	improved factory product	2nd lab panel	modified 2nd consumer ideal profile

*phase 1 in New Zealand; phase 2 in Thailand
**1st designates MU (Massey University); 2nd designates KU (Kasetsart University)
***Modified 2nd consumer ideal profile based on 'just right' as 'ideal'
So that, 'just right' score was used in the same manner as 'ideal' for calculation.

6.5.3 Principles of Sensory Profile Analysis Development

The main principles for sensory analysis development for the profiling techniques used in the PD process in this project were based on the fact that sensory attributes already acceptable as 'ideal' on the profile graph were dropped from further improvement. The remaining sensory attributes needed further improvement because they were not on their product ideal points. These remained in further sensory profile experiments and the panel forms included only those attributes. Therefore, during these stages of product profile development, changes of profile graph from a 'spider-web' profile to a 'rhombus' profile was necessary.

6.5.4 Taste Panel Form

Typical taste panel forms for the profile of the fresh product by linear scaling is discussed in 6.4.2 and shown in Appendix 6.1a,b, and for DSC-banana in Appendix 6.1c. The profile of the consumer test product by category scaling is discussed in section 3.3.3.3 in Chapter 3 and shown in Appendix 3.2M, and the profile of the stored product by category segmented-scaling is shown in Appendix 6.4b.

6.5.5 Setting up the Panel and Panel Oriention/Training

The panels used in the sensory analysis development experimentation and how they were oriented/trained are shown briefly in Table 6.3b. Details can be found under the associated topics.

6.5.6 Methods and Procedures

Methods and procedures were similar to those mentioned in Section 6.4 and are shown in Table 6.3c.

6.5.7 Panel Procedure

Panel procedures for the same group of experiments were similar. Experiments aimed at profiles of the fresh product, DSC-banana, and MP-snack had similar procedures to Section 6.4.6; while experiments aimed at profiles of consumer test products were similar to Section 3.3.3.3 in Chapter 3. Below are the procedures for the profiles of stored products, which were done in two phases.

Table 6.3b: Panel group setting and method of orientation/training the panel.

Panel Group	Panel Members	Panel Orientation/Training
1st lab panel	6 Thai graduate students in Massey Univ. aged from 25-35; 4 females, 2 males.	*Orientation on the tasting method done before the test; meaning of attribute terms explained; examples given by the author.
1st special panel	2 Thai graduate students in Food Tech. Dept. 1 researcher in Food Tech. Research Centre 1 lecturer in Food Tech. Dept.	Similar to *
1st consumer panel	13 Thai graduate students in Massey Univ. (different group from 1st lab panel); 5 females, 8 males.	Similar to *, with further explanation when asked for.
2nd lab panel	6 members of Agro-Industry Faculty staff, Kasetsart University. (4 from Product Development Dept. 2 from Biotechnology Dept. 4 females, 2 males)	Similar to *, (done by the author)
2nd consumer panel	36 school children at SATIT KASET (18 females, 18 males; 4 from each grade level from P1-P6, M1-M3; age ranged from 7-15)	Orientation on the tasting method done before the test; examples given. Meaning of attributes terms explained one at a time during the filling of the form; and further explanation given whenever asked. This was done by the author with the assistance of 4 graduate students in Home Economics Dept.
2nd special panel	6 members (family and friend type) 1 girl (teenage) 2 boys (teenage) 1 housekeeper (female) 1 male adult 1 technical personel in product development dept. in flour factory (female)	Similar to *
Consumer survey	1094 school children (608 females, 486 males; grade level P1-P6, M1-M3; in 6 schools in Bangkok and Nonthaburi.)	None
One member 2nd special panel	1 member (from 2nd special panel)	Discussion on the testing method done before the test.
Process operator panel	2 members (the author and the assistant)	Discussion on the testing method done before the test.

Table 6.3c: Experiment groups based on similarity of method used.

Methods and Techniques Used		Aim of Study	Experiments
Sensory Analysis	Statistical Analysis		
Linear scaling	Analysis of profile data (score, ratio, interval) correlation, ANOV	Profile of fresh product	1, 2, 5, 6, 7, 8, 9
Category scaling	Chi-square analysis Analysis of profile data (ratio) Correlation, T-test	Profile of consumer test product	15, 16, 17, 20
Linear scaling	Analysis of profile data (score, ratio, interval) Yates' and Regression Correlation, ANOV	Profile of DSC-banana	3, 4, 11
Category scaling (scales 1,2,3; and 1,2,...10)	Plackett and Burman Yates' and Regression	Profile of BSE-mungbean	12 13
Linear scaling	Yates' Correlation, T-test	Profile of MP-snack	14
Linear scaling; Category scaling	Analysis of profile data (score, ratio, interval) Yates' and Regression Correlation, T-test	Profiles of stored product	10a-e 18a-e
Descriptive method by further sensory inspection	Descriptive interpretation	Trend of profile of stored product	19

In the phase 1 storage test, a descriptive taste panel form was designed (Appendix 6.4a) for a preliminary test of the stored product and presented to two Thai graduate students in the Food Technology Department at Massey. Important factors gained from this test were that the main modes of deterioration appeared to be a change of colour from a light brown to a deep darker brown, the crumbling and drying of the texture. The comments obtained were used for the preparation of the taste panel form for the storage trial. On each testing day the panel was set up as follows-

: Samples to be used were removed from the constant temperature cabinet and allowed to equilibrate to room temperature.

: Panelists carried out the test at approx. 10:00 a.m.

: Panelists were presented with the form and samples coded with a three digit number; and also with an identified reference sample which had been stored at 4 C.

: A glass of water was also available.

In the phase 2 product storage test, prior to writing the taste panel form, a discussion with the 2nd lab panel was carried out. From the previous storage trial, colour, sweetness, rancidity, dryness, and hardness were selected as the most important attributes affected by deterioration. However, the discussion with the lab panel suggested that-

- : Colour attribute to be omitted because obvious results already been obtained from previous storage test, colour change could be easily observed by self inspection, and colour might influence the flavour judgment of the panel. Thus, it was decided that a red light should be used during the test.
- : Sweetness to remain because it was the most important attribute considered by the child consumer.
- : Rancidity to remain because it was the main mode of deterioration based on previous storage trial result.
- : Dryness to remain because it was considered to be related directly to crumbliness and cohesiveness which was the critical attribute of the product based on the result of the panel test of the LP formulated product.
- : Acceptability to be included to use as the final decision for sensory test.
- : Category segmented-scaling to be used because many samples to be tested at a time. Profiles obtained could still be compared with that of 2nd consumer panel product ideal (SATIT ideal/2).
- : All 14 samples to be tested together at a time. Four reasons given by the panel were: samples could be compared better; not too many questions; number of scales reduced; and not convenient for the panelists to do the test twice a day.

On each testing day, the panel was set up as has been described for phase 1. The exception was that a red light was used for the whole test, and one-third of a 45 g bar coded with a two digit number was used for a sample.

6.5.8 Sensory Inspections of Stored Product

After the systematically planned storage test period, the stored products were further subjectively inspected by one member of the 2nd special panel. Stored product samples were presented to this panelist, who was asked to evaluate the colour, rancidity, and acceptability of the product samples. Where 'obviously increased in' colour intensity or rancidity or 'not acceptable' was found, the mark 'x' was assigned to that sample. Where a 'trend' of those undesirable characteristics mentioned was found, the mark '(x)' was assigned.

6.6 COMPARISON STUDIES

6.6.1 Introduction

The application of different methods and techniques for the sensory analysis of products at different stages of the PD process by different panel groups has been mentioned. It was the purpose of this part of the study to investigate whether the different methods used measured the same thing and whether the different types of panels used had similar patterns of responses to the sensory attributes studied.

6.6.2 Comparison of the Panel Types

6.6.2.1 Aim and Objectives. The aim of the comparison study on the panel types was to relate one group of panels to the others, since all of these groups were used interchangeably during the development of the nutritionally-balanced snack bar by the systematic PD process. The main objectives were to -

: Compare the lab panel and the consumer panel.

: Compare 1st and 2nd panels of a similar type.

: Compare the three types of panels (lab, consumer panel, consumer survey).

: Compare product profiles of 2nd lab panel based on different ideals (own ideal and consumer panel ideal).

The comparisons of the panel types were made using the ratio mean data.

6.6.2.2 Comparison Study Plan. The comparisons of the panel types were made using the ratio mean data. Comparison studies were planned as shown in Table 6.4.

Table 6.4: Comparison study plan on sensory panel types.

Comparison (COMP)		Sensory Analysis Method/Technique Used	Statistical Analysis Method/Technique Used	Product Sample Used
Comparison between lab panel and consumer panel				
COMP 1	1st Lab panel vs 1st Consumer panel	Linear scaling	Ratio Numerical Graphical	1st Consumer test product
COMP 2	2nd Lab panel vs 2nd Consumer panel	Linear scaling	Ratio	1st Consumer test product
Comparison of 1st and 2nd panels of similar type				
COMP 3	1st Lab panel vs 2nd Lab panel	Linear scaling	Ratio	1st Consumer test product
COMP 4	1st Consumer panel vs 2nd Consumer panel	Linear scaling	Ratio	1st Consumer test product
Comparison of three types of panel				
COMP 5	2nd Lab panel vs 2nd Consumer panel vs Consumer survey	Category scaling	Chi-square analysis	2nd Consumer test product
Comparison of product profiles of 2nd Lab panel based on different ideals				
COMP 6	Lab panel ideal vs Consumer panel ideal	Linear scaling	Ratio	2nd Consumer test product

6.6.2.3 Comparison between Lab Panel and Consumer Panel. A comparison between the lab panel and the consumer panel (Table 6.5a) was made using their ratio means for attributes of 1st consumer test product using T-test technique (Appendix 6.5). No significant difference was found in the attributes studied for each pair. Thus, patterns of attribute ratio means were similar for both types of panel. Generally, more similarity was found between the 1st lab and consumer panels than between the 2nd ones. This was indicated by the lower t-value obtained and also by the closer figures for the ratio means of each attribute of the 1st groups of panel who were all adults. Age difference seemed to be the cause for more difference between the 2nd groups of panels. Although, in general, their attribute ratio mean patterns were similar, the ratio means for colour and aroma were much higher for the 2nd consumer panel than for the 2nd lab panel. An exception was for juiciness which was found to be lower than the ideal (0.76) for the 2nd lab panel but was higher than the ideal (1.19) for the 2nd consumer panel.

TABLE 6.5a: ATTRIBUTE RATIO MEANS OF 1ST CONSUMER TEST PRODUCT BY LAB AND CONSUMER PANELS

Attributes	Attribute Ratio Means			
	1st Panel		2nd Panel	
	Lab	Consumer	Lab	Consumer
Colour	1.2	1.0	1.1	1.6
Size	1.0	1.0	1.0	1.1
Sweet aroma	0.8	0.9	-	-
Nut aroma	1.0	1.0	1.0	1.4
Soft-Hard	1.1	1.0	1.4	1.2
Crumbly-Cohesive	1.0	1.0	1.0	1.0
Gritty	1.3	1.2	1.4	1.5
Dry-Juicy	0.9	1.0	0.8	1.2
Nutty flavour	1.0	0.9	1.0	1.1
Sesame flavour	0.8	0.7	1.3	1.1
Mellow-Sharp sweet	1.0	0.9	1.3	1.1
Fruity flavour	0.9	0.6	0.8	0.8
Mungbean flavour	1.1	1.0	1.2	1.1
Acceptability	0.7	0.8	0.8	0.8

1st lab panel = Adult lab panel in N.Z.
1st consumer panel = Adult consumer panel in N.Z.
2nd lab panel = Adult lab panel in Thailand
2nd consumer panel = Child consumer panel in Thailand

Among four critical attributes of this product -- colour, cohesiveness, grittiness, and sweetness -- three were given similar ratio means by the four groups of panels studied. An exception was for colour which was found to be further from the ideal for the 2nd consumer panel. Thus, this comparison indicated that in general all four groups measured the product attributes in the same way.

6.6.2.4 Comparison between 1st and 2nd Panels of Similar Type. Table 6.5a also shows that the consumer panels showed a greater difference in ratio means of nut aroma, grittiness, and fruity flavour than did the lab panels. Age appeared to be responsible for this difference in pattern between the consumer panel results. However, a greater difference in the ratio means of the lab panels was found in soft-hard texture, sesame flavour, mellow-sharp sweetness, and mungbean flavour. Current eating habits seemed to be responsible for the difference of the lab panels.

Though more differences were found in both cases, the pattern of difference was similar for both. For example, for grittiness, the ratio mean was 1.29 and 1.36 for 1st and 2nd lab panel and was 1.21 and 1.51 for 1st and 2nd consumer panel. This comparison result indicated that the 1st and 2nd panel of a similar type gave similar profiles of the product; and this also indicated that the greater the number of panelists the more obvious was the difference from the ideal.

6.6.2.5 Comparison of Three Types of Panels. A comparison of the lab panel, the consumer panel, and the consumer survey was made using the data from the acceptability test of 2nd consumer test product by category scaling (Table 6.5b). The comparison of sample means by a T-test technique indicated that all panels had a similar pattern of attribute ratio means. In this case, the product was judged by the lab panel to be 'just-right' in a discussion among the lab panel. The results from the consumer panel and the consumer survey are mean scores of the individual panelists' scores. The product profile judged by the consumer survey was further from the ideal than that judged by the consumer panel. This suggested that the difference of the sample from the ideal/just right may have depended partly on the numbers of panelists who judged it. There appeared to be a movement away from the ideal/just right with a higher number of panelists.

TABLE 6.5b: ATTRIBUTE SCORE MEANS OF.2ND CONSUMER TEST PRODUCT BY THREE PANEL TYPES

Selected Attribute	Score Means		
	Lab	CP	CS
Colour	(3)	2.6	2.4
Grittiness	(3)	2.8	-
Crumbliness-Cohesiveness	(3)	3.0	3.2
Sweetness	(3)	3.2	3.5

Notes: 1. Lab = Lab Panel; CP = Consumer Panel; CS = Consumer Survey

2. Figures in parenthesis = data from a discussion-type taste panel.

3. Category scale: 1 = too intense; 2 = slightly too intense; 3 = just right; 4 = slightly too weak; 5 = too weak

6.6.2.6 <u>Comparison of Product Profiles of 2nd Lab Panel Based on Their Own "Ideals" and on Consumer Panel "Ideals".</u> A comparison of the product profiles of 2nd lab panel was made using their own ideals and using 2nd consumer ideals. Firstly the panel was asked to score the attributes of 1st consumer test product and their ideal product on the profile test form. On a different day, they were asked to score the same product but this time against the ideal scores of the 2nd consumer panel which were already marked on the profile test form. The result in Table 6.5c proved that the attribute ratio means of the product did not change much when the ideal changed. A major exception was for colour and fruity flavour in which the means from 'own ideal' was higher than 'consumer ideal' for colour and vice versa for fruity flavour. The ideals of the 2nd lab panel and the 2nd consumer panel were in general similar. The major exception was for colour and fruity flavour. The lab panel had a lower colour ideal but a higher fruity ideal, or in other words the child consumer would like the developed product to be more intense in colour but lower in fruity flavour than that of the lab panel.

When the two sets of data were compared to that from the actual consumer panel, it seemed that the use of the consumer ideal on colour and the dry-juicy attribute confused the lab panel judgment. Their judgment on colour and dry-juicy was closer to the result from the consumer panel test (1.7 and 1.1 vs 1.6 for colour, 1.0 and 0.8 vs 1.2 for dry-juicy). More experiments were needed for this comparison study.

TABLE 6.5c: ATTRIBUTE RATIO MEANS OF PHASE 1 CONSUMER TEST PRODUCT BY 2ND LAB PANEL BASED ON DIFFERENT IDEALS

Attributes	Attribute Ratio Means				Child Consumer Panel Ratio (N=30)	
	Own Ideal (N=6)		Consumer Ideal (N=5)			
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Colour	1.7	0.5	1.1	0.3	1.6	0.8
Size	1.0	0.0	1.0	0.0	1.1	0.5
Aroma	1.1	0.4	1.0	0.3	1.4	0.9
Soft-Hard	1.1	0.2	1.4	0.3	1.2	0.7
Crumbly-Cohesive	1.2	0.5	1.0	0.2	1.0	0.3
Gritty	1.5	0.2	1.4	0.1	1.5	0.6
Dry-Juicy	1.0	0.5	0.8	0.2	1.2	1.0
Nutty flavour	1.1	0.5	1.0	0.3	1.1	0.6
Sesame flavour	1.4	0.6	1.3	0.2	1.1	0.5
Mellow-Sharp sweet	1.2	0.6	1.3	0.2	1.1	1.1
Fruity	0.2	0.1	0.8	0.3	0.8	0.7
Mungbean flavour	1.2	0.6	1.2	0.2	1.1	0.5
Acceptability	0.7	0.1	0.8	0.1	0.8	0.2

6.6.2.7 Conclusion on Relation of Results from Different Types of Panels. It was concluded, based on these comparison experiments that -

: The three panel types (five panel groups), used in the PD process for this project, were similar in their opinions on general product attributes and also on the critical attributes. The major exception was for colour and fruit flavour. The consumer panel (child) would like the product to be darker and less fruity in flavour than was desired by the lab panel (adult).

: When a great difference was found between the lab panel ideal and the consumer panel ideal, the consumer panel ideal can be used for the lab panel.

: When very similar ideals were found, the lab panel ideal can be used in their profile test form in order to avoid a confusion problem in understanding the consumer ideal profile.

Thus, in general the lab panel could predict the reactions of the consumer panel and the consumer survey in evaluating the product subjectively. However, for precision on colour and flavour judgment, some form of data adjustment might be needed when applied to different types of panels.

6.6.3 Comparison of the Three Methods of Analysing Linear Scaling Data

6.6.3.1 Aim and Objectives. The aim of the comparison study on profiling analysis methods for linear scaling data was to select the most suitable one for use in the PD process to develop a nutritional product for Thailand. The main objectives were to -

: Compare score, ratio, and interval methods using 'fixed ideal' based data.

: Compare score, ratio, and interval methods using 'moving ideal' based data.

In this study, the 'fixed ideal' was the ideal already assigned on the profile test line in the panel form; and the 'moving ideal' was the ideal to be assigned on the line by the individual panelists. The comparisons of the analysis methods were made using selected data obtained from the experiments shown in Table 6.3a.

6.6.3.2 <u>Comparison between Numerical Profiles Obtained from Score, Ratio, and Interval Data.</u> By comparing the 'fixed ideal' based data in Table 6.6 under the score column, one cannot tell, without an ideal how good the product was, while although under the interval column one can tell the directions of the difference from the ideal by the positive or negative signs, it is difficult to imagine the magnitude of the difference. Thus, in this case, ratio seemed to be the most effective because one can easily tell the directions of difference (<1 or >1) and at the same time can imagine the magnitude.

Similar results on the greater effectiveness of ratio data than interval data, and of interval than scoring data were found on different 'fixed ideal' based data and 'moving ideal' based data shown in Appendix 6.6a,b and 6.6c,d.

6.6.3.3 <u>Comparison of Correlation Coefficients Obtained from Ratio and Interval Data.</u> A comparison of correlation coefficients obtained from ratio and interval data was made on two different bases -- the 'fixed ideal' and the 'moving ideal' basis. For the 'fixed ideal' basis, the correlation coefficients obtained were similar whether the score, ratio, or interval method was used. This was proved by the result on the correlation coefficients of the sensory attributes of the 1st consumer test product by the 1st and the 2nd consumer panel tests (Appendix 6.7a,b).

For the 'moving ideal' basis, the correlation coefficients obtained from the two sets of data were different. The interval data were more sensitive and gave higher correlation coefficients among attributes than the ratio data. This was indicated by the result on correlation coefficients of the sensory attributes of the 1st consumer product by the 1st lab panel, 2nd lab panel, and 2nd consumer panel (Table 6.7 and Appendix 6.8a,b). For example in Appendix 6.8b the acceptability was correlated with the nutty flavour and the mellow-sharp sweet taste using the interval method, while it was correlated with only the nutty flavour using the ratio method.

TABLE 6.6: PROFILES OF LP REFORMULATED PRODUCT BY 1ST LAB PANEL USING THREE METHODS FOR ANALYSING DATA

Sensory Attributes	Profiles by Three Methods		
	Score Mean	Ratio Mean	Interval Mean
Colour	-	-	-
Size	-	-	-
Sweet aroma	4.6	0.9	-0.7
Nutty aroma	5.0	1.0	-0.1
Soft-Hard	5.4	1.1	0.6
Crumbly-Cohesive	5.9	1.0	-0.2
Gritty	4.9	1.2	0.8
Dry-Juicy	5.3	0.9	-0.5
Nutty flavour	6.5	1.0	0.2
Sesame flavour	6.0	1.1	0.4
Mellow-Sharp sweet	4.4	1.0	-0.1
Fruit flavour	3.0	0.8	-0.6
Mungbean flavour	3.5	0.7	-1.8
Acceptability	5.3	0.8	-1.7

TABLE 6.7: CORRELATION COEFFICIENTS OF SENSORY ATTRIBUTES OF THE LP FORMULATED PRODUCT USING RATIO AND INTERVAL DATA (MOVING IDEAL BASED DATA. by adult lab panel in New Zealand)

	Crumbly	Gritty	Dry	Soft-Hard	Fruit Flavour	Mungbean Flavour
Gritty	0.655 0.541					
Dry	-0.180 -0.436	-0.276 -0.258				
Soft-hard	0.714 0.671	0.827* 0.734	-0.576 -0.636			
Fruit-flavour	-0.974** -0.851*	-0.625 -0.850	0.301 0.549	-0.671 -0.892**		
Mungbean Flavour	0.223 -0.033	0.121 0.038	0.223 0.423	0.275 0.081	-0.038 -0.065	
Acceptability	0.627 0.548	0.381 0.358	-0.500 -0.621	0.576 0.660	-0.698 -0.514	-0.433 -0.582

* Significant at 5% level (r ≥ 0.7545; df = 4)
** Significant at 1% level (r ≥ 0.8745; df = 4)
Top figure: Ratio method
Bottom figure: Interval method

The reason for the greater sensitivity of the interval data was thought to be caused by the larger numbers in the interval data. This was one good point of the interval method.

6.6.3.4 <u>Pros and Cons of Score, Ratio, and Interval Methods Based on the Results from the Comparison Experiments.</u> The pros and cons of score, ratio, and interval methods of analysing profile test data based on the comparison studies above are summarized in Table 6.8.

TABLE 6.8: PROS AND CONS OF SCORE, RATIO, AND INTERVAL METHODS OF ANALYSING PROFILE TEST DATA

Pro-and-con attributes	Description of Pro-and-Con Attributes		
	Score Method	Ratio Method	Interval Method
Simplicity	Ideals needed to be shown for difference-magnitude and direction from what desired.	Ideals not needed to be shown for difference - magnitude and - direction from what desired	Ideals not needed to be shown for difference - magnitude, but - or + sign needed for the difference - direction from what desired.
Quickness	Most quick to calculate but most slow to present, read, and interpret.	One step more needed - for calculation, but most quick to present, read, and interpret.	One step more needed for calculation. Though more quick to present, read, and interpret than score method, slower than ratio method.
Sensitivity to Differences	Difference in the limit assigned on the profile test line (0.1-10). Differentiation between 'more different from ideal' and 'more close to ideal; difficult because of different basis of all ideals (as standard).	Difference in multiplying/dividing rate of the limit assigned on the profile test line (0.01-100). Differentiation between 'more different from ideal' and 'more close to ideal' most easy because of similar basis of all ideals which is '1'.	Difference in adding/subtracting rate of limit assigned on the profile test line (-9.9 to 9.9). Differentiation between 'more different from ideal' and 'more close to ideal' easier than score method because of similar basis of all ideals which is '0'.

6.6.3.5 Conclusion on Methods of Analysing Profile Data. The ratio method was the most suitable for analysing the sensory attribute data, 'fixed ideal' based or 'moving ideal' based, to get a product profile, to compare product profiles of different panels used in different steps in the PD process, to compare the product in different steps of improvements (or to study the improvement of the developed product), and to compare the consumer panel opinions with that actually obtained from the consumer survey. The reason for its suitability was because of its simplicity, quickness, and sensitivity to differences.

Some disadvantages were found in the application of the ratio method for analysing profiling data. These included -- less precision for data with small differences and too large a figure obtained when sample and ideal were greatly different. The large values were considered inappropriate when graphical profiles of the sensory attributes of the product were to be used for presentation.

6.6.4 Comparison of the Two Methods of Analysing Category Scaling Data

6.6.4.1 Aim and Objectives. The aim of the comparison study on the two methods of analysing category scaling data was to relate one method to another, since these two methods were suitable for use at different steps of the PD process, or in other words for different groups of panels. The main objectives were -

: To compare the ratio mean and score mean of the category scaling data.

: To investigate the possibility of analysing category scaling data by calculating the ratio means to get the ratio product profile.

6.6.4.2 Comparison Experiment. The comparison of the ratio mean and the score mean was made using the category data obtained from the acceptability test of 2nd consumer test product by 2nd consumer panel and by the consumer survey. For the ratio mean, the 'just right' score (5.0) was used as the ideal; and then the mean of the ratios was obtained by dividing the sample score of each attribute for each panelist by its ideal (or just right) score.

Table 6.9 shows comparisons of the mean profiles of the sensory attributes of the two panels. The data in the table indicated that although the two methods gave similar patterns for the product sensory profile, the ratio means portrayed the profiles of the product by the two panels better than that obtained by score means.

TABLE 6.9: MEAN PROFILES OF SENSORY ATTRIBUTES* BY CONSUMER PANEL AND CONSUMER SURVEY* USING TWO METHODS FOR ANALYSING CATEGORY SCALING DATA

Sensory Attributes	Mean Profiles	
	Ratio Means	Score Means
2nd Consumer Panel		
Colour	1.2	3.4
Grittiness	1.1	3.2
Cohesiveness	1.0	3.0
Sweetness	0.9	2.8
Consumer Survey		
Colour	1.2	3.6
Size	1.1	3.2
Texture (cohesive)	0.9	2.8
Flavour (sweet)	0.8	2.5

* using 2nd consumer test product

6.6.4.3 Conclusion on Analysing Category Profile Scaling. For category scaling data either the score mean or the ratio mean could be analysed to get the profile of the product. However, the ratio mean profile portrays the differences better. Thus, in the PD process, category scaling might be used on a consumer panel which has less capability in sensory analysis and the data obtained could be analysed for product ratio profiles.

6.6.5 Comparison of 1st and 2nd Consumer Test Products

6.6.5.1 Objective The objective of the comparison study between phase 1 and phase 2 consumer test products was to investigate the improvement of the developed product at these two stages of the PD process.

6.6.5.2 Comparison Experiments A comparison of 1st and 2nd consumer test products was made by using the data obtained from the acceptability test of both products by 2nd consumer panel. In this comparison study, only the critical attributes of these products were taken into consideration. These included colour, grittiness, cohesiveness, and sweetness. Since the acceptability tests of the two products were conducted at different stages of the PD process, different scaling methods were used -- linear scale for the 1st product and category scale for the 2nd product. However, an assumption was made on the possibility of the application of ratio profile analysis to category scale data. This was based on the results obtained in Section 6.6.4. Also, a similar assumption was made for interval profile analysis that the ratio of the sample score to the ideal score could be used.

The 2nd consumer test product was found to be much improved and close to or on the ideal. This was shown by the figures being closer to or equal to '1' for the critical attributes in 2nd consumer test product which are shown numerically in Table 6.10 and graphically in Figure 6.3.

Graphical score mean profiles of the two products could hardly show the differences between the two products. The ratio method showed most clearly the differences between the two products. The second stage developed product was much closer to the ideal. The distinctive difference was more apparent in the ratio method. Based on Anderberg (1973), the ratio method designates 'times of difference', while the interval method designates 'units of difference' and scores the order of the objects (Sample and Ideal) along the scale. That means that for the ratio scale, if the intensity of the sample attribute is greater than that of the ideal (S > I), then one may say that it is S/I times greater than I.

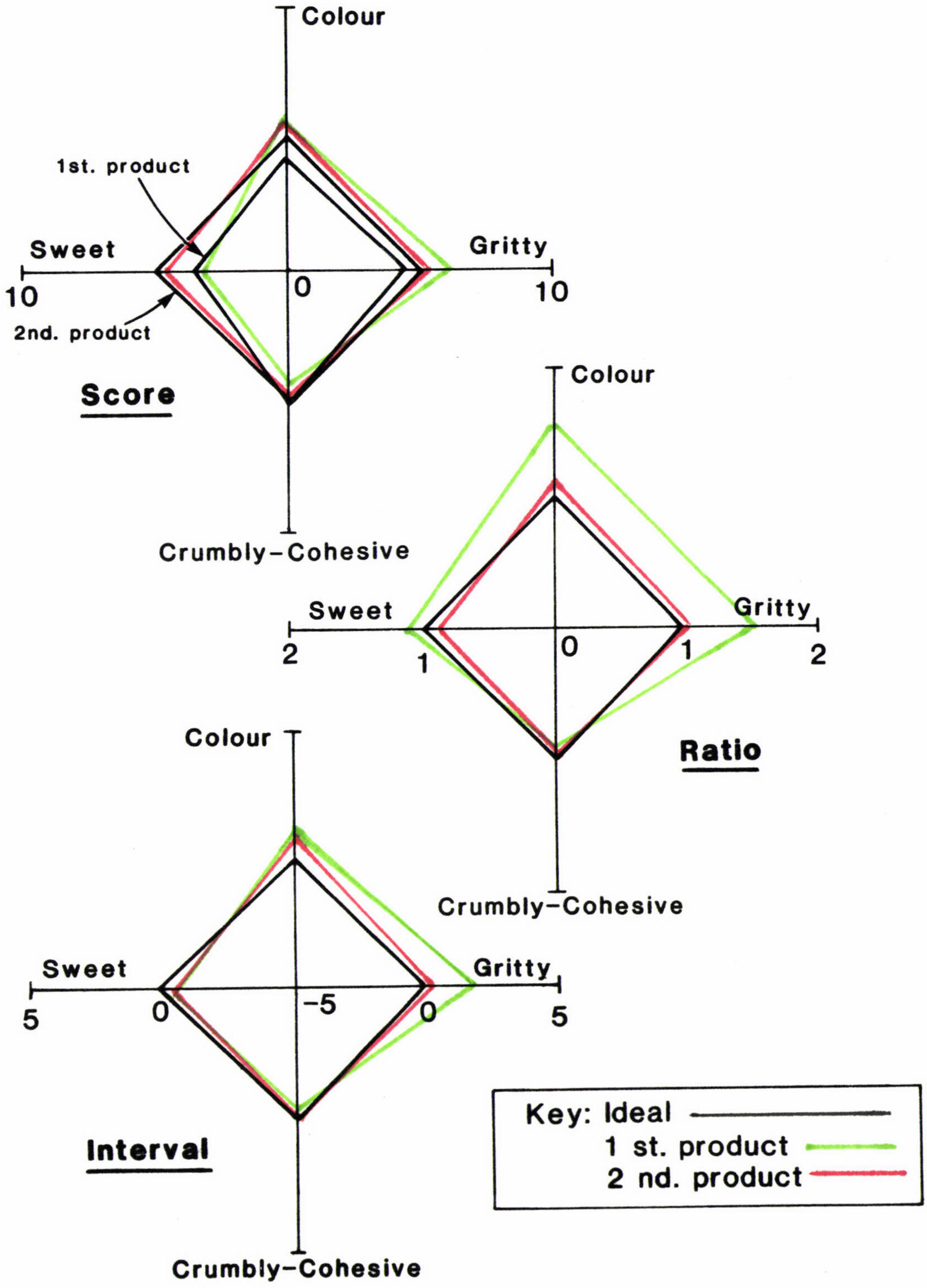


Figure 6.3: Comparison of Sensory Profiles of 1st and 2nd Stage Developed Products by 2nd Consumer Panel Using Three Methods of Analysis

TABLE 6.10: SENSORY ATTRIBUTES MEANS OF 2ND CONSUMER TEST PRODUCT BY 2ND CONSUMER PANEL

Attributes	Means			
	Score		Ratio	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Colour	5.76	1.35	1.15	0.27
Grittiness	5.48	1.15	1.11	0.24
Crumbliness-Cohesiveness	5.00	1.20	1.00	0.24
Sweetness	4.66	1.32	0.93	0.26

When the difference between the ideal (assume the ideal score mean = 5 for each of the four attributes studied) and the 2nd consumer test product sample was investigated by a t-test technique, the result showed that the colour and grittiness of the developed product was statistically different from the ideal ('t' of colour = 3.04** and 't' of grittiness = 2.30*). However, in this PD project where the 'close-to-ideal' ratio mean was considered desirable and where a small improvement was possible during the production stages (e.g. by EVOP technique), no further improvement of the product was considered needed at this stage.

6.6.5.3 Conclusion on Acceptability of 2nd Consumer Test Product. Based on this comparison study, 2nd consumer test product was improved and the product was considered suitable for further consumer survey.

6.6.6 Comparison of the Ideal Product Profiles of Different Panels

6.6.6.1 Objective The objective of the comparison study of the ideal product profiles of different panels was to relate the profile of the 2nd consumer panel (child panel) to the ideals of the 1st and 2nd lab panels.

6.6.6.2 Comparison Experiment A comparison of the 1st and 2nd lab panels and the 2nd consumer panel was made using the data obtained from the acceptability tests on 1st consumer test product. An exception was for 1st lab panel of which the LP formulated product was used. However, the two products were considered to be of the same type and the method and procedures for the generation of the ideal product profiles of the three panels were similar (discussed in Section 6.4).

Table 6.11 shows the ideal product profiles by score means of the 1st lab panel, 2nd lab panel, and 2nd consumer panel. The data on each attribute between panels proved that the three panels had similar ideals on colour, size, and texture (soft-hard, gritty, dry-juicy). An exception for texture was the cohesiveness. Flavour was considered the main part of the difference in the ideals. Among flavour attributes -- nut aroma, nutty and sesame flavour, mellow-sharp sweet, fruit and mungbean flavour -- fruit flavour was the only flavour that was lower than the ideal of the child consumer panel. This confirmed the preference of the child consumer for a fruit product as found in the first survey in Chapter 3. Interestingly, the two 2nd panels held in Thailand had very similar ideals on sensory attributes, while the 1st panel which was held in New Zealand had higher ideal scores. The exception was for fruit flavour (3.6 for 'New Zealand' panel and 4.8 and 4.3 for 'Thailand' panels). The comments given by the 1st panel proved that fruit flavour was not desirable in this type of product because they related this product to 'GRAYASAHT' the typical Thai roasted rice and nut bar. The difference of the 1st from the 2nd group of panels was thought to be based on the difference in their current food habits.

This comparison seemed to prove that it was important to have the ideal product profile generated by representatives of the target consumer. If it proves impossible to get the specified type of panel, it is suggested that a lab panel in a similar current food habit environment should be set up. If this is impossible, e.g. the profile generation has to be conducted overseas, a modification on the ideal profile obtained might be necessary. Information, whether from literature review or a past consumer survey, could be used as the basis for this data modification.

6.6.6.3 Conclusion on Ideal Product Profiles. Ideal product profiles are best generated by representatives of the target consumer. If not available, a panel formed among panelists having current food habits similar to the target consumer is suggested. If panelists used are from a different environment and a modification of the profile obtained from the panel is necessary, information from a past consumer survey or a literature review can be used.

TABLE 6.11: IDEAL PRODUCT PROFILES BY SCORE MEANS OF 1ST AND 2ND LAB PANELS AND 2ND CONSUMER PANEL

Sensory Attributes	Panel		
	1st Lab	2nd Lab	2nd Consumer
Colour	5.0*	4.2	4.4
Size	5.0*	5.1	5.1
Sweet aroma	5.2	-	-
Nutty aroma	5.1	5.0	4.5
Soft-Hard	4.9	4.5	4.5
Crumbly-Cohesive	6.1	5.2	5.1
Gritty	4.1	4.9	4.4
Dry-Juicy	5.8	5.5	5.2
Nutty flavour	6.3	5.3	4.5
Sesame flavour	5.6	4.0	4.3
Mellow sweet-Sharp sweet	4.4	3.2	3.7
Fruit flavour	3.6	4.8	4.3
Mungbean flavour	5.2	4.4	4.3

* adapted from descriptive scores (just right colour and size)

6.7 SETTING UP REFERENCE C.V. VALUES FOR SENSORY ANALYSIS OF DEVELOPED PRODUCT BY PROFILING TECHNIQUE

6.7.1 Introduction

Generally, measures of the variability or spread of the data can be made by such techniqes as range, mean absolute deviation, variance and standard deviation, and coefficient of variation (Chatfield, 1975). In this study, standard deviation was used. A technique called 'coefficient of variation (C.V.)' can be applied for measuring the variability or the spread in relative terms by dividing the standard deviation by the sample mean. Although, in general, a low C.V. value suggests high precision of the data, the variability or the spread of the data still cannot be absolutely judged. This is because the C.V. value depends on the type and method of measurement. Thus, a reference to previous data from a similar experiment is necessary to judge the accuracy of particular experiments.

Therefore, there was a need for reference values for use in the judgment of data variability in profile testing for the beginners in profile test experimenting. It was the purpose of this study to set up the reference C.V. values for the sensory attributes of the developed nutritional product for use in the acceptability judgment of data spread or in other words the variability of opinions among panelists of the same type of panel. These included the lab panel, the consumer panel, and the consumer survey. The reference C.V. values of sensory attributes obtained were expected to be used as the reference values for sensory analysis by profiling techniques of similar products in the PD system.

6.7.2 Method and Procedures

The C.V. value was calculated by dividing the standard deviation by the sample mean of selected representative ratio mean data, and the product was multiplied by 100 to give a percentage. The C.V. values for similar product characteristics were then averaged, and the 'reference C.V. value' was obtained. For example, the data from EXP 1, 2, 5, 7, and 9 were from the product acceptability test by 1st and 2nd lab panels. An assumption was made that both of these lab panels were of a similar type (according to the result in 6.6.3.3). The 'reference C.V. values' were experimentally used for the judgment of variability of similar product characteristics. Mean data with a standard deviation which would give a C.V. value larger than the 'reference C.V.' was considered of a large variability, while that with a standard deviation which would give C.V. values smaller than the 'reference C.V.' was of a small variability.

Table 6.12a is the ratio means together with their standard deviations of product profiles by lab panels, and how the 'reference C.V. values' were obtained. Calculations of reference C.V. values from the consumer panel, the consumer survey, the ideal product profile data, and the storage test data are shown in Appendix 6.9a,b,c,d.

6.7.3 Results

The 'reference C.V. values' for the overall data studied are shown in Table 6.12b.

TABLE 6.12a: RATIO MEANS AND STANDARD DEVIATIONS FOR PRODUCT PROFILES BY LAB PANEL (N=6) AND REFERENCE C.V. VALUES

Product Sensory Attributes	Data										C.V. (%)					Reference C.V. Values (%)
	EXP 1		EXP 2		EXP 5		EXP 7		EXP 9		EXP 1	EXP 2	EXP 5	EXP 7	EXP 9	
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}						
Colour	-	-	-	-	1.2	0.2	1.7	0.5	1.1	0.3	-	-	16.67	29.41	27.27	25
Size	-	-	-	-	1.0	0.0	1.0	0.0	1.0	0.0	-	-	0	0	0	0
Sweet aroma	0.9	0.2	1.1	0.3	0.8	0.1	-	-	-	-	22.22	27.27	12.50	-	-	21
Nut aroma	1.0	0.4	1.2	0.4	1.0	0.2	1.1	0.4	1.0	0.3	40.00	33.33	20.00	36.36	30.00	32
Soft-Hard	1.1	0.7	1.3	0.4	1.1	0.3	1.1	0.2	1.4	0.1	63.64	30.77	27.27	18.18	7.14	29
Crumbly-Cohesive	0.6	0.2	1.1	0.3	1.0	0.1	1.2	0.5	1.0	0.2	33.33	27.27	10.00	41.78	20.00	27
Gritty	1.4	0.4	1.6	0.4	1.3	0.4	1.5	0.2	1.4	0.1	28.57	25.00	30.77	13.33	7.14	21
Dry-Juicy	1.1	0.3	0.9	0.3	0.9	0.1	1.0	0.5	0.8	0.2	27.27	33.33	11.11	50.00	25.00	29
Nutty Flavour	1.0	0.4	1.1	0.3	1.0	0.1	1.1	0.5	1.0	0.3	40.00	27.27	10.00	45.45	30.00	31
Sesame flavour	0.9	0.4	1.1	0.2	0.8	0.2	1.4	0.6	1.3	0.2	44.44	18.18	25.00	46.86	15.38	29
Mellow sweet-Sharp sweet	0.9	0.1	1.0	0.2	1.0	0.1	1.2	0.6	1.3	0.2	11.11	20.00	10.00	50.00	15.38	21
Fruity flavour	1.0	1.5	0.9	0.5	0.9	0.3	0.2	0.1	0.8	0.3	150.00	55.56	33.33	50.00	37.50	65
Mungbean flavour	1.3	0.7	0.6	0.3	0.9	0.2	1.2	0.6	1.2	0.2	53.85	50.00	22.22	50.00	16.67	39
Acceptability	0.7	0.1	0.8	0.1	0.7	0.2	0.7	0.1	0.8	0.1	14.29	12.50	28.57	14.29	12.50	16

σ^{n-1} = S.D.

TABLE 6.12b: REFERENCE C.V. VALUES (%)

Product Sensory Attributes	Reference C.V. Values					
	Ideal Profile		Fresh Product Profile			Stored Product Profile
	LP*	CP**	LP	CP	CS*	LP
Colour	29	39	25	40	25	-
Size	-	31	0	28	-	-
Sweet aroma	23	-	21	33	-	-
Nut aroma	25	40	32	42	-	-
Soft-Hard	23	36	29	49	-	-
Crumbly-Cohesive	23	29	27	35	44	-
Gritty	26	43	21	37	-	-
Dry-Juicy	32	39	15	52	-	12
Nutty flavour	29	27	31	39	-	-
Sesame flavour	27	35	29	44	-	-
Mellow-Sharp Sweet	35	57	21	67	63	11
Fruity flavour	38	51	65	69	-	-
Mungbean flavour	41	35	21	33	-	-
Accept-ability	-	-	16	25	50	12
Rancidity	-	-	-	-	-	16
Hardness	-	-	-	-	-	16

* Lab Panel, N=6

** Consumer Panel, N=30

*** Consumer Survey, N=1094

\- Not investigated

6.7.4 The Application of Reference C.V. Values for Judgment of Standard Deviation Size

An example was given for the application of 'reference C.V. values' on the data of 1st and 2nd lab panels on the 1st consumer test product profile (Table 6.12a EXP 5 vs EXP 9) and the main findings were -

: The 1st lab panel (MU lab panel) had largely different opinions on grittiness (31 vs 21 of reference) and acceptability (29 vs 16).

: The 2nd lab panel (KU lab panel) had minor different opinions on product sample sensory attributes (C.V. for all attributes lower than the reference).

: A comparison of attribute C.V. between the two panels suggested that in general the 1st panel agreed more on flavour than texture while the 2nd panel was vice versa.

: Generally, Reference C.V.s of 20-30% could be assumed for the experiments. Data with C.V.s higher than this could be assumed to have too high a variability and the experiment would have to be repeated or the data analysed further to determine the type of distribution.

6.7.5 Discussion and Conclusion on Use of "C.V." Values

Reference C.V. Values set up could be used as a guide for an examination of 'spread' of the data, or in other words the agreement/disagreement among the panelists. However, these data were considered only suitable for applications when using the data of similar product characteristics from similar panels. Further investigations on this topic was recommended with more systematically designed experiments.

6.8 DISCUSSIONS AND RECOMMENDATIONS ON SENSORY TESTING METHODS IN PRODUCT DEVELOPMENT

The advantage of the ratio method in distinguishing the difference of the sample from the ideal made it well suited for use in the development of profiles in the PD system. It was recommended that the ratio profile analysis be used with the product carefully developed based on the consumer requirement. In this way, the 1st product sample to be tested should already be close to what the consumer required (or the consumer ideal).

A profile test using a line for attribute intensity judgment was suitable for a panel with some level of training, because it was a sensitive scale. For a panel with lower capabilities for sensory judgment, e.g. a young child panel, category scaling should be used. Category scales can be transformed into a 'ratio mean' using the 'just right' score as the ideal. This was believed to be a simple and effective method. For a child consumer panel, a five-category 'just right' scale was considered suitable. Lower numbers of categories resulted in losing discrimination, while a higher number of categories introduced increasing errors.

For the evaluation of a developed nutritional snack bar-like product for Thai children, it was recommended that -

: Ideal product profile be generated by representatives of the target consumer.

: Lab panel be used for prediction of consumer responses.

: Ratio method be used for analysing profiling data. For effectiveness of its application, trained panel was required.

: Either linear or category scaling might be used for child panel; however, the data should be analysed by ratio method.

: A final point of development be set using the 'close to' or 'on' the ideal profile. Subjective judgment based on other concerned factors be used.

: Product quality test be based on subjective method.

: Precision of the experiments be based on C.V. Reference C.V. values could be used as a guide for examination of variability of the data.

: Whenever unusual disagreement was found among the panelists (extremely large C.V.value), an examination of other related analysis of the panel results should take place.

CHAPTER 7

PRODUCT EVALUATION AND PRODUCT QUALITY PREDICTION

7.1 INTRODUCTION

At the present time, product evaluation is a major focus of food product development. The product evaluation conducted at each step of the PD process has been recognised to have an increasingly important role in the scientific aspect of the product development system because it determines the quality of the finished product. There is a need for evaluation of not only the products developed at the different stages but also of the raw materials and the intermediate materials. For every product development project, there is a need for a planned evaluation system.

Product evaluation is usually based on the physical, chemical, physico-chemical, microscopic, microbiological and sensory properties, but, for a nutritional product, nutritional evaluation is also necessary. Undoubtedly, at the commercialisation step, the quality of the finished product is based on the requirements of the buyer. This is considered of the greatest importance, because it is the buyer's requirements which are used as the basis for subjective measurements of quality, and objective measurement results are commonly examined in correlation with the results from the subjective method. Also, evaluation of the storage life of the finished product is necessary.

In Thailand, evaluation of the nutritional products developed by the government sector has been based on chemical and biological testing methods. Though in some cases, acceptability tests were included in the studies, no correlations with other measurements were examined. The application of systematic planned storage tests along with an acceptability evaluation, which is the most important evaluation of any developed food product for commercialization, has been limited. No attempt has been made to build analytical models for predicting product quality during distribution and marketing.

Therefore, the aim of this study was to develop an evaluation system, particularly for products but also for raw materials and intermediate materials, for all stages of the product development process to develop a nutritional product. These included -

: Determination of Nutritional Quality Test
: Determination of Objective Test
: Determination of Microbiological Test
: Determination of Subjective Test
: Determination of Storage Test
: Estimation of product shelf-life and product quality prediction
: Determination of product adjustment based on product quality prediction

Finally, a systematic product evaluation model was to be designed using the overall findings.

7.2 METHODS AND TECHNIQUES FOR EVALUATION OF DEVELOPED NUTRITIONAL PRODUCT

A great number of articles were found on methods and techniques for evaluation of new/developed nutritional products from the nutritional aspect (Roe and Kruther, 1942; Association of Vitamin Chemists, 1966; Harris and Karmas, 1975; Friedman, 1975; Friedman, 1978; and AOAC, 1979 and 1984). Most of the food analysis texts included methods and techniques for evaluating the nutritional properties of the food as well.

Although predictions of nutrient losses through storage tests have been investigated in many studies, few were found on the nutrient loss in a developed nutritional product through planned storage tests (Chittaporn, 1977; Karel, 1979; Labuza, 1981; and FTRC, 1983a and 1983b). The Accelerated Shelf-Life Test (ASLT) was the effective method used as a storage test in their studies. Critical environmental factors were chosen and used as input variables in the designs for the storage tests. The Arrhenius Relationship was the model considered as the best for the shelf-life test, and the mode of food product deterioration was scientifically assigned and used as the basis for the selection of the specific model (equation).

Though in some studies other tests, subjective or objective, were also used during the investigation, none was on the correlation of the different tests in order to determine a systematic model for use in evaluating a new nutritional product for an intervention programme.

In the development of nutritional products in Thailand, methods and techniques for product evaluation were normally applied at the final step for the finished product. These included sensory analysis, proximate analysis, determinations of selected vitamins, minerals, and amino acids, and the bioassay (IFRPD 1970-1982; Nutrition Research Center, 1970-1982; Siegel et al., 1975; Siegel et al., 1976; Chittaporn, 1977; and Ngarmsak, 1983). None of the studies mentioned was on the evaluation of product through a systematic planned design of storage test nor on the prediction of product quality. The emphasis in the studies was commonly on the nutritional properties rather than the combination of nutritional, sensory, chemical, physical, physico-chemical, and microbiological aspects which was considered important to the success of the commercial product development project because it would be beneficial to not only the target consumer but the investor as well.

Protein quality has been measured using various techniques. Each has its advantages and disadvantages. Among techniques best-known to the nutritionists -- chemical score, biological value (BV), net present utilization (NPU), and protein efficiency ratio (PER), chemical scoring was considered simple and inexpensive. The chemical score was defined (Whitney and Hamilton, 1981) as "a rating of the quality of a test protein arrived at by comparing its amino acid pattern with that of a reference protein". Through chemical scoring, the limiting amino acids of the test protein can be identified. However, the chief weaknesses of this technique are that: it fails to predict the digestibility of a protein; it relies on the chemical procedure in which certain amino acids may be destroyed; and it is blind to other features of the test protein such as toxic materials.

7.3 METHODS AND PROCEDURES FOR THE PRESENT DEVELOPED NUTRITIONAL PRODUCT

7.3.1 Methods and Procedures for Product at Different Stages of Development

The methods and procedures for product testing, including intermediate materials, at different stages of development were described in detail in Chapter 2 on "Project Methods". Nutrition quality tests, moisture content and Aw value measurement, microbiological tests and subjective tests were used for the consumer test and the factory products.

7.3.2 Storage Test

7.3.2.1 Introduction. Nutritionally-balanced snack bars had been processed by using local raw materials and appropriate technology existing in Thailand on a cottage factory scale. The product had been packaged in a polypropylene film packet (11.4 x 8.9 cm) to be used for full scale production. Also, an oriented polypropylene laminated aluminum foil packet was used as a comparison.

A preliminary storage trial (Appendix 7.1M) on the 1st consumer test product (product sample produced in New Zealand; moisture content = 11.2%) suggested that the main modes of deterioration of the snack bars were microbiological susceptibility and sensory properties -- colour, rancidity, and maybe hardness or dryness. The predicted shelf-life of the snack bar was over 3 months based on the sensory property and under 3 months based on the microbiological susceptibility. Therefore, the processed product mentioned above was arbitrarily controlled to be $\leq$ 10.2% final moisture content (i.e. at least 1% under that of the previous sample) so as to lengthen its shelf-life from microbiological spoilage.

The aims of this storage test were to confirm the main modes of deterioration of the snack bars and to predict a storage life for the factory product. The data obtained from the product quality prediction was also to be used for the determination of the final product adjustment and for optimising the storage condition.

7.3.2.2 Background. The nutritionally-balanced snack product developed for selling to urban school-age children on the Thailand market will be transported and sold at the temperature and relative humidity (RH) of Bangkok (year mean 28 C, 75% RH; details of monthly temperatures and relative humidities in Appendix 7.2M). The snack bar was made of white sesame seeds, peanuts, mungbean, banana, white sugar, glucose syrup and a nutrient-mix of four vitamins. Preparation of the product was conducted in a situation simulating a typical cottage Thai-snack factory, the type where the products were expected to be produced commercially. The product was processed one week before the start of the storage test. During the week before the storage test, the processed products were stored in a room with air conditioning ($\simeq$ 25 C) during the day time and with no air conditioning ($\simeq$ 25-28 C) during the night time.

7.3.2.3 Experimental Design for Storage Test. For the study of product shelf-life and also for the comparison of different experimental designs in the storage tests, seven different temperature and humidities were used for storing the packets of snack-bars as shown in Table 7.1. From these seven conditions, the results were statistically analysed using Regression and Yates' techniques.

350 snack bars were used for the storage test, 175 bars of which were packaged in a polypropylene (PP) packet, (11.4 x 8.9 cm size; 0.1 mm thickness) and the other 175 bars in oriented polypropylene laminated (OPP) aluminum foil (AF) packets of the same size and thickness. For convenience the 'OPP + AF packet' was referred to as the 'AF packet' in this study.

7.3.2.4 Reference Samples. Reference samples were packed in AF packets and then in sealed cans and held at a cold room temperature of 4 C. The purpose of the reference sample was to provide a standard which could be used to maintain the accuracy of the taste panel over the period of time studied. It was expected that products in aluminum foil packets would keep longer than those in PP packets. It was also expected that the packets at 45C 95% RH would last approximately 4 weeks. Room temperature was also applied in order to be used for the estimation of 'beginning-time' of spoilage under ambient conditions.

TABLE 7.1 : STORAGE CONDITIONS AND THEIR ABBREVIATIONS

Types of Packets	Storage Conditions		Abbreviations
	Temperature	Relative Humidity	
	°C	%	
Polypropylene	25	75	PP 25/75
Polypropylene	25	95	PP 25/95
Polypropylene	35	85	PP 35/85
Polypropylene	45	75	PP 45/75
Polypropylene	45	95	PP 45/95
Polypropylene	35	75	PP 35/75
Polypropylene	Ambient Temperature ($\simeq$ 32°C)	Ambient Relative Humidity ($\simeq$ 72%)	PP Rm temp/Rm RH
Oriented polypropylene laminated aluminium foil (AF)	25	75	Af 25/75
Oriented polypropylene laminated aluminium foil	25	95	Af 25/95
Oriented polypropylene laminated aluminium foil	35	85	AF 35/85
Oriented polypropylene laminated aluminium foil	45	75	AF 45/75
Oriented polypropylene laminated aluminium foil	45	95	AF 45/95
Orineted polypropylene laminated aluminium foil	35	75	AF 35/75
AF + Can	4	Ambient Relative Humidity	REFERENCE

Notes: 1. 35°C/75% RH for plotting the Time/Temperature graph.

2. Ambient temperature and Relative humidity included in the estimation of beginning - time of spoilage (see Appendix 7.2M for temperature and relative humidities of Bangkok).

7.3.2.5 Materials and Equipment for Storage Test.

Equipment:

1 Warming cabinet at 45 C

1 Warming cabinet at 35 C

1 Air conditioned room at 25 C

6 Desiccators

- 3 at 75% RH
- 1 at 85% RH
- 2 at 95% RH
- 1 cold room at 4 C

Materials:

350 packets of snack bars (20 PP packets and 20 AF packets in each desiccator or each condition)

Saturated sodium chloride solution (26.5%; > 31.7 g NaCl per 88.1 ml water) for 75% RH desiccators

Saturated potassium chloride solution (26.5%; > 31.2 g KCl per 86.8 ml water) for 85% RH desiccator

Saturated potassium nitrate solution (28.0%; > 33.4 g KNO_3 per 86.0 ml water) for 95% RH desiccators

7.3.2.6 The Date for Storage Test Study. Packets of snack bar samples were placed in the different conditions stated, on Wednesday 13th February 1985. Samples were removed for quality tests at the specified times. Five packets of each condition were needed at a time for the tests: 1 for a moisture test, 1 for a microbiological test, and 2 for sensory evaluation by 6 panelists. After 21 days, the remaining packets were removed and stored at ambient temperatures and humidities; they were examined for up to 50 days storage. The testing dates are shown in Table 7.2.

Table 7.2 : DATES FOR QUALITY TESTS OF STORED SAMPLES

Dates	No. of days stored	Quality Tests
<u>Systematic storage</u>		
Wed 13th Feb	0	SE, MC, TPC, YM
Mon 18th Feb	5	SE, MC, TPC, YM
Fri 22nd Feb	9	SE, MC, TPC, YM
Wed 27th Feb	14	SE, MC, TPC, YM
Wed 6th March	21	SE, MC, TPC, YM
<u>Further Storage at Ambient Condition</u>		
Fri 15th March	30	SI, MC
Wed 20th March	35	SI
Wed 27th March	42	SI
Wed 3rd April	50	SI, MC

Notes: 1. SE = Sensory Evaluation
MC = Moisture Content Measurement
TPC = Total Plate Count
YM = Yeast and Mold Count
SI = Further Sensory Inspection

2. MC measurement after the planned date was done in ordinary drying oven (Those on planned date by vacuum drying oven).

3. Weekends and holiday led to the unconstant time interval.

7.3.2.7 Methods and Techniques for Quality Testing and Analysis. Quality testing of the stored product was carried out on moisture content, total plate count, yeast and mould count, and sensory profiling analysis. Methods and techniques used followed the descriptions in Section 2.4.2-2.4.5.

7.4 EVALUATION OF PRODUCT AT DIFFERENT STAGES OF DEVELOPMENT

7.4.1 Intermediate-Material Evaluation

The results for the quality test of the intermediate materials during the production of the final products were: % SS of DSC-banana and of B-syrup 85%; % moisture content of BSE-mungbean 12.5-13%. These were within the limits of the constraints. A correlation was obtained between the red colour of the DSC-banana using the taste panel red ratio mean and the reflectance measurement, so that an objective test could be used in the process control instead of the taste panel. Also the compression and extrusion by the INSTRON was compared with the sensory method using ratio chew mean. The results are shown in Table 7.3 and it can be seen that the 'x' and 'y' values had a high correlation with the red ratio mean. Although the 'r' value between Force and Chew was not at a statistically significant level, it did show some correlation and could be used to control the texture of the DSC-banana during processing.

TABLE 7.3: COMPARISON OF SUBJECTIVE TEST AND OBJECTIVE TESTS OF INTERMEDIATE-MATERIALS USING CORRELATION

Comparison (COMP)	Comparison of		Data		r value*	Product Used
	Physical Test	Sensory Test	Physical Test	Sensory Test		
COMP 1	'X' value	Red Ratio Mean	5.0	1.0	-0.927	1st DSC-banana
			5.2	0.8		
			5.9	0.8		
			6.7	0.3		
COMP 2	'Y' value	Red Ratio Mean	6.1	1.0	-0.952	1st DSC-banana
			6.3	0.8		
			6.8	0.8		
			7.6	0.3		
COMP 3	Force (compression & extrusion)	Chew Ratio Mean	8.3	1.0	0.630	1st DSC-banana
			8.4	0.6		
			9.4	0.8		
			9.5	1.2		

$r_2 \geq 0.95$, at 95% level of significance

$r_2 \geq 0.99$, at 99% level of Significance

7.4.2 Nutritional Evaluation

Table 7.4a compares the nutritional evaluation of the products at the major steps in the PD process with the nutritional requirement of the child consumer. The proximate analysis indicated that the final products, whether 1st or 2nd consumer test product or factory product, provided sufficient energy and protein. The energy and protein required in the product by the child consumer were $\geq$ 387 Calories and $\geq$ 7 g respectively per 100 g (Table 5.6 in Chapter 5) while the energy and protein provided by the products were 436 Calories and 13.9 g for 1st consumer test product, 447 Calories and 13.3 g for 2nd consumer test product, and 453 Calories and 16.0 g for the factory product. This partly showed how the product was successfully developed nutritionally based on the nutritional requirement of the child consumer.

Fatty ingredients were increased in the developed product in order to achieve the required energy. In doing this, no upper limit constraint was set for fat. All three final products were higher in fat content than the child requirement (Requirement 9.0; Products 18.3, 18.3; 22.5 g/100 g). This was considered not harmful to the children because the average fat intake of Thai children was lower than the standard.

For the factory product, the high fat content of the product was thought to be the result of the change in the peanut used. The peanut normally used in GRAYASAHT (product of RIN factory) at the factory was used, and this came from a different source from that which was used during the experimentation.

Table 7.4a : NUTRITIONAL COMPOSITION OF PRODUCTS AT DIFFERENT STAGES (in 100 g)

Nutritional Attributes	1st Consumer Test Product	2nd Consumer Test Product	Factory Product	Nutritional Requirement by Child Consumer	
				Minimum	Maximum
Proximate Analysis (g)					
Moisture content	12.15	9.11	12.60	-	-
Fat	18.30	18.27	22.45	9.0	None*
Protein	13.86	13.33	16.00	5.0	None
Carbohydrate (by difference)	53.84	57.36	46.86	-	-
Ash	1.86	1.93	2.09	-	-
Energy (Calories; by calculation)	436	447	453	387	None
Protein Calories/Total calories (% by calculation)	13	12	14	7	None
Specific Nutrients					
Fibre (g)	12.7(Dietary)	1.28(Crude)**	5.27(Crude)***	1.9(dietary)	4.7
Vitamin A (IU)	n.a.	1066.70	n.a.	625	None

* Maximum was opened in order to achieve required energy (initial maximum requirement = 15.0)

** Approximately 3.2 as dietary fibre

*** Approximately 13.2 as dietary fibre

n.a. not available

The 'Ratio Protein Calories to Total Calories (PC/TC)' of the products were similar to that required by the children (Requirement 13%; Products 13, 12, 14).

The dietary fibre of the 1st consumer test product (12.7%) was considered high. Only crude fibre was analysed for the 2nd consumer product and the factory product. However, the results could be related roughly to dietary fibre. According to Whitney and Hamilton (1981), "The fibre that remains in the human digestive tract after the body's normal action on food is known as dietary fibre. For every gram of crude fibre in a food, there are probably about 2 or 3 grams of dietary fibre". Thus, the average figure of 2.5 was used as a factor for relating the crude fibre obtained to dietary fibre. The results were 3.2 g/100 g for the 2nd consumer test product and 13.2 g/100 g for the factory product.

It was considered at this stage that the dietary fibre in the 2nd consumer test product was at the level required by the children, while the other two products were rather high. The result of the 1st consumer test product was in doubt because when the analysis was taken (over 6 months after production), the product was mouldy. This might have affected the result. As for the factory product, this figure was a rough approximation by calculation using the factor mentioned above. There is a need to determine the dietary fibre in the developed product because it appeared slightly high for young children.

The result for vitamin A (1066.7 IU compared to 625 IU for the requirement) suggested that the developed product was much higher in this vitamin than the requirement. It seemed that the addition of this vitamin during the preparation was not necessary.

An attempt was made to determine the level of vitamin C. However, it was not possible to adapt a standard method to suit this product during the time of nutrient analysing. A reliable result could not be obtained.

Although one determination was made for amino acids, replication could not be done. However, the results (Table 7.4b) obtained were used as a guide to the amino acid profile of the developed product, and also were used for the chemical-score calculation (Appendix 7.1). The results in Table 7.4b suggested that the protein pattern of the developed product was reasonably similar to that of the reference protein. The major exception was for isoleucine (Reference pattern 32; Product pattern 18). A rating of the quality of the product protein by the chemical score method suggested that isoleucine tended to be a limiting amino acid of the developed product. However, this needs further study before a final conclusion could be made.

TABLE 7.4b: AMINO ACID COMPOSITION OF DEVELOPED PRODUCT
(Protein Content 17.0%)

Essential Amino Acids*	2nd Consumer Test Product mg/100g product	2nd Consumer Test Product Protein Pattern value mg/g total protein	Reference*** Protein Pattern Value mg/g total protein
Isoleucine**	304	18	32
Leucine	934	55	56
Lysine	684	40	44
Phenylalanine) Tyrosine)	639) 381) 1020	60	48
Cystine) Methionine)	144) 188) 332	20	28
Threonine	473	28	32
Tryptophane	170	10	8
Valine	483	28	40

* The non-essential amino acids were: Arginine = 1534; Histidine = 449; Alanine = 603; Aspartic acid = 1406; Glutamic acid = 2535; Glycine = 657; Proline = 518; Serine = 719.mg/100g product.

** Limiting amino acid (Chemical score = 45 by 'A/T' method and = 62 by 'A/E' method).

*** Minimum requirement set at the level of 80% of the FAO/WHO (1973) amino acid pattern.

7.4.3 Microbiological Test, Objective Test, and Subjective Test of Products

In this part, the results of the objective and subjective tests are only for the final products and the stored products. The results of the objective and subjective tests of the intermediate/finished product during the formulation and process development steps can be found in Chapter 5 on Formulation and Process Development and Statistics, and in Chapter 6 on Sensory Analysis Development and Statistics.

The raw data obtained from the taste panels are shown in Appendix 7.3M, while their means and standard deviations are shown in Appendix 7.2a. Moisture contents of stored products are shown in Appendix 7.2b, and total plate count in Appendix 7.2c. Also, the changes of the stored product mean profiles are shown diagrammatically in Appendix 7.2d for a better visualization of the changes caused by treatments under the 2x2 factorial design with the centre point included.

Table 7.5 compares the critical attributes of final products with those specified in the constraints set at the previous steps of development. The Total plate count of the three final products was below the critical point generally acceptable, while no colony of yeast or mould was found on consumer test product. The result of this microbiological test suggested that the product developed was acceptable microbiologically.

The 2nd consumer test product was the right quality for moisture content (9.11%) and water activity (0.722) based on the final developed constraint set according to the 1st consumer test result (< 10.2% for moisture content and < 0.78 for water activity), but the factory product was slightly high in moisture and water activity. Different equipment (e.g. mixer type) and personnel (e.g. unfamiliar with the techniques used for this product) used in the factory were thought to be responsible for this lower quality result.

TABLE 7.5: COMPARISON OF CRITICAL ATTRIBUTES OF FINAL PRODUCTS AND CONSTRAINTS

Critical Product Attributes	1st Consumer Test Product	2nd Consumer Test Product	Factory Product	Product Specification in Final Constraint
Microbiological Test				
Total plate count (colonies/g of product)	1.0×10^3*	1.4×10^3	3.8×10^3	$< 10^6$**
Yeast and mould count (colonies/g of product)	-	none	1.8×10^3	$< 10^5$**
Objective Test				
Moisture content	11.20	9.11	12.60	$\leq$ 10.2
Water activity	0.78	0.722***	0.782***	< 0.78
Subjective Test****				
Colour ratio mean	1.6	1.2	0.9	1.0
Size ratio mean	1.1	1.1	-	1.0
Texture ratio mean	1.0 (cohesiveness) 1.5 (grittiness)	0.9	0.8 (cohesiveness) 1.1 (grittiness)	1.0 1.0
Flavour ratio mean	1.1	0.8	1.0	1.0
Acceptability ratio mean	0.8	0.6	-	1.0

* TPC at Day 18 of product stored at 25°C/75% Rh

** Number of colonies generally acceptable for food.

*** Aw of products kept in refrigerator for 9.5 months for 2nd Consumer test product (Moisture Content = 10.9%) and for 7.5 months for factory product (Moisture Content = 12.9%)

**** by 2nd Consumer panel for 1st consumer test product
by consumer survey for 2nd consumer test product. Figures in parenthesis were score means using category scaling by 2nd lab panel for factory product.

\- not investigated

Since the moisture content of the factory product was higher than that of the constraint, it is considered important to control the moisture content of the product in the factory conditions. Two possible solutions are to keep down the %SS of DSC-banana used for the product and to set a suitable end point for the mixing of the ingredients during heating.

Comparison of the sensory attribute ratio means of the three final products with those of the ideal suggested that the products were, though not at, close to the ideal. The developed products were considered acceptable to the consumer panel for 1st consumer test product, to the consumer survey for 2nd consumer test product, and to the lab panel for the factory product.

7.4.4 Conclusion on Quality of Final Product

In conclusion, the final developed product was near the right quality for critical attributes, including energy, protein, moisture content, water activity, and sensory quality (colour, size, texture, flavour, and acceptability).

7.5 PRODUCT EVALUATION DURING DETERMINATION OF STORAGE LIFE

7.5.1 The Change of Stored Product Ratio Profile with Time

Sensory ratio profiles of product samples stored at different periods of time are graphically shown in Figure 7.1. These were the averaged results from all treatments at the same period of time. The main findings were -

: Dryness and hardness had a similar pattern of change during storage. At Day 5 the stored product was rather dry and hard, but with a longer storage time it was found to soften and become more moist in these two texture attributes. The dryness and hardness at Day 5 lowered the product acceptability. However, when the product texture attributes softened and became more moist at later dates of storage, the acceptability improved. At Day 14 where the product was found similar to that of Day 0 for hardness, the acceptability score was close to the ideal.

: Sweetness had a similar pattern of change during storage to that of hardness and also dryness except at Day 14. When the dryness and hardness increased, the sweetness of the product decreased.

: Acceptability had a pattern of change during the early part of the storage very similar to hardness and slightly less similar to dryness.

: Rancidity was increasing with time, but did not affect acceptability until Day 21 when acceptability decreased again. The rate of change was faster for rancidity than for acceptability.

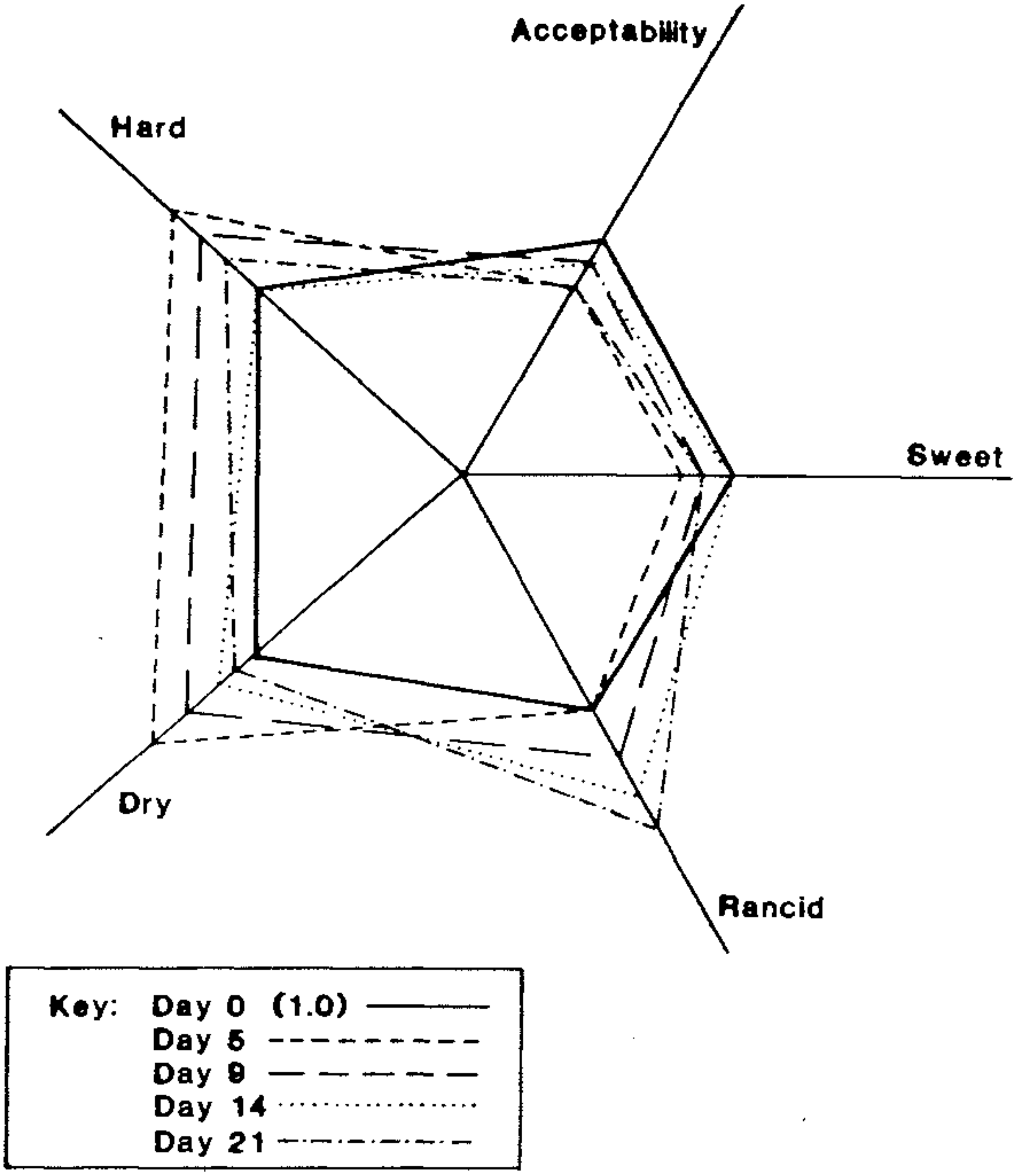


Figure 7.1: Ratio Profile Change of Stored Product with Time

Further analysis by a T-Test (Appendix 7.3a) indicated that the sensory attributes at Day 0 were significantly different for sweetness, rancidity, and hardness, from those at Day 9 and later, but for dryness and acceptability from those at Day 5 and later.

The result from this experiment indicated that for short term storage, dryness and hardness were 'problem' attributes for the stored product, while in the long term the rancidity reduced the acceptability of the product. Thus, an improvement in storage conditions to prevent deterioration of these 'problem' attributes in the product, especially that of rancidity, was considered necessary.

7.5.2 Changes of Profiles of Stored Products in Different Packages and at Different Storage Temperatures

The sensory mean profiles of product samples stored for 21 days at 25, 35, 45 C and 75% RH were compared graphically with those at 4 C and those at Day 0 (Figure 7.2). This figure showed that product sensory attributes deteriorated with the temperature of storage, whether the product was packed in polypropylene or laminated aluminum foil packet. Although the detrimental effects were not parallel with the storage temperature, they were in a similar pattern. That is at Day 21 of storage, the product had decreased in sweetness and acceptability and increased in rancidity. For the product stored at 25 C, dryness and hardness were found to be similar to those at Day 0 but for those stored at 35 C and 45 C there was a slight increase in dryness and hardness.

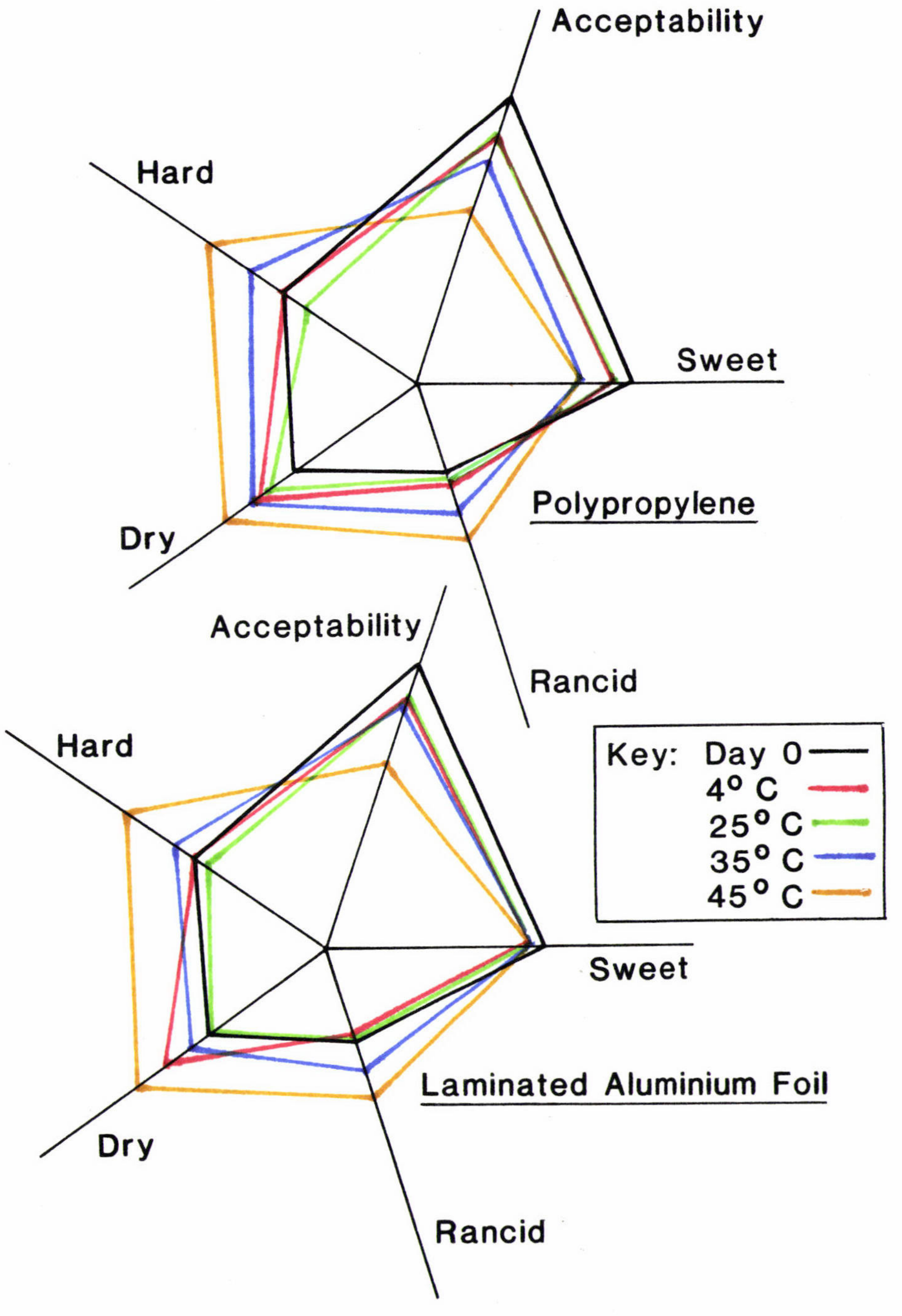


Figure 7.2: Sensory Mean Profiles of Product Samples Stored 21 days at 75% RH and at Different Storage Temperatures and in Different Packages Compared with the Profile at Day 0 and of Product Stored at 4°C.

It seemed that product stored at 25 C was more suitable for use as a reference for product texture testing. At 4 C, the temperature was too low for this product which was an intermediate moisture food, and therefore it damaged certain sensory attributes of the product especially the texture (dryness and hardness). Thus, a storage temperature of 4 C was considered suitable only for the testing of rancidity and acceptability of the product, while 25 C was suitable for the texture test.

7.5.3 Comparison between Reference and Samples of Other Storage Conditions

Comparison was made between reference (4 C) and samples of other storage conditions using sensory test and objective test data and using T-test technique (Appendix 7.3b). The data for the T-test was the average of the five-day data from the storage tests (Day 0, 5, 9, 14, 21). The reason of the averaging was to smooth out the raw data. Table 7.6 shows selected T-test results. The main finding from this table was that the reference sample was significantly different in dryness and acceptability from the samples stored at the following conditions.

: 45/75 and 45/95 C/%RH; PP or AF packet.

: 35/75, 35/85, and Ambient/Ambient C/%RH; PP or AF packet; The exception was for sample at 35/75 C/%RH in AF packet.

TABLE 7.6: COMPARISON BETWEEN REFERENCE AND SAMPLES OF OTHER STORAGE CONDITIONS

Storage Conditions of Samples	t-value (reference vs sample)						
Package, °C/% R.H.	Sweetness	Rancidity	Dryness	Hardness	Acceptability	Moisture Content	Total Plate Count
PP 25/75	-1.26	0.41	1.68	0.60	-2.06	-0.30	-1.36
25/95	-1.78	1.56	1.16	0.40	-2.06	0.23	-1.02
35/85	-1.32	1.54	3.04*	1.98	-2.75*	-0.03	-1.36
45/75	-2.85*	2.59	3.04*	3.11*	-3.81*	-0.39	-1.62
45/95	-1.93	2.36	2.89*	1.29	-3.74*	0.38	-1.09
35/75	-2.16	1.63	2.64*	2.36	-3.07*	0.89	-1.72
Ambient/Ambient	-1.91	1.32	3.14*	2.96	-3.04*	0.05	-3.04*
AF 25/75	-1.32	-1.58	0.81	-0.20	-1.80	-1.04	-1.70
25/95	-2.30	0.64	2.23	-0.44	-1.63	0.22	-1.29
35/85	-1.73	2.41	1.82	1.98	-3.19*	-0.90	-1.27
45/75	-1.77	2.46	3.44*	2.35	-3.52*	0.31	-2.05
45/95	-2.30	1.77	2.82*	3.88*	-3.50*	0.18	-1.69
35/75	-1.79	1.90	1.92	3.09*	-3.0*	0.18	-1.23
(4/Ambient = Reference)[2]							

[1] Data for T-test: Averaging from 5 days of storage (Day 0, 5, 9, 14, 21)

[2] Packed in AF and sealed can. * Statistically different at 95% level.

The ambient temperature and relative humidity of Bangkok during the test was approximately 30/75 C/%RH (range 22-36 C; 50-90% RH; shown in Appendix 7.2M). Thus, based on the main findings above, it could be concluded that in the range of relative humidity studied (75-95%), the temperature of 35 C or higher made the stored product, PP or AF packed, dryer and less acceptable (see raw data in Appendix 7.3M). However, this was not true for the bars in AF packets stored at 35/75 C/%RH. These bars were similar in sensory attribute characteristics to those stored at 4 C which were used as reference samples.

This finding indicated that the dryness and acceptability of the product did depend on the storage temperature. A suitable temperature for storing the product, PP or AF packed, seemed to be 25 C or slightly lower at any relative humidity in the range of 75-95%. However, there was a need to detail the effects of temperature and relative humidity on product attributes.

7.5.4 Significant Effects of Input Variables on Product Sensory Attributes

The main effects at Day 14 of input variables -- temperature and relative humidity -- on stored product sensory attributes by Yates' and Stepwise Regression analysis method are summarized in Table 7.7a, while the detail on significant effects and significant models by the two methods are shown in Appendix 7.4a,b. Day 14 data was chosen for this study because it appeared that the difference in the 'effects' of all treatments started to become apparent at Day 14. At Day 21 the deteriorations were so strong that most of the products had noticeably changed, and the 'effects' of all treatments looked similar. The determination of the significant effects at Days 5, 9, 14 and 21 is shown in Appendix 7.4M and the complete factorial analysis Appendix 7.5M.

The significance by the stepwise regression method indicated that temperature did have a strong effect on the rancidity, dryness, acceptability, and moisture content of the stored product in the PP packet at Day 14. This was also true when Yates' analysis was applied. The exception was for the total plate count. For the AF packet, the effect was rather from the interaction of both variables. However, temperature was found to have more effect by Yates' analysis.

TABLE 7.7a: MAIN EFFECTS OF STORAGE CONDITIONS AT DAY 14 BY YATES' AND STEPWISE REGRESSION ANALYSIS

Product Attribute	Main Effects: Yates'	Main Effects: Stepwise Regression
PP Packet		
Sweetness	-	-
Rancidity	(T)	T
Dryness	(T)	T
Hardness	(RH)↓	-
Acceptability	(T)↓	T↓
Moisture Content	(T)	T
Total Plate Count	(T)↓, (INT)	-
AF Packet		
Sweetness	-	-
Rancidity	(T)	INT
Dryness	(T)	INT
Hardness	(T)	INT
Acceptability	(T)↓	-
Moisture Content	(T)↓, (INT)↓	
Total Plate Count	(T)↓	T↓ RH, INT

NOTES

1. T = Temperature; RH = Relative Humidity; INT = Interaction
2. PP = Polypropylene; AF = Oriented polypropylene laminated aluminum foil
3. Character in parenthesis = trend of significance by an 'estimate' in Yates' technique (on experiment without replication)
4. ↓ = inverse effect

TABLE 7.7b: SELECTED MODELS FOR OPTIMISATION OF TEMPERATURE FOR PRODUCTS IN PP PACKETS AND PREDICTED ATTRIBUTES AT 25°C

Attributes	Selected Models	Predicted Attribute Score at 25°C	Actual Attribute Score: 25°C/75%RH	25°C 95%RH	Ambient/Ambient
Rancidity	$\hat{Y}$ Day 14 = 2.00 + 0.35 X_1				
	$\hat{Y}$ Day 14 = 0.775 + 0.035 X_1	1.7	1.5	1.8	2.0
Dryness	$\hat{Y}$ Day 14 = 2.85 + 0.35 X_1				
	$\hat{Y}$ Day 14 = 1.625 + 0.035 X_1	2.5	2.5	2.3	3.0
Acceptability	$\hat{Y}$ Day 14 = 3.20 - 0.5 X_1				
	$\hat{Y}$ Day 14 = 4.95 - 0.05 X_1	3.7	3.7	3.7	3.0
Moisture Content	$\hat{Y}$ Day 14 = 9.97 + 0.24 X_1				
	$\hat{Y}$ Day 14 = 9.13 + 0.024 X_1	9.7	9.6	9.8	10.7

Notes:

1. Top model = Coded; Bottom model = Uncoded
2. X_1 = Temperature (high = 45°C; low = 25°C)
   X_2 = Relative humidity (high = 95%; low = 75%)
3. Expression for uncoding-factor:

$$\text{Coded value} = \frac{\text{Actual value} - \frac{\text{High} + \text{low}}{2}}{\frac{\text{high} - \text{low}}{2}}$$

These findings indicated that rancidity and dryness were the main product attributes affected by storage conditions especially by temperature for the bars in the PP packet. Therefore, there was a need to optimize temperature variables in order that the developed product could be kept approximately 3 months.

7.5.5 Selected Significant Models

Table 7.7b are models from Appendix 7.4a (Yates' analysis) selected for use in the optimisation of temperature for products stored in the PP packet. Models from Yates' analysis were chosen since this technique was expected to be used by the average product developer because of its simplicity. Only the PP packet, which was the type of packet in the concept, was included in this investigation. Since temperature had detrimental effects on rancidity, dryness, and acceptability, the lowest temperature level in the experimental design (25 C) was chosen for subjection to the uncoded models. The predicted attribute values indicated that in the range of temperature and relative humidity studied the product in PP packet stored at 25 C would remain in better quality than that at room temperature (designated by 'Ambient/Ambient' in the Table). The comparison of these prediction results with those of the actual attribute scores at 25 C 75% RH (also shown in the Table) indicated that the models used were reasonably accurate (proved by similar results obtained). These findings on predicted attributes were to be used in comparison with shelf-life estimation.

7.5.6 Changes in Moisture Content During Storage

The moisture content of the product before storage was within the limits set, but the change in moisture content could not be studied in detail during storage because of the fluctuating results obtained (Appendix 7.2b). Leakage of packets perhaps caused by the high storage temperature seemed to be the main reason for the fluctuations.

7.5.7 Conclusion on Product Quality During Storage

In conclusion, the quality of the sensory attributes of the final developed product were not retained in storage. Thus, there was a need for a further study on how long these attributes retained their quality, or in other words, an estimation of shelf-life and product quality prediction. Since, in the long term, rancidity was the 'problem' attribute which reduced the acceptability of the product, rancidity and acceptability were the sensory attributes chosen for the study of product shelf-life.

7.6 ESTIMATION OF SHELF-LIFE AND PRODUCT QUALITY PREDICTION

7.6.1 Introduction

The main aim behind the storage test of the developed snack product in this study was to analyse the data obtained from systematic planned storage tests so as to produce an estimate of the product shelf-life and finally to determine the adjustment needed to the product to improve the storage life.

7.6.2 Determination of the 'k' Value

Using the assumption that the Arrhenius Relationship holds for degradation at elevated temperatures, Shelf-life Plots were prepared using selected attribute scores, acceptability and rancidity, from the sensory evaluation panel. It was assumed that it was a first order relationship so the following equation was used.

$$\ln N/N_o = -kt$$

Where N_o = Initial sensory score for the attribute
N = Sensory score for the attribute after time 't'
k = Rate of deterioration of the attribute studied
t = Time

Selected attributes for the study were rancidity and acceptability. Therefore the data obtained for these two attributes were rearranged for the purpose of shelf-life estimation as shown in Appendix 7.5a,b. In brief, the data was divided into two sets as follows:

1st set of data: (Appendix 7.5a)
1. Polypropylene packets (PP)
   at 75% RH
   at 25, 35, 45 C
2. Laminated aluminum foil packets (AF)
   at 75% RH
   at 25, 35, 45 C

2nd set of data: (Appendix 7.5b)
1. PP
   at 95% RH
   at 25, 45 C
2. AF
   at 95% RH
   at 25, 45 C

The assumption was made that a 'slightly unacceptable' product (score 1.9) was considered to be the 'reject point' for the acceptability of stored product and a 'slightly present' product (score 2.5) for the rancidity. As some of the products were not rancid or unacceptable at the end of the 21 days storage test, the results were extrapolated until the 'reject point' was reached. Extrapolation from the actual data was made using the 'standard quick method of Labuza' (Labuza, 1981) in order to obtain the time necessary to reach the 'reject point' value.

Therefore at reject time 't',

for acceptability: N/No = 1.9/4.2 = 0.453

for rancidity: N/No = 2.5/1.3 = 1.923

'k' was calculated using these values and the predicted storage times 't' for each storage condition. Calculations were divided into 2 sets as follows -

: Calculation of 'k' values using data at 75% RH (Appendix 7.6a)

: Calculation of 'k' values using data at 95% RH (Appendix 7.6b)

7.6.3 Linear Plots and Main Findings

Linear plottings were made for 'k' values against the reciprocal of the temperature in K (1/T). This was not the 'true k', but it was the 'k' at that certain temperature only. Thus in this study, that certain temperature was subscripted to 'k', e.g. 'k25', in the description. A comparison was made between linear plots at 75% RH and those at 95% RH. The plottings were divided into two sets as follows -

: Linear plots of 'k' values using rancidity scores for shelf-life estimation of PP and AF bar-packets based on -- 75% RH; 25, 35, 45 C and 95% RH; 25, 45 C (Figure 7.3a).

: Linear plots of 'k' values using acceptability scores for shelf-life estimation of PP and AF bar-packets based on -- 75% RH; 25, 35, 45 C and 95% RH; 25, 45 C (Figure 7.3b).

The lines were determined using a linear regression for the 75%RH 'k' values (see Appendix 7.6M) and by connecting the two points obtained at 95% RH. The main findings from Figure 7.3a,b were-

: In general, PP and AF packets gave a similar pattern of product quality deterioration with temperature. The higher the storage temperature the greater was the deterioration.

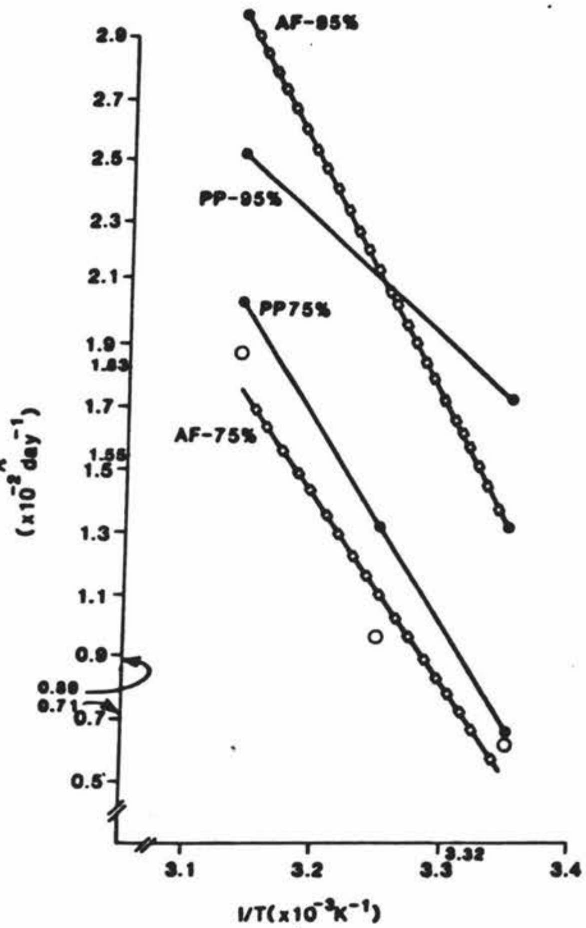


Figure 7.3a: Linear Plots of 'k' Values Using Rancidity Scores for Shelf-Life Estimation of the Bars in PP and AF Packets at 75, 95% RH and 25, 35, 45°C.

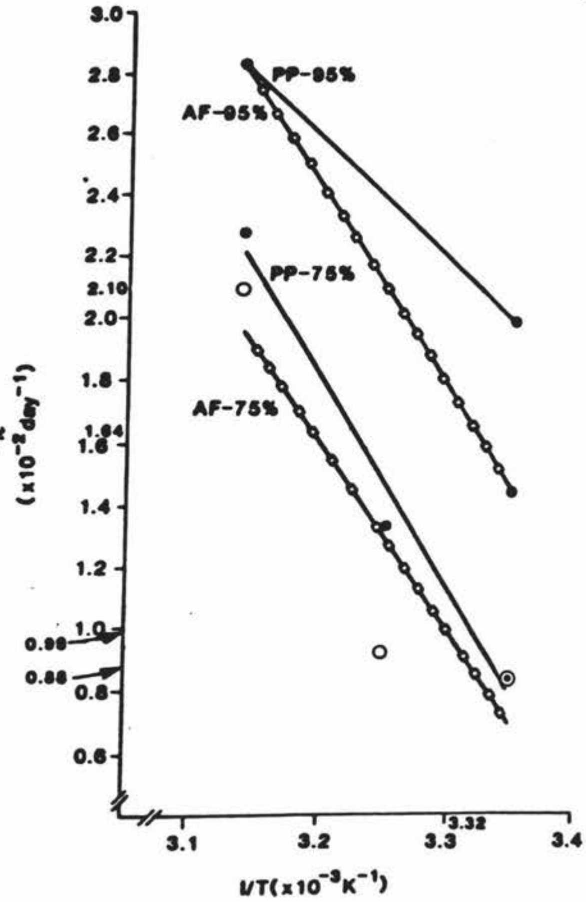


Figure 7.3b: Linear Plots of 'k' Values Using Acceptability Scores for Shelf-Life Estimation of the Bars in PP and AF Packets at 75, 95% RH and 25, 35, 45°C.

: Generally, there was little difference between PP and AF at 75% RH. At 95% RH the product in AF was better than that in PP at lower temperatures but at the high temperature of 45 C, the acceptability of the products in both packets appeared to be similar. The high temperature might have caused leakage with this type and thickness of AF packet. However, these results at 95% RH were based on only two-point observations.

: Relative humidity definitely affected the acceptability and rancidity of the stored product. The product kept longer at the lower relative humidity of 75% RH than at 95% RH.

: Thus, because of the similar rates of deterioration of the products in the AF and PP packets, it was decided that as PP was cheaper, it could be chosen for packaging the product.

7.6.4 Calculation of Shelf-Life

Shelf-life at a typical Bangkok temperature of 28 C was calculated using the linear plots for both rancidity and acceptability and tabulated for comparison in Table 7.8. The calculations follow the following example on the linear plots of 'k' values using acceptability scores for shelf-life estimation of the bars (Figure 7.3b). The 'k28' value of the bar in PP packet stored at 75% RH and at 1/T of $3.32 \times 10^{-3} \times K^{-1}$ (or at temperature of 28 C), was as follows:-

$$'k28' = -0.99 \times 10^{-2} \text{ day}^{-1}$$

From formula:

$$\begin{aligned} \ln (N/No) &= kt \\ \ln (1.9/4.2) &= -0.99 \times 10^{-2} \times t \\ \ln 0.453 &= -0.99 \times 10^{-2} \times t \\ -0.792 &= -0.99 \times 10^{-2} \times t \\ t &= -0.792/(-0.99 \times 10^{-2}) \\ &= 80 \end{aligned}$$

Thus, shelf-life at 28 C 75% RH of the bars packed in PP would be approximately 80 days by prediction.

TABLE 7.8: CALCULATION OF SHELF-LIFE AT 28°C OF STORAGE TEMPERATURE BASED ON SELECTED PRODUCT ATTRIBUTE QUALITY

Packets	k (day^{-1})	ln(N/NO) = kt	t (days)
		Based on Rancidity	
		(1) At 75% RH; 28°C	
PP	0.89×10^{-2}	ln (2.5/1.3) = $0.89 \times 10^{-2} \times t$	74
AF	0.71×10^{-2}	ln (2.5/1.3) = $0.71 \times 10^{-2} \times t$	92
		(2) At 95% RH; 28°C	
PP	1.83×10^{-2}	ln (2.5/1.3) = $1.83 \times 10^{-2} \times t$	36
AF	1.55×10^{-2}	ln (2.5/1.3) = $1.55 \times 10^{-2} \times t$	42
		Based on Acceptability	
		(1) At 75% RH; 28°C	
PP	-0.99×10^{-2}	ln (1.9/4.2) = $-0.99 \times 10^{-2} \times t$	80
AF	-0.88×10^{-2}	ln (1.9/4.2) = $-0.88 \times 10^{-2} \times t$	90
		(2) At 95% RH; 28°C	
PP	-2.10×10^{-2}	ln (1.9/4.2) = $-2.10 \times 10^{-2} \times t$	38
AF	-1.64×10^{-2}	ln (1.9/4.2) = $-1.64 \times 10^{-2} \times t$	48

The results in Table 7.8 indicated that the product in an AF packet kept approximately 11-20% longer than that in a PP packet from the point of its rancidity and acceptability attributes. This table also showed that the developed product would keep 80 days based on product acceptability by using the PP packet and by storing at 75% RH 28 C (compared with the constraint of 90 days). This was based on the pessimistic assumption of the 'reject point' for the sensory attributes studied. The bars in the AF packet could keep 90 days at 75% RH 28 C. However, all the bars could retain their sensory quality less than 50 days when stored at 95% RH. These types of packets could not protect the developed product from high relative humidities and high temperatures. Since this was based on only two-point observations, further study based on three-point observations and the use of linear regression to obtain the 'k' values was needed to confirm this finding.

Because when the temperatures and relative humidity increase, the product quality decreases, the product should be protected from high temperature and relative humidity. Vacuum packing is one possibility. Using double bags of PP type is another way to retain the product at Aw below 0.78. Good sealing is considered necessary for the developed product.

7.6.5 Comparison between Calculated Shelf-Life and Further Sensory Inspection Result

7.6.5.1 Objectives. The objectives of the comparison between calculated shelf-life and further sensory inspection results at ambient storage under Bangkok conditions were -

: To check the accuracy of the shelf-life prediction method.

: To determine the most suitable matrix of data used for shelf-life prediction.

7.6.5.2 Comparison Experiment. A comparison was made on the rancidity and acceptability attributes of the product. The data used for the calculation of shelf-life was from the results of two matrices of data, namely at 75% RH and at 95% RH (Table 7.8). These were compared against the results of the further sensory inspection (Appendix 7.7) on rancidity and acceptability which was judged by one member of the 2nd special panel (previously discussed in Table 6.3b and 6.3c).

No investigation was done after Day 50. However, the results obtained did suggest that the rancidity (> 50 days) and acceptability (> 50 days) of the product found in further sensory inspection coincided with the predicted shelf-life of the bars in PP packet at 75% RH and 28 C (74 days for rancidity and 80 days for acceptability). The predicted shelf-life at 95% RH and 28 C (36 days for rancidity and 38 days for acceptability) was lower than that of further inspection (> 50 days for both attributes). The more severe condition of relative humidity was considered responsible for this lower result. A relative humidity of 75% and temperature of 25 C were considered similar to the daily conditions of Bangkok (approx. 75% RH, 28 C). Thus it seems more suitable to use the data obtained at 75% RH to predict shelf-life. The severe conditions at 95% RH caused changes in the packaging especially at high temperatures and gave results that were difficult to use in shelf-life predictions. It appears that such severe conditions should not occur in Bangkok during normal storage of the product.

7.6.5.3 Discussion and Conclusion on Shelf-Life. Based on the matrix of '75% RH; 25, 35, 45 C', the sensory quality (i.e. without rancidity and with high acceptability) of the stored products in a PP packet would last for nearly 3 months. However, this prediction was based on the pessimistic assumption of the 'reject point' (scale 1.9 or 'slightly unacceptable' for acceptability, and scale 2.5 'or slightly present' for rancidity). If an optimistic assumption -- e.g. scale 1.0 or 'unacceptable' for acceptability and scale 4.0 or 'slightly strong' for rancidity -- was applied, the predicted shelf-life of product would be over 3 months.

It was considered that 21 days is slightly too short time for the accelerated test of the developed product. 25 days might be more suitable as this would reduce the inaccuracy of extrapolation in determining the reject time.

In this study, at 95% RH only two point observations (25 and 45 C) were used. More accurate results would have been obtained if a point at 35 C had been included. The condition at 95% RH and 45 C appeared too severe for storage tests on this type of packaging, and it might be preferable to use temperatures of 20 C, 30 C, 40 C.

In conclusion, the Arrhenius Relationship model using '75% RH and 25, 35, 45 C' as the matrix (or experimental design) was considered effective for shelf-life prediction for the developed IMF nutritional product because it gave results similar to ambient storage. It was possible to use a PP packet for the developed product as it would keep for 3 months or more in this type of packaging. However, optimisation is needed for storage conditions especially that of temperature. If the product is to be kept in ambient conditions in Thailand, a well sealed packet is needed.

7.6.6 Determination of Product Adjustment Based on Product Quality Prediction

Based on the product shelf-life study in the previous section, the quality of the developed product was degraded through rancidity, dryness, and hardness. Of the three, rancidity was considered the most important attribute that related to the product acceptability. Thus, rancidity was considered a critical attribute for product quality degradation.

The predicted shelf-life at 75% RH 28 C, which is the average condition in Bangkok, of the product based on acceptability was nearly 3 months (80 days) for the PP packet and was 3 months for the AF packet, while the desired shelf-life in the product concept was 3 months. When rancidity was used as the base, the shelf-life was shorter. Thus, an adjustment of the product was considered necessary. The following are the possible means for adjustment -

: The use of antioxidant.

: The use of an AF packet, but shelf-life extension was only approx. 20% (while the cost increase might be higher than 20%).

: Moisture content of the product be retained at lower than 10% by the use of double PP packets or the use of vacuum packing.

: Quality control of nut ingredients during purchasing and storage.

: Optimization of the storage condition to slow down the rancidity reaction.

Decreasing the fat content of the product might be another possible way to reduce rancidity off-flavour during storage. It was not considered for further study because of firstly the infeasible solutions for other nutrient constraints obtained during the LP experiments when the fat-containing ingredients were changed and secondly the doubt of consumer acceptability when sesame seeds and peanuts, the major sources of fat, are reduced in the formula.

7.7 DISCUSSION AND CONCLUSION

The quality test, objectively and subjectively, needs skilled personnel for 'precision' and needs suitable methods and techniques of measurement for 'accuracy' of the results. Though most of the measurement methods and techniques used were reasonably suitable for the present study, limited time inhibited the development of suitable techniques for this product. For certain chemical analyses e.g. vitamin analysis, more trials on practical measurements should have been done until constant results could be obtained on a known-sample before the quality test of the product was started.

For a storage test of a developed nutritional product by ASLT, the matrix suggested was '70, 90% RH; 25, 35, 45 C'. The Arrhenius Relationship Model was suggested for product shelf-life prediction. These conditions of storage could be used for optimisation of storage condition by Yates' analysis (2 x 2 factorial experiment) and for estimation of shelf-life by linear plotting technique.

Based on the acceptability and rancidity prediction, it was recommended that the developed product be packed in a PP packet. The moisture content of the product should be retained at lower than 10% by the use of double PP packets or by the use of vacuum packing. Nut raw materials should be controlled during purchasing and storing. The storage temperature and relative humidity for the developed product should be at 25 C 75% RH in order to prevent the rancidity of the product while retaining other sensory qualities.

In conclusion, the results of this study showed that an estimate of product shelf-life could be produced reasonably accurately from changes in product attributes which could be obtained from a systematic planned storage test.

CHAPTER 8

DISCUSSION AND CONCLUSION

8.1 THE NECESSITY FOR THE PROJECT AND THE AIM OF THE THESIS

There is a need for the development of nutritional products for nutrition intervention programmes in Thailand. Fully commercial development of nutritional products developed in the past was delayed because they were not highly acceptable to the target consumers, this being the most important criterion for guaranteeing the private investor taking over the commercialisation of a food product. Most of the past product development methods were based on trial and error, but in this study, a systematic product development process proved to be a promising tool for such a product development project.

This thesis aimed at developing a nutritional product for a nutrition intervention programme for Thailand using quantitative techniques throughout a systematic product development process. The systematic PD process was designed to be used as a prototype model for nutritional snack product development in Thailand. Quantitative techniques used included consumer survey for determining consumer needs and attitudes, linear programming for product formulation development, factorial design together with Yates' analysis for process development, profile analysis for sensory quality testing, and Arrhenius Relationship for shelf-life estimation. The systematic product development process started from product idea generation, screening of products, analysis evaluation or business analysis, development of formulation and process, and then testing of production, product shelf-life, and consumer product acceptability. Though the last step of market testing before commercialization was not investigated, the information collected from the final testing step which determined the consumer responses to the product was used to predict the market size.

8.2 THE SYSTEMATIC MODELS DESIGNED FOR THE PRODUCT DEVELOPMENT PROCESS

Models of the systematic methods for the major steps and the overall system of nutritional product development for a nutrition intervention programme in Thailand were designed, and the time needed for completing the whole system was estimated. Also shown in each diagram was how sensory analysis especially ratio profile test was used interactively with certain major activities for the purpose of screening the most acceptable product for further development.

8.2.1 Model for Formulation Development

In the formulation development model (Figure 8.1), after the objectives of formulation and its main constraints are set, based on the result of product screening and evaluation, and after the development of the product concept, data for linear programming are prepared. The data required for the formulation of nutritional products include: composition and cost of possible raw materials, nutrient loss during processing, nutritional requirements of the target consumers, and minimum/maximum amounts of ingredients in the recipe based on 'best-estimate' experiments and on 'in-house' evaluation.

The data on nutrient loss during processing are used for the adjustment of the composition of the raw materials, while the data on nutritional requirements are for the levels and ranges of the nutritional constraints, and the data on minimum/maximum amounts of ingredients are for raw material bounds.

Formulation development is done using the linear programming technique. The LP package programme is a fast and effective way to the LP solution. For sensory testing, linear scaling together with profile analysis, correlation and ANOV/T-test using a lab panel is an effective product profiling method for screening the product characteristics to give the most suitable product profile. The product sensory profile selected is then developed so that it will change into the ideal product profile. In achieving this, interaction between the profile tests and the product preparation trials is studied until the product profile is accepted by the lab panel.

During the testing of the LP formulae, the testing of technical possibility, and the testing of product acceptability, modification of data and of technical technique might be imperative. The least-acceptable or least-promising formulae are dropped, and the most-acceptable and the most-promising technically is/are selected for further development. It is important that formula selection at the step before process development should be based on the consumer panel test.

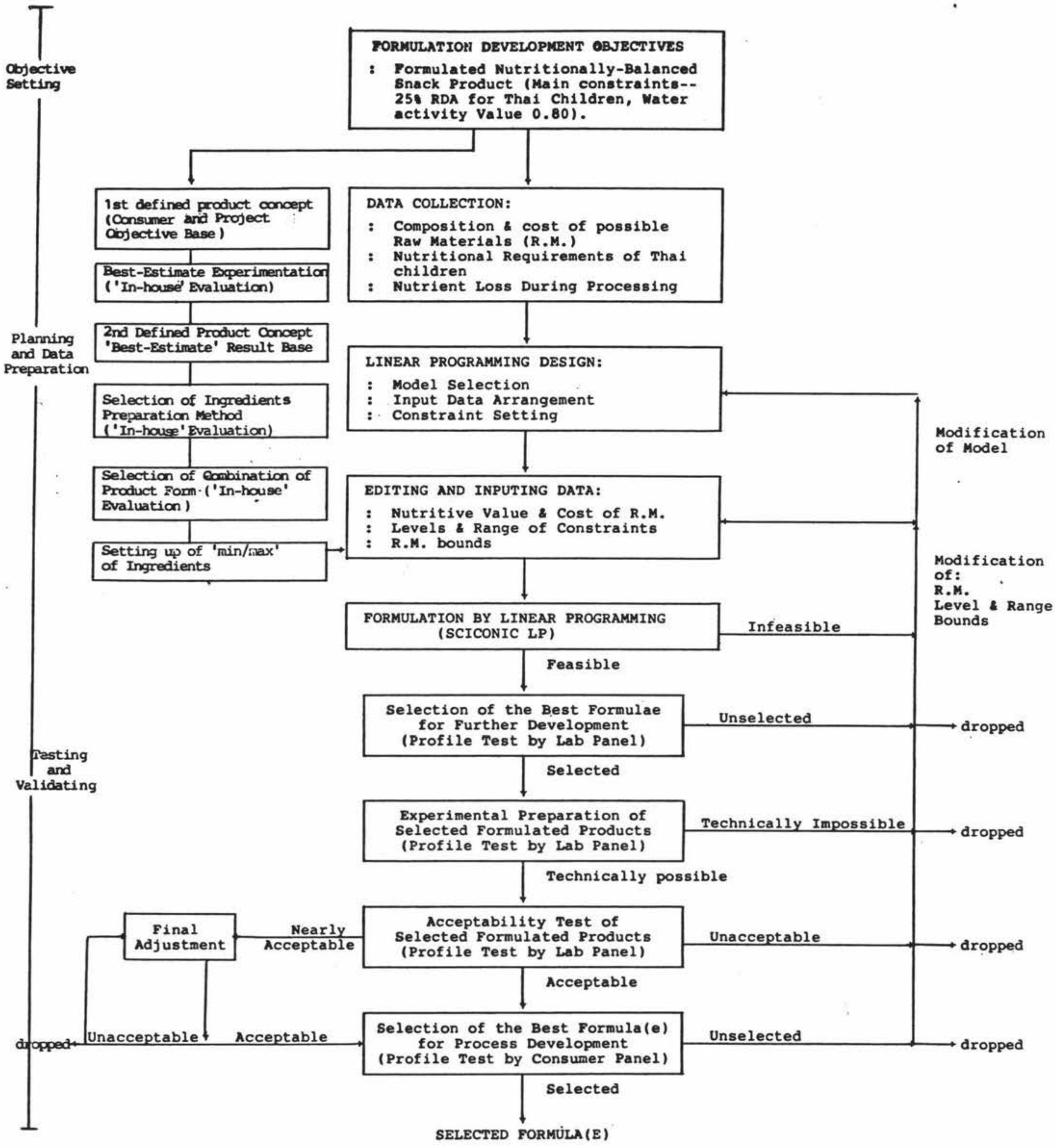


Figure 8.1: Illustrative Model for Formulation Development of Nutritionally-Balanced Snack Product

8.2.2 Model for Process Development

For the process development model (Figure 8.2), after the objectives of the process development and its main constraints are set, planning is made on the optimization method and on the data preparation. Data is prepared by the outlining of processes and raw materials, the screening of process alternatives, and the selection of unit operations. Process conditions are optimised by the application of factorial experimentation together with Yate's analysis; and the combination of the optimised unit operations will lead to the whole process for the product being developed. Before the optimisation testing, input variables can be screened by using the Plackett and Burman Technique. Testing of the whole process in a production trial and testing of the product produced by the consumer panel are necessary. After the developed product is accepted, production of the products can be undertaken for an acceptability test by a consumer survey.

8.2.3 Model for Sensory Analysis Development

For sensory analysis development (Figure 8.3), improvement of the sensory profile of the prototype products towards the profile of the consumers' ideal product is set as the main objective. The selection of the sensory attributes for the product profile is considered very important; and this should be done by an experienced technical panel using the information from the earlier consumer survey. Three types of taste panels are used during the sensory analysis development process -- lab panel, special panel and consumer panel. The number of panel members suggested is 6 for the lab panel and for the special panel, and approximately 30 for the consumer panel. For the lab panel, those with current food habits similar to the target consumer are preferred because they are to work with the profile of the product desired by the consumer. Unlike the lab panel, the special panel, who are to work with the characteristics of the intermediate products desired by the next process specified by the researcher, do not need to have similar food habits to the consumers but they must be skilled in sensory testing. Thus, personnel with a high capability in differentiating product characteristics are preferred for the special panel.

For the consumer panel, it is important that the panelists represent the target consumers and in particular represent consumers with different demographics. It is also important that the ideal product

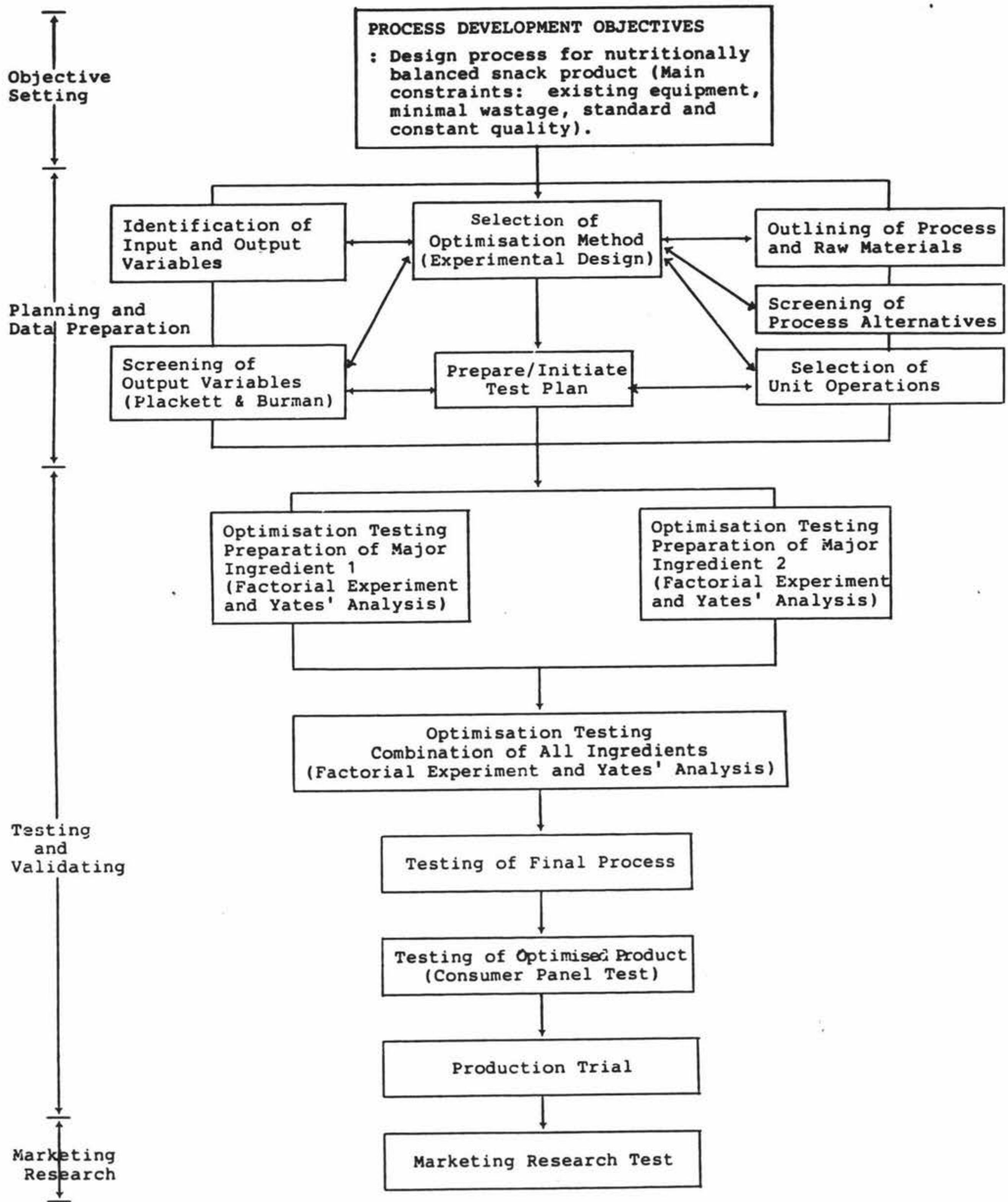


Figure 8.2: Illustrative Model for Process Development of Nutritionally-Balanced Snack Product

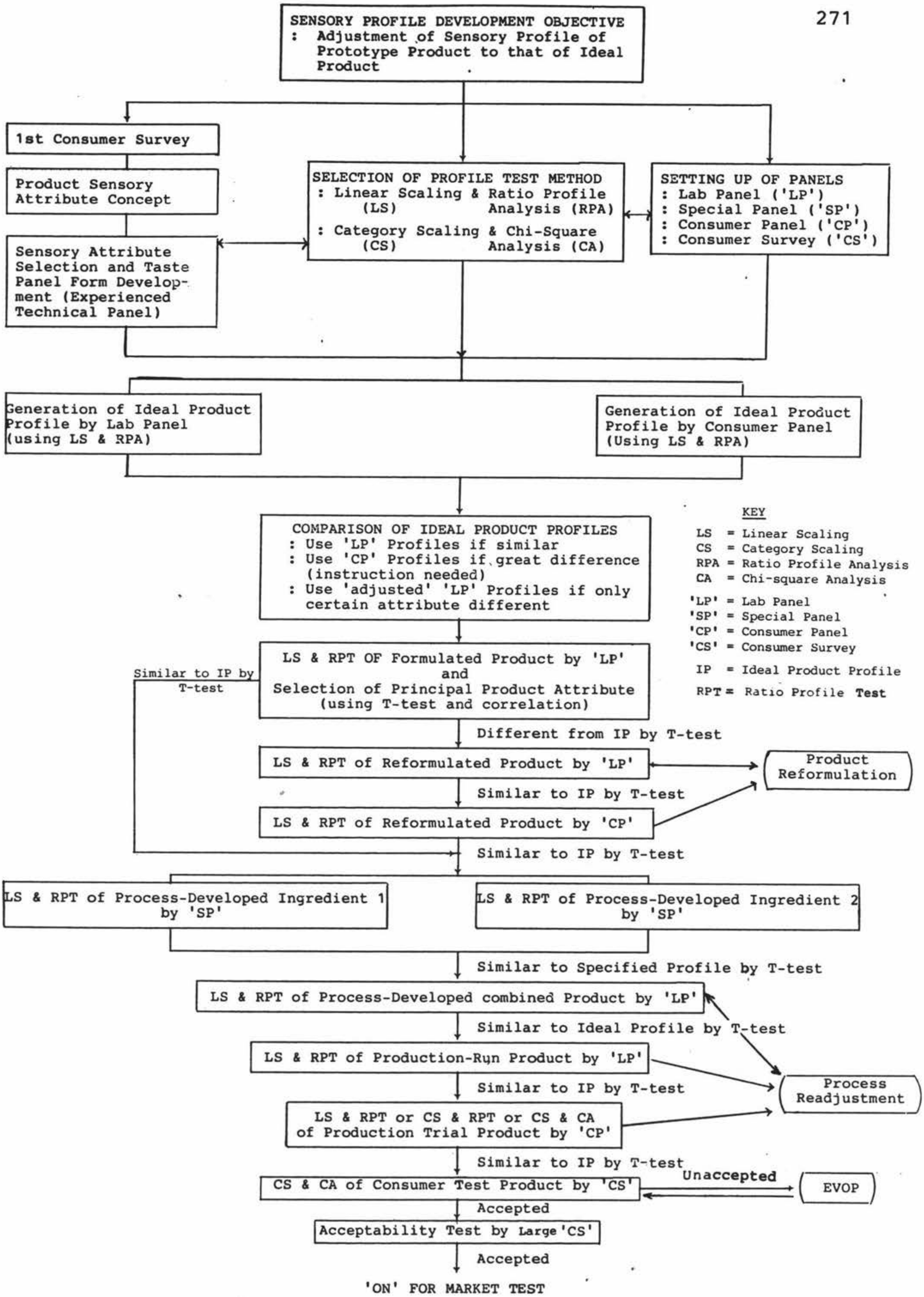


FIGURE 8.3: Illustrative Model for Sensory Analysis Development of Nutritional Product Development Process

profile be generated by the representatives of the target consumers. If this is impossible, an ideal product profile can be generated by a lab panel with similar characteristics to those of the target consumers especially in their food habits. However, comparison of the profiles from the lab panel and from the consumer panel is suggested as a good method for the selection of the ideal product profile. If their profiles are very similar, the lab panel profile can be used in order to avoid 'attribute intensity' confusion of the lab panel. If great differences are found, the consumer panel profile should be used with a thorough instruction for the lab panel on its use. Differences found only in certain attributes suggests that the lab panel profile can be used but adjustment should be made on 'problem' attributes.

Linear scaling and ratio profile analysis is the effective product profile technique recommended for use during the formulation and process development steps by the lab panel. Correlation between sensory attributes is recommended for use to help decisions on the selection of attributes. The ANOV/T-test between the mean ratio scores of different formulae (or treatments) is recommended for decisions on the selection of formulae for further study. The ANOV/T-test is also recommended for the decision to end the sensory profile development of the product produced by the whole optimised-process. That is, improvement of the formula and process will be stopped when the product sample profile is similar to the product ideal profile.

The category scaling profile test is an effective method recommended for use after a positive result is obtained from the final lab panel test. The five-category 'just right' scale was suitable for general scaling. The consumer panel is used for the product test at this step. The profiles can be obtained by either using the ratio method or chi-square analysis. If accepted, by using the ANOV/T-test on the sample means and ideal means, the product is finally tested by a consumer survey using the category scaling method and chi-square analysis.

8.2.4 Model for Product Evaluation

For the product evaluation model (Figure 8.4), after the objectives of the evaluation are set, a selection of evaluation methods is made. A subjective test is considered important for the acceptance aspect, while a microbiological test is for the safety aspect for a commercial product. A nutritional test is necessary under legislation for any nutritional product. A storage test of the stored product is imperative for a successful commercial food product.

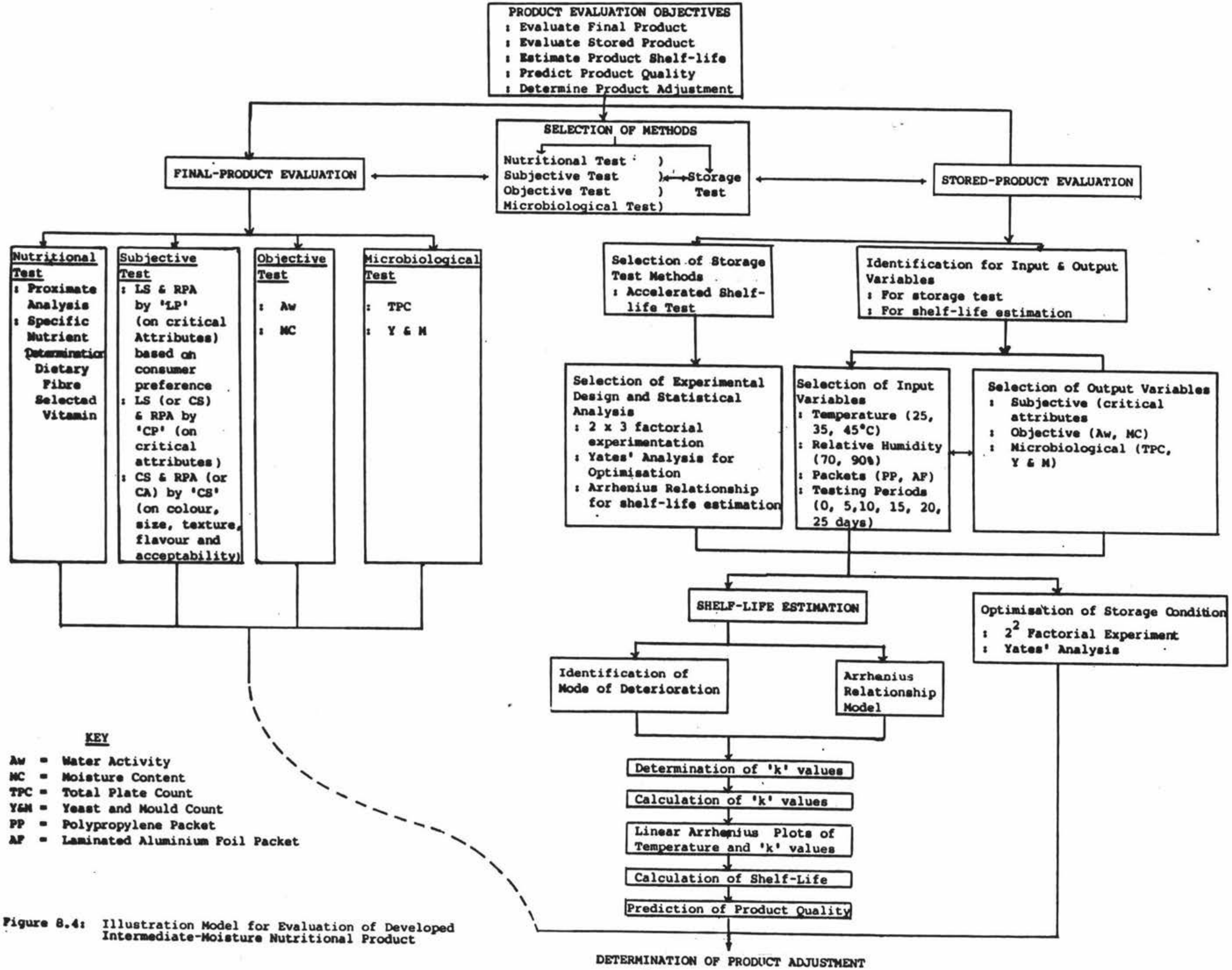
For the nutritional test, proximate analysis is the simplest chemical method for the measurement of protein, fat, crude fibre, ash, and moisture content of the final product. The carbohydrate measurement can be obtained by difference, and energy by calculation. Essential amino acid determination is considered important for the profile of the protein quality of the product. Specific nutrients considered worthwhile for the nutritional determination include dietary fibre and selected vitamins and/or minerals depending on individual products.

For the subjective test, only critical attributes are studied firstly by the lab panel. When the product is found to be similar to the ideal, it is further evaluated by the consumer panel and finally by a consumer survey.

For the objective test, water activity and moisture content is recommended for the evaluation of intermediate-moisture food, while for the microbiological test, a total plate count is suggested. If the product is high in sugar, it is considered worthwhile to include a yeast and mould count.

ASLT is suggested for the method of storage test. Twenty five days of storage with a quality test every five days might be used. 2 x 3 factorial is suggested for the experimental design, and temperature and relative humidity for input condition-variables. The low and high levels can be 25 and 45 C for temperature and 70 and 90% for relative humidity. By this design, a simple Yates' analysis can be used for the optimisation of storage condition. The addition of a temperature level of 35 C into the design at 70 and 90% RH is necessary for the prediction of the storage-life of the product, when Arrhenius Relationship and linear plot for 'k' values with temperature are to be applied. A centre point of 35 C and 80% RH is necessary for regression analysis to determine the empirical relationship between shelf-life and temperature, and shelf-life and relative humidity.

Since low storage temperatures are detrimentral to the texture of this product e.g. at 4 C the product will be dryer and harder than that



KEY

Aw = Water Activity
MC = Moisture Content
TPC = Total Plate Count
Y&M = Yeast and Mould Count
PP = Polypropylene Packet
AF = Laminated Aluminium Foil Packet

Figure 8.4: Illustration Model for Evaluation of Developed Intermediate-Moisture Nutritional Product

kept at 25 C, a suitable condition for the reference sample seemed to be 25 C and 70% RH in the texture aspect. However for the rancidity aspect, a low temperature of 4 C is suitable because it retards the development of a rancid flavour in the product. For acceptability, 4 C is also suggested because it directly correlates with the rancidity attribute.

The data matrix for the prediction of shelf-life is 70, 90% RH; 25, 35, 45 C. Rancidity, dryness, and acceptability are the three suggested sensory attributes that the prediction might be based on; and this quality prediction is used for the determination of product adjustment.

8.2.5 Framework of the Systematic NPD Model

Figure 8.5 is the framework of the overall systematic model for nutritional product development process (NPD Model). Emphasis was on illustrating the flow of the development activities (in the main frame) and major method/technique used for each development activity (shown along with the arrow sign). Also emphasized is the point at which the ratio profile test had a role in the formula/product screening, product profile development, and the sensory quality analysis. A logic diagram for the developmental activities of the present project is given in Appendix 8.1 to be used as a guide for designing the NPD master plan.

The present study took 20 months from the first step of the overall model to the stage of final adjustment of product. Since major development steps of ideal product generation, process development, and testing of the product had to be done in 2 phases -- firstly in New Zealand and finally in Thailand, it is assumed that the average time to finish this system is approximately 1 year.

8.2.6 Discussion on Models

There appeared to be three important objectives for the five proposed models. The first two models illustrated how the activities in the important nutritional product development (NPD) stages -- product formulation and process development -- were conducted. Another two models illustrated how the major related activities to the above two NPD activities -- sensory analysis and product evaluation -- were

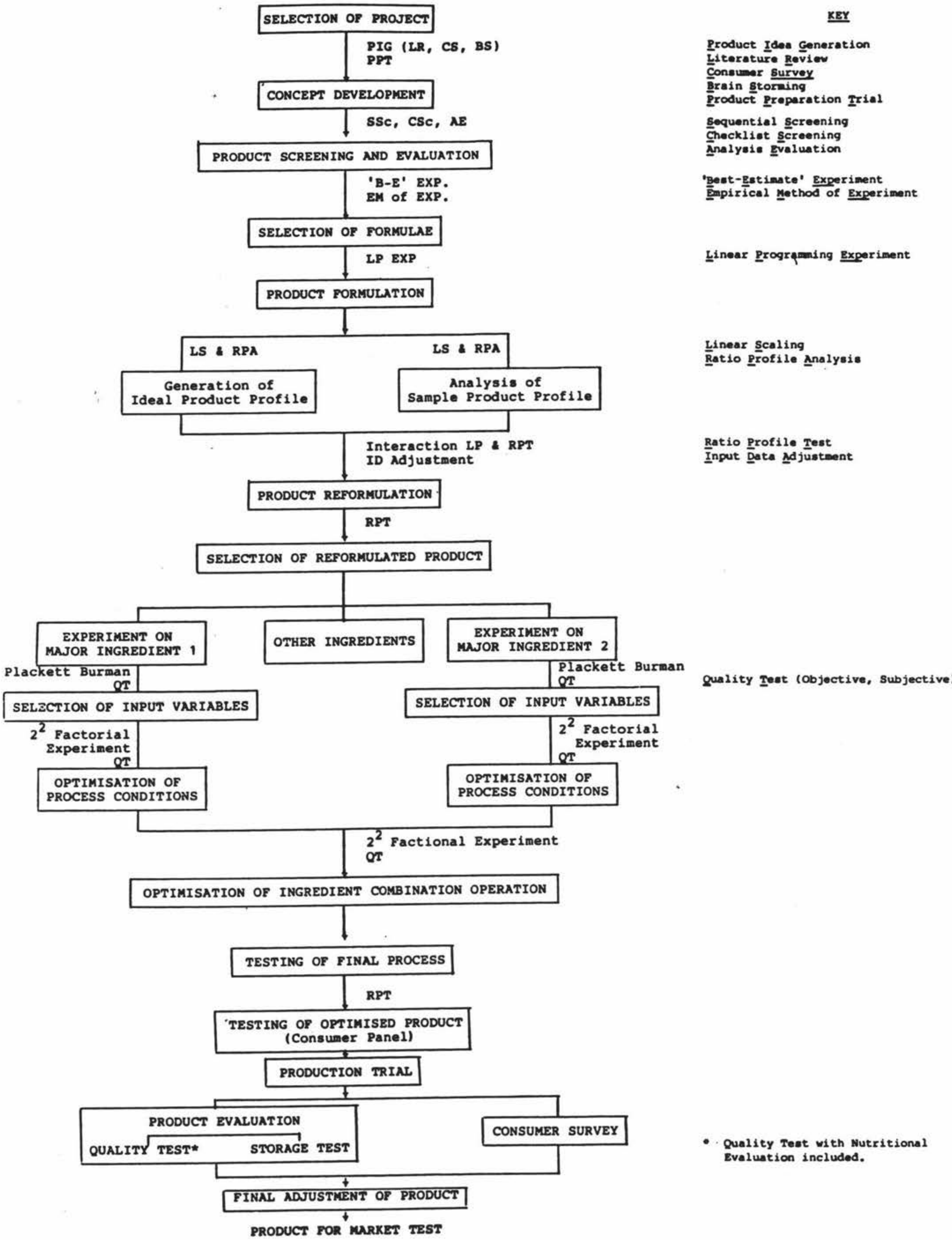


Figure 8.5: Framework of Systematic Nutritional Product Development Model (NPD Model).

developed and used interactively during the PD process. By the use of the overall systematic NPD Model (the last model presented), the product developer can detail the master plan for the overall system of the NPD project. This makes it possible for budget, personnel, and time to be estimated.

Although the five proposed models are expected to be applied directly to the development of intermediate-moisture nutritional products for a nutritional intervention programme in Thailand, with minor modification they can be used as a guide to the development of other types of nutritional products and/or for nutritional intervention programmes in other countries.

These models are expected to be used commercially by either the private sector or the collaboration of the government and the private sector. These models are also expected to be used by international agencies involved in nutritional problems of the world.

8.3 SPECIFICATION OF THE PRODUCT

Table 8.1 presents major points of specification of the developed product. These are the product qualities to be achieved in production.

8.4 SPECIFICATION OF THE PROCESS

The main processing sequences are given in the Process Flow Chart in Figure 8.6. Table 8.2 is the major point of specification of the developed processes. Material Balance for the process is given in Appendix 8.2, raw material specifications in Appendix 8.3.

8.5 FURTHER VALIDATION BEFORE PRODUCTION OF THE PRODUCT ON AN INDUSTRIAL SCALE

Further studies are required when this product is to be produced by private industry as follows -

: Analysis of major nutritional components of raw materials used and then design of raw material specification. (See Appendix 8.3 for preliminary raw material specification using data obtained from this study.)

TABLE 8.1: MAJOR POINTS OF SPECIFICATION OF THE DEVELOPED PRODUCT

Specification Attribute	Specification
Product Description	Product is a 'mix-press' bar which is nutritionally balanced and made of roasted nuts, deep-syrup cooked banana, 'boil-hot stir-evaporate' mungbean and banana-syrup.
Product Characteristics	
Product	Weight 44 g; Bar shape 10.2 cm x 3.8 cm x 1.1 cm
Product Packaging	Polypropylene-film packet: Size 11.4 cm x 8.9 cm; Film thickness 0.1 mm.
Product Storage	Preferable at 25°C or less; out of sunlight and radiant heat sources; in dry place.
Product Formulation	Batch size: 50 kg; Yield: approx. 1030 bars (see Appendix 8.2 for material balance)

Ingredient	%	Kg
Deep-syrup cooked banana	26.0	13.00
'Boil-Hot Stir-Evaporate' Mungbean	25.0	12.50
Glucose syrup	7.5	3.75
Banana syrup	7.5	3.75
Roasted White Sesame Seeds	20.0	10.00
Skinned Roasted Peanuts	14.0	7.00
	100.0	50.0

Quality Control Test

Specification Attribute	Specification	Value
Nutritional Test	Proximate Analysis (content in 100 g developed product)	
	Moisture content (g)	$\leq$ 10
	Fat (g)	$\geq$ 9
	Protein (g)	$\geq$ 5
	Ash	-
	Carbohydrate	-
	Energy (calories; by calculation)	$\geq$390
	Protein calories/total calories (%)	$\geq$ 8
	Specific Nutrients	
	Fibre (crude, g)	3.3 ± 1.5
Microbiological Test	Total Plate count (colonies/g of product)	$< 10^4$
	Yeast and mould count (colonies/g of product)	$< 10^4$
Objective Test	Moisture content (%)	$\leq$ 10
	Water activity	$<$ 0.78
Subjective Test	Colour ratio mean	1 ± 0.3
	Size ratio mean	1 ± 0.3
	Texture ratio mean	1 ± 0.3
	Flavour ratio mean	1 ± 0.3
	Acceptability ratio mean	1 ± 0.4

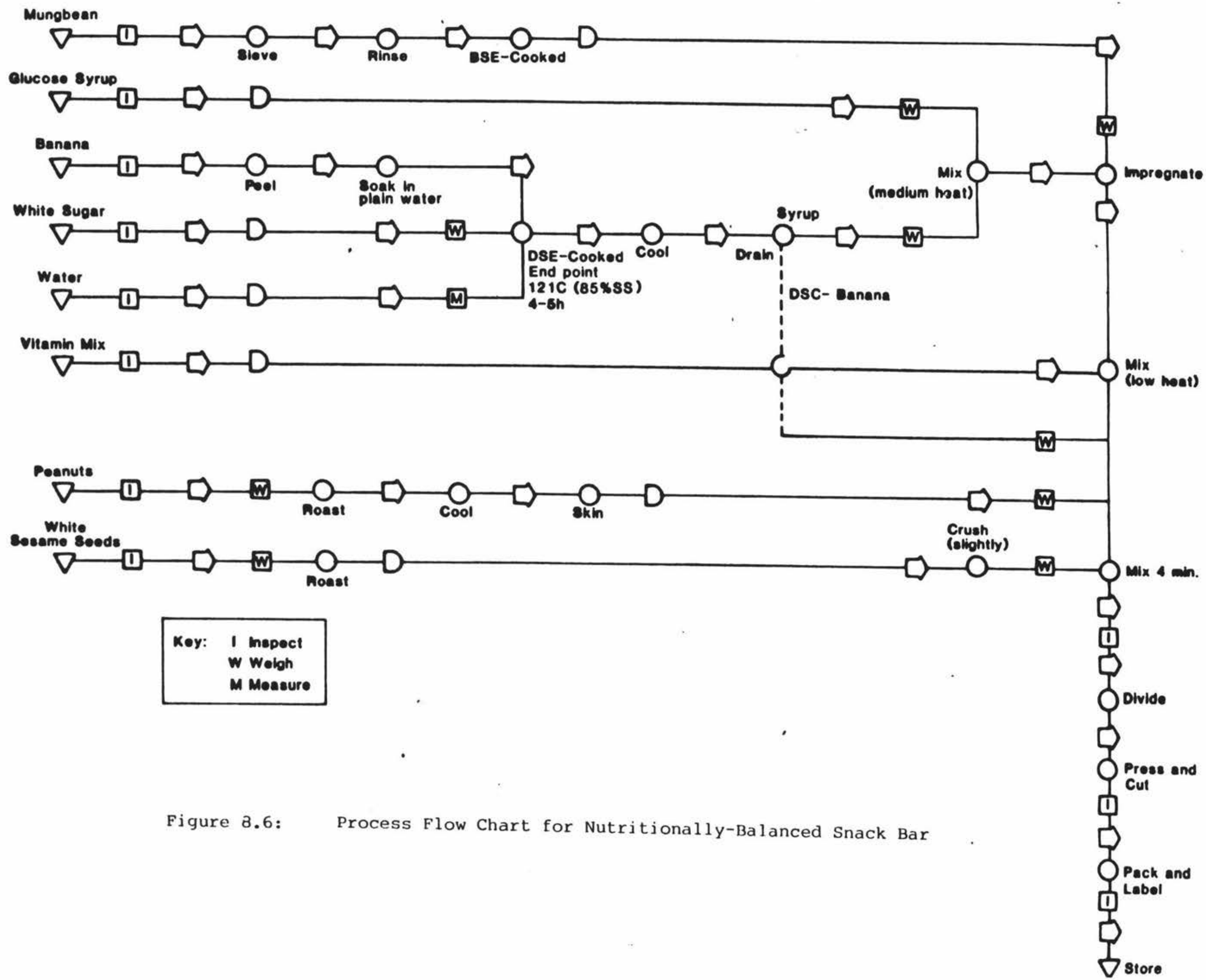


Figure 8.6: Process Flow Chart for Nutritionally-Balanced Snack Bar

TABLE 8.2: MAJOR POINTS OF SPECIFICATION OF THE DEVELOPED PROCESSES/OPERATIONS

Specification Process/Operation Attributes	Major Points of Specification
DSC-Banana Process	
Peeling of Banana	Using stainless steel knife; keep peeled bananas under plain water
Boiling of Banana	Boil peeled bananas in water until soft (1 hr); using stainless steel kettle
Deep-syrup Cooking of Banana	Add water and sugar into the boiling-banana kettle and continue boiling at medium heat until the temperature of the syrup and the DSC-Banana is 121°C or the %SS is 85%. Keep the DSC-bananas under the cooking-syrup (Banana-syrup or B-syrup) until they are cooled down.
Draining of DSC-Banana	Using stainless steel drainers and containers.
BSE-Mungmean Process	
Sorting of Mungbean	Sieve size; 5.5 wires/cm^2 and 16 wires/cm^2. Visual inspection for stone or other foreign materials be made.
Washing of Mungbean	Wash 1 second under plain water. Stir to float the impurities before pouring off the washing water.
Boiling of Mungbean	Using stainless steel kettle. Boil for ½ hr at medium heat.
Hot-stirring of Boiled-Mungbean	Using the boiling-kettle but with the mechanical stainless steel stirrer applied. The paddle part of the stirrer should be able to scrape the cooked-mungbean at the bottom of the kettle during the hot-stirring process of 2 hrs.
Evaporating of Hot-stirred Munbean	Using the boiling-kettle but with the mechanical stainless steel stir-evaporator applied. (If not available manual evaporating can be done by constant scraping and stirring) for 1 hr at low heat.
MP-Snack Operation	
Syrup-Impregnation of BSE-Mungbean	Heat BSE-mungbean at low heat until hot. Gradually add heated B-syrup into the heated BSE-mungbean. Scrape and stir constantly until the mungbean is impregnated with the syrup and the mixture is rather dry (Quick rough test can be done by the use of refractometer. The final %SS for the syrup is 79%).
Mixing of Impregnated-Mungbean and Other Prepared Ingredients	Mix impregnated-mungbean and DSC-banana on the mechanical mixer using medium speed (speed 2 if three speed mixer) for ½ min. Add half prepared peanuts and sesame seeds and mix using speed 1 for ½ min and then speed 2 for 2 min. Add the other half of peanuts and sesame seeds and mix using speed 1 for 1 min. The mixture will form a 'mix dough'.
Pressing of the Dough	Divide the 'mix dough' into 1.1 kg doughs. Spread on the processing-cutting equipment, using rubber gloves or plastic bags while handling the mix. Sprinkle with shredded peanuts and roll to arrange the mixture properly. Press with mechanical stainless steel pressing plate until reaching the marked level. Wind up the pressing plate.
Cutting of the Pressed Mixture	Place the stainless steel segmented cutter into the frame. Apply the pressing plate until it reaches the marked level. Unpress and unmould the snack bars.

- : Processing specification design (Operation, Equipment, Plant Layout, Schematic Process Layout) .
- : Water activity study on intermediate materials at major steps of the process.
- : Determination of type and amount of antioxidant to be used.
- : Development of equipment for DSC-, BSE-, and MP-process suitable for larger scale production.
- : Designing in-line quality control.
- : Recosting to update the cost of the product. (See Appendix 8.4 for product costing.)
- : Further Feasibility study of the developed product (Market, Administration, Financial, and Technical Feasibility)
- : Market Plan (Market Segments, Consumer characteristics, Sales organization, Market channels, Promotion, Price, Launching the Product).

Major distribution channels used in the Thai market are varied as shown briefly in Appendix 8.5. The channel to be selected for use depends on many factors. For example, the 'P - W - R - C' and 'P - R - C' are suitable for a small factory, while the 'P - A - W - R - C' and 'P - A - R - C' are suitable for a large factory. (P = Producer; W = Wholesale; R = Retail; C = Consumer; A = Agency). Modification of the product packet and cost based on the technology used is needed when a normal commercial channel is chosen; and a budget for advertising and promotion is considered necessary when mass marketing of the product is the policy.

Another possible way to distribute the product to the real target consumer is through the existing 'School Aid Programme'. This programme is subsidized by the Government. Since the product does not pass through the distributer, it can be sold at a cheap price for the target consumer.

A recommendation was made that some form of subsidization for the manufacturers be made by the Government at the initial stage of the production of the nutritional snack product aimed at a nutrition intervention purpose. This was believed to be an encouragement for the private sector to take part in solving nutrition problems in Thailand.

8.6 CONCLUSION

In conclusion, this study was successful in developing a nutritional snack product (Figure 8.7) for urban school-age Thais. Though the product quality was not at an ideal level, the product had a high level of nutritional values especially energy and protein, could be kept for nearly 3 months, and was reasonably accepted by the target consumer. The product can be processed cheaply in a simple plant and with existing technology available at an average snack factory in Thailand.

Moreover, prototype models for the major activity steps of systematic PD process were designed. These were used effectively in the development of a nutritional product in this study. Finally, the project was believed to be worth continuing for commercialization by the private sector.

Figure 8.7: Nutritionally-Balanced Snack Product Developed for Urban School-Age Thais.

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APPENDIX 1.1

PHONETICS FOR THAI CONSONANTS AND VOWELS

Thai Consonants	Phonetics	Thai Vowels	Phonetics
ก	G	-ะ แ-ะ	A
ขฃคฅฆ	K	-า แ-	AH
ง	NG	-ิ	I
จ	J	-ี	EE
ฉ ช ฌ	CH	-ึ -ื เ-ือะ เ-ือ	UE
ซ ศ ษ ส	S	-ุ	U
ญ ย	Y	-ู	OO
ฎ ด	D	เ-ะ เ-	E
ฏฐฑฒตถทธ	T	โ-ะ โ- เ-าะ -อ	O
ณ น	N	เ-อะ เ-อ	OE
บ	B	เ-ียะ เ-ีย	EA
ป ผ พ ภ	P	-ัวะ -ัว	UO
ฝ ฟ	F	-ำ	AM
ม	M	ไ- ใ-	AI
ร	R	เ-า	AO
ล	L		
ว	W		
ห ฮ	H		
อ	O		

APPENDIX 1.2

CLASSIFICATION OF THAI SNACK FOODS

Basis	Classification	Examples
1. Snack-Type	Savoury	Crispy rice sheet, curry puff
	Sweet	Cassava flour cookie, mungbean cake
2. Main Ingredient	Cereals and flours	Puffed dried-steamed-rice, Stuffed rice flour pressed patite cake
	Legumes and nuts	Mungbean cake, peanut brittle
	Eggs	Coconut milk custard, egg-yolk drop
	Meat and fish	Fried dried-spicy-beef, shrimp fritter
	Vegetables and fruits	Deep-syrup cooked banana, glaced fried taro slices
	Flour:	
	Fermented	Steamed bun, Fried bread-twin, Palmyra sweetbread
	Unfermented	Rice flour ark shell, prawn cracker, steamed cup cake
3. Organoleptic Property		
3.1 Flavour		
3.1.1 Flavour combination	Single primary flavour	-
	Two combination flavour	Round sheet of puffed rice flour mixture (roast/ricy/sweet)
	Three combination flavour	Fried rice flour twist (fried floury/sweet/salty)
	Four combination flavour	Prawn cracker (cereal/shrimp/salty/peppery)
	Five or more combination flavour	Cassava flour cookie (baked floury/coconut creamy/sweet/baked eyy-yolk/incense candle aroma)
3.1.2 Primary flavour	Sweet	Egg yolk thread
	Salty	Potato chips
	Sour	Sour fruit candy
	Creamy	Broiled creamy rice in bamboo sections
3.2 Texture	Soft and tender	Steamed folded tartlet with stuffing
	Fluffy	Steamed cup cake
	Crispy	Puffed rice
	Crunchy	Fried mungbean-in-rice-flour bun
3.3 Appearance		
3.3.1 Colour	White	Thai noodle
	Creamy	Cassava flour cookie
	Yellow	Egg-yolk thread
	Green	Layered firm pudding
	Black	Chewy pudding wrapped in burn banana leave
3.3.2 Form	Round	Cassava flour cookie
	Square	Mashed mungbean square
	Rhombus	Black firm pudding
	Ring	Golden ring with syrup topping
	Fruits	Mashed mungbean with colourful gelatine coating
3.3.3 Size	Patite	Cassava flour cookie
	Small	Rice flour ark shell
	Medium	Mashed mungbean in mungbean flour gel
	Large	Curry puff
	Extra large	Sauted flaky bread
3.3.4 Status	Liquid	Banana in coconut milk syrup
	Paste	Pudding
	Semi-dried	Mashed mungbean square
	Dried	Flower petal cookie
3.4 Method of Cooking	Dry-heat cooking	Crispy rolls
	Moist-heat cooking	Steamed cup cake
	Heating-in-fat process	Banana fritter
	Electronic cooking	-
	Others	Dried banana, Fermented steamed-rice
3.5 Method of Storage	Room temperature storage	Cassava flour cookie
	Chilled storage	Egg-yolk thread
	Frozen storage	Ice cream
3.6 Held-in-hand Convenience	Held-in-hand convenience	Pumpkin cracker, Crispy rolls, Golden pressed patite cake
	Held-in-hand inconvenience	Tapioca pearl pudding, Rice flour dumplings, Baked mungbean custard
3.7 Source	Hand-made	Fluted deep-syrup cooked egg yolk
	Small scale factory	Baked mungbean pastry
	Medium and large scale factory	Coconut butter biscuit
3.8 Typical or Traditional	Typical Thai KANOM:	
	General KANOM	Rice flour ark shell
	Specialty KANOM	Egg-yolk thread for auspicious occasion
	Modern Thai snacks:	
	General snacks	Agar gel with coconut cream topping
	Specialty snacks	layered firm pudding with decoration for wedding day

APPENDIX 1.3

Summary of Methods Of Processing Snack Foods in Thailand

Classes of Methods	Methods	Description	Method of Heat Transfer
Dry-heat process	1. Baking	Cooking in an oven or other enclosed vessel.	Hot air and reflected radiant heat.
	2. Roasting	Cooking meat in an oven or cooking food in hot container without water or oil.	Conduction
	3. Broiling	Direct heating.	Radiation and some convection.
	4. Baking by direct transference of heat.	Heating food with a metal mould either on one or two sides.	Conduction, radiation.
	5. Dry puffing.	Heating food with heated materials.	Conduction, convection
	6. Extrusion cooking.	Cooking food by a combination of pressure, heat, and mechanical shear.	Conduction, convection
Moist-heat process	1. Steaming	Cooking directly by steam or in a steam-heated vessel.	Conduction, convection
	2. Steaming under pressure	Cooking by steam under pressure.	Conduction.
	3. Steam puffing	Cooking food by a combination of steam, pressure.	Convection.
	4. Boiling	Cooking in boiling water.	Conduction.
	5. Simmering (stewing, poaching)	Cooking in water below its boiling point.	Conduction.
	6. Hot-stirring	Heating food in liquid with constant stirring to the desirable viscosity.	Conduction
	7. Deep-syrup cooking	Cooking food in hot syrup.	Conduction.
	8. Deep-syrup soaking	Soaking blanched food (usually fruits) in syrup solution to the saturation point.	Conduction (or convection)
	9. Extruding after cooking	Cooking food by hot-stirring method and then extrude.	Conduction

APPENDIX 1.3 Continued

Classes of Methods	Methods	Description	Method of Heat Transfer
Frying-in-fat process	1. Sauteing	Heating food on the greased metal surface.	Conduction
	2. Stir-frying	Cooking food in small amount of oil with or without liquid.	Conduction
	3. Shallow-fat frying	Food partly immersed in heated fat	Conduction
	4. Deep-fat frying	Food completely immersed in heated fat.	Conduction.
Electronic process	1. Microwave cooking	Food subjected to micro-wave radiation in an oven	Heat generated in food.
Other process	1. Drying or dehydration	Reduction of food moisture by the sunlight or hot air	Radiation and convection
	2. Fermentation	Preserving food by the application of the action of living organisms and their enzymes.	-
	3. Uncooked	-	-

APPENDIX 3.1

DETAILED RESPONSES (%) FROM THE 1st SURVEY

(Selected Responses Only)

Attribute Categories		Total	Sex M	Sex F	Age >15	Age 13-15	Age 10-12	Age <10
1. SNACK BUYING BEHAVIOUR AND ATTITUDES IN GENERAL								
Snack Type Preferred	Base	160	80	80	39	41	40	40
Sweet		73	73	73	77	66	65	83
Savoury		27	27	27	23	34	35	17
Frequency of snacking after school	Base	160	80	80	39	41	40	40
Everyday		51	45	58	38	49	73	45
Once in a while		22	28	17	38	17	10	25
Every two or three days		19	19	19	10	25	17	23
Once a week		3	1	4	4	2	0	5
Never		5	7	2	10	7	0	2
Person normally buying snack	Base	160	80	80	39	41	40	40
Yourself		43	48	39	64	39	30	40
Others (parents etc)		27	22	31	13	29	40	25
Both		30	30	30	23	32	30	35
Pocket Money (for snack only) per day in Bahts		160	80	80	39	41	40	40
5 or less		18	16	19	8	10	10	42
6-10		43	49	36	20	24	73	53
11-15		14	15	14	18	22	12	5
16-20		11	10	12	23	22	0	0
21 or more		14	10	19	31	22	5	0
Money spent for snack a day in Bahts	Base	160	80	80	39	41	40	40
5 or less		28	29	28	5	22	27	57
6-10		40	40	40	31	39	60	30
11-15		16	14	19	28	22	10	5
16-20		10	12	7	21	12	3	5
21 or more		6	5	5	15	5	0	3

APPENDIX 3.1 Cont'd

Attribute Categories		Total	Sex M	Sex F	Age >15	Age 13-15	Age 10-12	Age <10
2. TIME FOR SNACKS AND DINNER								
Snack Time on Weekend	Base	159	80	79	39	40	40	40
Afternoon		35	38	33	10	0	3	13
Morning afternoon night		28	21	34	36	40	30	35
Morning afternoon		26	31	20	3	10	0	8
Morning		6	5	8	23	20	37	22
Night		5	5	5	28	30	30	22
3. PREFERENCE FOR THE THREE SUGGESTED PRODUCTS								
Main Reasons for the least eating frequency of selected types of snacks								
Rice-crisp:	Base	28	16	12	2	11	9	6
Inconvenient to buy		57	63	50	0	55	67	67
Not palatable		32	25	42	100	36	11	33
Other reasons		11	12	8	0	9	22	0
Thai -cookie:	Base	29	16	13	7	10	9	3
Inconvenient to buy		45	50	39	57	20	56	67
Not palatable		44	44	46	43	60	44	0
Other reasons		11	6	15	0	20	0	33
Thai -pastry:	Base	15	8	7	5	6	2	2
Inconvenient to buy		33	50	14	60	17	0	100
Not palatable		47	25	71	40	33	100	0
Other reasons		20	25	15	0	50	0	0

(Other reasons: too expensive, low nutrition value, short storage life)

APPENDIX 3.1 Cont'd

Attribute Categories	Total	Sex M	Sex F	Age >15	Age 13-15	Age 10-12	Age <10
Willingness for buying of product to be developed							
Rice-crisp: Base	160	80	80	39	41	40	40
Yes	47	49	45	54	56	38	40
Not sure	39	36	41	28	34	52	40
No	14	15	14	18	10	10	20
Thai -cookie: Base	160	80	80	39	41	40	40
Yes	57	63	53	64	59	53	55
Not sure	49	26	31	28	24	37	25
No	14	11	16	8	17	10	20
Thai -pastry: Base	160	80	80	39	41	40	40
Yes	66	61	71	72	71	63	60
Not sure	25	28	21	18	22	30	27
No	7	11	8	10	7	7	13
Money expected to buy the product you have chosen to be developed (in Bahts) Base	159	80	79	39	41	40	39
5 or less	28	34	23	15	19	27	51
6-10	49	46	51	51	54	58	31
11-15	15	14	16	26	17	5	13
16-20	5	5	5	5	5	5	5
21 or more	3	1	5	3	5	5	0

APPENDIX 3.1 Cont'd.

Attribute Categories	Total	Sex M	Sex F	Age >15	Age 13-15	Age 10-12	Age <10
Expected buying frequency for the product to be developed Base	160	80	80	39	41	40	40
High frequency	8	9	8	10	7	13	3
Moderate frequency	64	62	66	64	71	70	52
Low frequency	28	29	26	26	22	17	45
Most acceptable package Base	160	80	80	39	41	40	40
Aluminium foil bag in paper carton	34	34	34	28	37	40	30
Plastic bag in paper carton	22	24	21	36	17	23	15
Plastic bag	21	16	26	10	17	22	35
Opaque bag of window type	16	16	15	21	22	8	13
Aluminium foil bag	7	10	4	5	7	7	7
Acceptable price expected (in Bahts) per package Base	159	80	79	39	41	40	39
1-3	31	31	32	23	24	35	44
4-6	33	38	28	28	37	30	36
7-9	20	20	20	31	24	15	10
10-12	13	9	18	15	15	13	10
13 or more	3	2	2	3	0	7	0

APPENDIX 3.2

VERBATIM COMMENTS FROM THE SECOND SURVEY

1. Dislikes/Difficulties with Snack Bars*

Dislikes/ Difficulties	Number of Responses				Total	Percentage (Base:1094)
	PAN	SAT	P-B	SAM		
Flavour :						
Not sweet enough	75	45	69	59	248	22.7
Sour	14	30	34	63	141	12.9
Bitter	9	25	11	18	63	5.8
Too sweet	7	24	12	9	52	4.8
Astringent	1	3	4	6	14	1.3
Saltiness needed	-	6	4	-	10	0.9
Weak flavour intensity	-	-	2	5	7	0.6
Salty	-	-	2	2	4	0.4
Strong flavour intensity	-	-	2	-	2	0.2
Burnt flavour	-	2	-	-	2	0.2
Sickly flavour	-	-	1	1	2	0.2
Texture :						
Crumbly	2	14	18	12	46	4.2
Not chewy enough	-	7	5	23	35	3.2
Too soft	18	4	4	2	28	2.6
Too tough	3	11	8	5	27	2.5
Not cohesive enough	-	5	14	6	25	2.3
Too chewy	5	9	1	3	18	1.6
Hard	1	6	4	-	11	1.0
Sandy	3	2	-	4	9	0.8
Not crispy	2	1	5	1	9	0.8
Dry	-	5	-	2	7	0.6
Rough	1	1	-	-	2	0.2
Not soft	-	-	1	-	1	0.1
Sticky to teeth	1	-	-	-	1	0.1

1. Dislikes/Difficulties with Snack Bars (Cont.)

Dislikes/ Difficulties	Number of Responses				Total	Percentage (Base:1094)
	PAN	SAT	P-B	SAM		
Others :						
Too much sesame seeds	7	8	2	4	21	1.9
Not enough peanuts	-	4	5	4	13	1.2
Aroma improved	3	8	-	2	13	1.2
Strong color intensity	-	3	4	5	12	1.1
Color improved	-	1	-	2	3	0.3
Form improved	-	1	-	2	3	0.3
Too-small size	-	1	1	1	3	0.3
Too-large size	-	1	-	1	2	0.2
Too much peanuts	-	1	-	1	2	0.2
Package improved	1	1	-	-	2	0.2
Too strong aroma	-	-	-	2	2	0.2
Unsatisfied aroma	-	1	-	1	2	0.2
Rancid	1	-	-	-	1	0.1
Putrid	-	1	-	-	1	0.1
Chilli-powder flavour	-	1	-	-	1	0.1

*More than one response could be given by one respondent.

2. Major Reason for Not Buying.*

Reasons for Not Buying	Number of Responses				Total	Percentage (Base:159)
	PAN	SAT	P-B	SAM		
Not delicious	12	34	6	13	65	40.9
Dislike of this type of product	5	9	4	6	24	15.1
Sourness	2	5	-	6	13	8.2
Not tasty	2	3	1	2	8	5.0
Bitterness	3	1	1	2	7	4.4
Crumbleness	4	-	1	-	5	3.1
Not sweet enough	-	3	-	1	4	2.5
Too bland	4	-	-	-	4	2.5
Too much sesame seeds	2	1	-	-	3	1.9
Sickly flavour	1	1	-	1	3	1.9
Too sweet	-	2	-	-	2	1.3
Rough texture	-	-	1	1	2	1.3
Stale flavour	-	-	-	2	2	1.3
Strange flavour	-	1	-	-	1	0.6
Durian flavour	-	-	-	1	1	0.6
Dryness	-	-	-	1	1	0.6
Black spot	-	-	-	1	1	0.6
Not chewy	-	-	-	1	1	0.6
Too Soft	-	1	-	-	1	0.6
Too Cohesive	-	1	-	-	1	0.6
Not homogeneous	1	-	-	-	1	0.6
Don't want to spend money	-	1	-	-	1	0.6
Unknown product	-	1	-	-	1	0.6
Better product available for choice	-	-	-	1	1	0.6
Not in need	-	-	-	1	1	0.6
Doubt in quality	-	-	1	-	1	0.6

* More than one response could be **given** by one respondent.

3. Brand name proposed by children

Schools	Brand Name		Meaning
PAN	KANOM MASSEY		Massey Snack
	GRAYASAHT TIP		
	AHAHN SUGKAPAHP		Health Food
	TONG TANG		
SAT	GLANG		
	AROI HOH		
	AROI	(2)	Delicious
	TAU NGA	(2)	Peanuts & Sesame Seeds
	KANOM AD		Pressed Snack
	RUOM Mit		
	MASSEY-KASET		Massey-Kaset Snack
	SOM SUON		Balanced
	AHAHN GUON		Hot-Stirred Snack
	TUO ANAMAI		Healthy Peanuts
	KARACE MALT		
	MANS		Nutty
P-B	AHÄHN ME PRAYOT		
	POCHANA PAAROI		
	POCHANA GAHN		Nutrition
	AROI		Delicious
SAM	NGA PASOM TUOGUON		Sesame seeds and Hot Stirred Mungbean Mix
	KANOM NGA	(2)	Sesame seeds Snack
	KANOM TUO		Peanut Snack

Number in parenthesis = number respondents.
Those not numbered = 1 respondent.

APPENDIX 3. 3

DETAILED RESPONSES (%) FROM THE 2ND SURVEY

Attribute Category		Total	Sex		Age			School			
			F	M	>12	10-12	<10	PAN	SAT	P-B	SAM
Color	Base	1092	606	486	298	420	374	276	272	270	274
1. Too intense		14	15	14	19	13	12	8	17	16	16
2. Sl.too intense		34	35	32	43	36	24	32	42	34	29
3. Just right		47	47	49	34	48	58	58	37	45	50
4. Sl.too pale		4	3	4	3	3	5	1	3	4	5
5. Too pale		1	0	1	1	0	1	1	1	1	0
	Mean 2.4			n.s			**				**
	S.D. 0.8										
Size	Base	1094	608	486	299	421	374	276	274	270	274
1. Too large		5	4	5	5	4	6	7	6	4	2
2. Sl.too large		15	16	14	19	16	13	15	23	10	14
3. Just right		72	73	71	64	73	77	71	62	77	77
4. Sl.too small		7	6	8	10	6	4	6	7	7	6
5. Too small		1	1	2	2	1	0	1	2	2	1
	Mean 2.8			n.s			**				**
	S.D. 0.7										

Attribute Category		Total	Sex		Age			School			
			F	M	>12	10-12	<10	PAN	SAT	P-B	SAM
Texture	Base	1092	607	485	298	420	374	275	273	270	274
1. Too cohesive		6	5	7	4	5	7	6	5	6	5
2. Sl.too cohesive		14	12	16	10	12	18	11	15	14	14
3. Just right		44	42	46	23	45	60	47	43	42	43
4. Sl.too crumbly		29	32	26	47	33	11	26	29	32	31
5. Too crumbly		7	9	5	16	5	4	10	8	6	7
	Mean 3.2			**			**				n.s
	S.D. 1.0										
Flavour	Base	1093	608	485	298	421	374	276	273	270	274
1. Too sweet		6	5	8	3	5	10	5	5	8	8
2. Sl.too sweet		10	10	10	6	11	12	8	14	10	7
3. Just right		34	33	35	20	30	49	33	38	30	34
4. Sl.too bland		25	25	25	36	27	16	27	24	29	23
5. Too bland		25	27	22	35	27	13	27	19	23	28
	Mean 3.5			n.s			**				*
	S.D. 1.2										

APPENDIX 3.3: DETAILED RESPONSES (%) FROM THE 2ND SURVEY

Attribute Category	Total	Sex: F	Sex: M	Age: >12	Age: 10-12	Age: <10	School: PAN	School: SAT	School: P-B	School: SAM
Preference Base	1091	605	486	297	420	374	275	274	270	272
1. Like very much	18	15	22	3	11	37	20	13	19	18
2. Like	26	25	28	14	31	32	28	25	33	20
3. Neither like nor dislike	33	35	31	45	40	16	34	35	29	36
4. Dislike	16	19	11	26	12	11	12	19	14	17
5. Dislike very much	7	6	8	12	6	4	6	8	5	9
Mean 2.7			**			**				**
S.D. 1.2										
Amount eaten at a time: Base	1089	606	483	297	419	373	275	273	268	273
1. 5 pieces	5	4	6	4	4	7	3	7	8	3
2. 4 pieces	4	3	5	1	3	6	4	5	4	2
3. 3 pieces	16	12	20	7	20	19	18	13	21	11
4. 2 pieces	26	25	27	23	30	24	29	22	26	27
5. 1 piece	49	56	42	65	43	44	46	53	41	57
Mean 4.1			**			**				**
S.D. 1.2										

Attribute Category	Total	Sex: F	Sex: M	Age: >12	Age: 10-12	Age: <10	School: PAN	School: SAT	School: P-B	School: SAM
Drink Type After Snacking Base	1088	605	483	297	419	372	275	270	269	274
1. Nothing	3	3	3	1	5	4	1	5	3	3
2. Water	54	50	58	36	54	67	39	68	49	58
3. Health Drink	12	10	15	5	9	20	19	7	16	6
4. Fruit Juice	11	14	8	20	11	4	10	8	6	21
5. Carbonated Drink	20	23	16	38	21	5	31	12	26	12
			**			**				**
Price for 1-Bar Packet Base	1089	605	484	297	421	371	274	273	268	274
1. >3 Bahts	6	6	7	3	6	10	4	11	4	5
2. 3 Bahts	21	20	22	13	23	25	19	34	14	17
3. 2 Bahts	48	50	45	49	53	40	57	40	45	48
4. 1 Baht	22	22	22	29	16	23	19	10	36	24
5. <1 Baht	3	2	4	6	2	2	1	5	1	6
Mean 2.9			n.s			**				**
S.D. 0.9										

APPENDIX 3.3: DETAILED RESPONSES (%) FROM THE 2ND SURVEY

Attribute Category		Total	Sex: F	Sex: M	Age: >12	Age: 10-12	Age: <10	School: PAN	School: SAT	School: P-B	School: SAM
Price for 3-bar Packet	Base	1089	607	482	298	420	371	273	273	269	274
1. >6 Bahts		12	10	15	6	16	13	10	21	7	11
2. 6 Bahts		29	28	30	21	33	31	27	34	28	27
3. 5 Bahts		28	32	23	39	29	17	32	25	26	28
4. 4 Bahts		13	13	13	13	11	16	14	9	20	10
5. <4 Bahts		18	17	19	21	11	23	19	12	19	23
	Mean 2.9			**			**				**
	S.D. 1.3										
Buying Willingness	Base	1091	608	483	298	419	374	274	274	269	274
1. Buy		52	47	57	31	54	65	50	47	69	41
2. Not buy		14	17	11	28	12	7	13	20	9	16
3. Not sure		34	36	32	41	34	28	37	33	22	43
				**			**				**
Major Reason for Buying	Base	563	289	274	94	230	239	136	129	186	112
1. Nutritional advantage		61	64	59	57	64	60	69	50	61	65
2. Thai Product Favoured		13	12	14	19	13	11	16	9	14	12
3. Peanut & Sesame Preference		7	7	7	13	6	7	5	4	11	7
4. Palatability		18	17	19	9	17	22	10	36	13	16
5. Other Reasons		1	0	1	2	0	0	0	1	1	0
				n.s			**				**

Attribute Category		Total	Sex: F	Sex: M	Age: >12	Age: 10-12	Age: <10	School: PAN	School: SAT	School: P-B	School: SAM
Buying Frequency	Base	561	287	274	91	230	240	135	129	186	111
1. High frequency		11	10	12	9	5	17	12	11	13	5
2. Moderate frequency		63	63	63	57	74	54	60	65	62	66
3. Low frequency		26	27	25	34	21	29	28	24	25	29
	Mean 2.2			n.s			**				n.s
	S.D. ?										
Branding Suitability :	Base	1070	596	474	288	418	364	266	273	267	264
1. Suitable		63	63	62	49	65	71	60	54	72	66
2. Unsuitable		10	8	13	16	9	6	8	12	11	9
3. Don't know		27	29	25	35	26	23	32	34	17	25
				**			**				**

** , n.s = statistically significant, not significant among sexes, ages, or schools

APPENDIX 4.1

CASH OUTFLOW AND CASH INFLOW OVER 8 YEARS OF PRODUCT 1

(Deep-syrup cooked fruits in thin layers of pressed flour-mixture)

Year	Cash outflow (Bahts)			Cash inflow			
	Research & dev. cost	Fixed capital cost	Working capital cost	Sales quantity ('000,000)	Sales revenue ('000,000 B)	Production Costs B	Net revenue B
0	158,571	750,000					
1			112,500	1.5	4.5	3,996,900	503,100
2				2.0	6.0	5,329,200	670,800
3				3.0	9.0	7,993,800	1,006,200
4				4.0	12.0	10,658,400	1,341,600
5				5.0	15.0	13,323,000	1,677,000
6				5.0	15.0	13,323,000	1,677,000
7				3.0	9.0	7,993,800	1,006,200
8				1.5	4.5	3,996,900	503,100
		Total		25.0	75.5		

APPENDIX 4.2

NET PRESENT VALUE FOR PRODUCT 1 AT 16% RATE OF INTEREST

(Deep-syrup cooked fruits in thin layers of pressed flour mixture)

Year after introduction	0	1	2	3	4	5	6	7	8	9	Total
Investment cash flow	908751	112500									
Present value factor	1.000	0.862									
Investment present value	908751	96975									1005726
Revenue from sales	-	4500000	6000000	9000000	12000000	15000000	15000000	9000000	4500000		
Production costs	-	3996900	5329200	7993800	10658400	13323000	13323000	7993800	3996900		
Profit before tax	-	503100	67800	1006200	1341600	1677000	1677000	10062000	503100		
Tax (50%)	-	-	251550	335400	503100	670800	838500	838500	503100	-251500	
Profit after tax		503100	419250	670800	838500	1006200	838500	167700	0	-251500	
Present value factor	1.000	0.862	0.743	0.641	0.552	0.476	0.410	0.354	0.305	0.263	
Earning present value		433672	311503	429983	462852	478951	343785	59366	0	-66145	2453967
Net present value											1448241

APPENDIX 4.3

FACTOR DESCRIPTIONS AND RATE DEFINITION FOR PROBABILITY EVALUATION CRITERIA

Factors	Ratings	Factor Descriptions
1. Availability and cost of raw materials	Very good (10)	Utilize 100 % main raw materials which are indigenous, year-around availability, and cheap.
	Good (8)	Utilize 96-99% main raw materials which are indigenous year-around availability, and cheap.
	Average (6)	Utilize 91-95% main raw materials which are indigenous, year-around availability, and cheap.
	Poor (4)	Utilize 86-90% main raw materials which are indigenous, year-around availability, and cheap.
	Very poor (2)	Utilize 80-85 main raw materials which are indigenous, year-around availability, and cheap.
		(Imported main ingredients of over 20% not considered for use in products.)
2. Quality/price relationship	Very good (10)	Priced below all competiting products of similar quality.
	Good (8)	Priced below most competing products of similar quality.
	Average (6)	Approximately the same price as competing products of similar quality.
	Poor (4)	Price above many competing products of similar quality.
	Very poor (2)	Priced above all competing products of similar quality.
3. Profitability	Very good (10)	NPV-Index more than 100%.
	Good (8)	NPV-Index more than 80%.
	Average (6)	NPV-Index more than 60%
	Poor (4)	NPV-Index more than 40%
	Very poor (2)	NPV-Index more than 20%
4. Expected competitive situation	Very good (10)	Product and process that substantially restrict number of competitors.
	Good (8)	Product and process that other firms will not want to invest in additional facilities, unless extremely well suited.
	Average (6)	Product and process that will not profitable for other companies to compete, unless as strong as this firm.
	Poor (4)	Product and process that will allow large, medium, and some smaller companies to compete.
	Very poor (2)	Product and process that all companies can profitably enter market.
5. Effect of processing on nutrients.	Very good (10)	No/very short time of low heat treatment or process designed for nutritive value retention.
	Good (8)	Short time of high heat treatment, 10% of destruction of important nutrients.
	Average (6)	Moderate time of moderate heat treatment, 20% of destruction of important nutrients.
	Poor (4)	Long time of moderate heat treatment, 30% of destruction of important nutrients.
	Very poor (2)	Long time of high heat treatment, 50% of destruction of important nutrients.
6. Ease of enrichment	Very good (10)	Existing process already in use for enrichment successfully.
	Good (8)	Existing process already in use for enrichment but with minor adaptation, it could be used for enrichment successfully.
	Average (6)	Existing process never in use for enrichment. Sources of information for adaptation available if it would be used for enrichment.
	Poor (4)	Existing process never in use for enrichment. Sources of information for adaptation available if it would be used for enrichment. Some more research and development required.
	Very poor (2)	Existing process never in use for enrichment. No source of information was found. Much research and development required. Adaptation of the process needed.
7 Equipment necessary	Very good (10)	Can be produced with equipment that is presently idle.
	Good (8)	Can be produced with present equipment, but production will have to be scheduled with other products.
	Average (6)	Can be produced largely with present equipment, but the company will have to purchase some additional equipment.
	Poor (4)	Company will have to buy a great deal of new equipment, but some present equipment can be used.
	Very poor (2)	Company will have to buy all new equipment.
8. Production capacity	Very good (10)	Production capacity of >40 metric tons per day.
	Good (8)	Production capacity 31-40 metric tons per day.
	Average (6)	Production capacity 21-30 metric tons per day.
	Poor (4)	Production capacity 11-20 metric tons per day.
	Very poor (2)	Production capacity 10 metric tons or below per day.

APPENDIX 5.1

FOOD RAW MATERIAL COMPOSITIONS
(per 100 g edible portion)

APPENDIX 5.1: Food Raw Material Compositions: 1

Food Raw Materials / Cost and Nutrients	Banana	Coconut Milk	Flour, Glutinous	Flour, wheat	Oils, Soybean	Peanuts	Rice, Glutinous	Sesame Seeds, White	Sugar, Brown	Sugar, White
Cost (Baht)	0.3000	0.8933	0.7700	1.3000	1.6750	1.1830	0.5820	1.0530	0.7830	0.8700
Energy (calories)	119.0000	259.0000	372.0000	364.0000	884.0000	564.0000	359.0000	582.0000	389.0000	351.0000
Protein, digested (g)	0.9000	3.9000	5.6000	7.7000	0.0000	3.7000	7.1000	13.4000	0.9400	0.0000
Fat (g)	0.4000	28.2000	0.4000	1.0000	99.9000	47.5000	1.6000	52.8000	0.3000	0.0000
Fibre (g)	1.8000	0.0000	0.3000	3.0000	0.0000	2.4000	2.4000	14.4000	0.0000	0.0000
Calcium (mg)	11.0000	11.0000	12.0000	17.0000	0.0000	69.0000	16.0000	750.0000	178.0000	1.0000
Phosphorous (mg)	24.0000	132.0000	148.0000	95.0000	0.0000	401.0000	130.0000	614.0000	72.0000	1.0000
Iron (mg)	0.7000	1.4000	0.8000	1.0000	0.0000	2.1000	1.2000	12.0000	5.8000	0.1000
Vitamin A (IU)	540.0000	0.0000	0.0000	0.0000	6.0000	35.0000	0.0000	5.0000		0.0000
Thiamine (mg)	0.0200	0.0500	0.1000	0.1800	0.0000	1.1400	0.1600	0.7200	0.0500	0.0000
Riboflavin (mg)	0.2300	0.0200	0.0200	0.0500	0.0000	0.1300	0.0600	0.1700	0.1000	0.0000
Niacin (mg)	0.6000	0.4000	1.7000	1.3000	0.0000	17.2000	2.4000	5.1000	0.3000	0.0000
Vitamin C (mg)	12.0000	1.0000	0.0000	0.0000	0.0000	11.0000	0.0000	0.0000	0.0000	0.0000
Vitamin B6 (mg)	0.3200	0.0300	0.0800	0.4400	0.0000	0.4000	0.6200	1.2500	0.0000	0.0000
Vitamin B12 (µg)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Folic acid (µg)	9.7000	4.0000	5.6000	49.0000	0.0000	55.0000	20.0000	0.0000	0.0000	0.0000
Pantothenic acid (mg)	0.3100	0.0500	0.1500	1.2000	0.000	2.8000	1.5000	2.7600	0.0000	0.0000
Prot. Cal/Total Cal	0.0300	0.0600	0.0600	0.0900	0.0000	0.0300	0.0800	0.0900	0.0100	0.0000
Unsat. FA/Total Fats		0.1348	0.6111	0.7619	0.8178	0.7268	0.6111	0.7197		0.0000
Isoleucine (mg)	20.0000	161.0000	298.0000	373.0000	0.0000	211.0000	265.0000	952.0000	22.0000	0.0000
Leucine (mg)	38.0000	339.0000	560.0000	664.0000	0.0000	400.0000	635.0000	1583.0000	32.0000	0.0000
Lysine (mg)	36.0000	177.0000	283.0000	210.0000	0.0000	221.0000	247.0000	637.0000	15.0000	0.0000
Methionine (mg)	3.0000	62.0000	157.0000	146.0000	0.0000	72.0000	79.0000	663.0000	7.0000	0.0000
Cystine (mg)	19.0000	120.0000	72.0000	170.0000	0.0000	78.0000	114.0000	202.0000	1.0000	0.0000
Phenylalanine (mg)	30.0000	233.0000	364.0000	433.0000	0.0000	311.0000	274.0000	1099.0000	18.0000	0.0000
Tyrosine (mg)	19.0000	166.0000	185.0000	287.0000	0.0000	244.0000	133.0000	712.0000	56.0000	0.0000
Threonine (mg)	28.0000	189.0000	254.0000	249.0000	0.0000	163.0000	212.0000	959.0000	23.0000	0.0000
Tryptophan (mg)	65.0000	65.0000	77.0000	106.0000	0.0000	65.0000	167.0000	283.0000	9.0000	0.0000
Valine (mg)	29.0000	281.0000	276.0000	418.0000	0.0000	261.0000	280.0000	1151.0000	31.0000	0.0000

APPENDIX 5.1: Food Raw Material Compositions :2

	Mungbean	Pumpkin	Cowpea flour	Liver powder, beef	Liver powder, chicken	Coconut cream	Mungbean skinned
Cost	0.9730	0.2680	0.6000	40.000	40.00	1.3400	1.0100
Weight	1.0000	1.0000	1.0000	1.000	1.00	1.0000	1.0000
Calories	356.0000	27.0000	366.0000	446.000	469.00	388.5000	369.3000
Protein digested (Thai)	19.0320	0.5000	21.3000	64.110	66.30	5.8500	19.7260
Fat	1.0000	0.2000	1.3000	10.800	14.27	42.3000	1.0300
Fibre	4.3000	0.5000	9.8000	0.000	0.00	0.0000	4.4600
Calcium	125.0000	24.0000	125.0000	24.390	51.28	16.5000	129.6700
Phosphorus	340.0000	33.0000	434.0000	1080.140	556.78	198.0000	352.7000
Iron (mg)	5.7000	0.7000	7.4000	30.310	12.82	2.1000	5.9000
Vitamin A (IU)	130.0000	1308.0000	19.0000	152934.000	117948.00	0.0000	134.8600
Vitamin B1	0.6600	0.0300	0.6700	1.120	1.14	0.0750	0.6900
Vitamin B2	0.2200	0.0400	0.2500	5.850	16.45	0.0300	0.2200
Niacin (mg)	2.4000	0.5000	2.6000	44.600	41.03	0.6000	2.5000
Vitamin C (mg)	10.0000	14.0000	1.0000	83.620	128.21	1.5000	10.3700
Vitamin B6 (mg)	0.5800	0.1100	0.4700	2.860	2.86	0.0450	0.6000
Vitamin B12 (µg)	0.0000	0.0000	0.0000	183.620	183.62	0.0000	0.0000
Folic acid (µg)	20.0000	17.0000	500.0000	871.080	871.08	6.0000	20.7500
Pantothenic acid (mg)	0.9750	9.3000	1.4000	26.830	26.83	0.0750	1.0114
Isoleucine (mg)	287.0000	17.0000	1997.0000	3898.960	3729.44	241.5000	1161.1000
Leucine (mg)	450.0000	23.0000	2548.0000	6334.50	6059.09	508.5000	1820.5400
Lycine (mg)	456.0000	48.0000	1983.0000	5306.62	5075.90	265.50	1844.8100
Methionine	69.0000	16.0000	412.0000	2233.45	2136.34	93.00	279.1500
Cystine	38.0000	38.0000	163.0000	846.690	809.880	180.0000	153.7300
Phenylalanine (mg)	396.0000	20.0000	1552.0000	3909.410	3739.440	349.5000	1492.8400
Tyrosine (mg)	106.0000	9.0000	781.0000	2404.180	2299.650	249.0000	428.8400
Threonine	213.0000	27.0000	1202.0000	2627.180	2512.960	283.5000	861.7200
Tryptophane (mg)	37.0000	7.0000	426.0000	975.610	933.190	97.5000	149.6900
Valine (mg)	320.0000	14.0000	2050.0000	4662.020	4459.320	421.5000	1294.6100
Protein cal./Total cal.	0.2140	0.0741	0.2328	0.580	0.570	0.0600	0.2137
Unsat. fat/Total Fat	0.7268	0.0000	0.7619	0.470	0.470	0.1348	0.7268

APPENDIX 5.1: FOOD RAW MATERIAL COMPOSITIONS: 3

	Whole Egg	Egg Yolk	Cassava Flour	Egg Yolk Powder	Glucose Syrup	Banana Syrup
Cost (Bahts)	2.3100	7.4500	0.5000	17.6100	1.5000	0.5800
Energy(Calories)	163.0000	336.0000	354.0000	713.3800	364.0000	287.8600
Protein, digested (g)	12.5000	15.8000	0.4200	33.5500	0.0000	0.7000
Fat (g)	11.5000	29.0000	0.2000	61.5700	0.0000	0.2220
Fibre (g)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Calcium (mg)	61.0000	154.0000	0.0000	326.9600	7.4100	131.7200
Phosphorus (mg)	222.0000	479.0000	0.0000	1016.9900	11.1100	53.2800
Iron (mg)	3.2000	6.3000	0.0000	13.3800	0.3700	4.2900
Vitamin A (IU)	1950.0000	4025.0000	0.0000	8545.6500	0.0000	0.0000
Thiamine (mg)	0.1000	0.24000	0.0000	0.5100	0.0000	0.0370
Riboflavin (mg)	0.4000	0.4700	0.0000	1.0000	0.0000	0.0740
Niacin (mg)	0.1000	0.0000	0.0000	0.0000	0.0000	0.2220
Vitamin C (mg)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vitamin B6 (mg)	0.1000	0.3100	0.1100	0.6600	0.0000	0.0000
Vitamin B12 (µg)	2.0000	6.0000	0.0000	12.7400	0.0000	0.0000
folic acid (µg)	4.3000	12.9000	0.0240	27.3900	0.0000	0.0000
Pantothenic acid (mg)	1.7000	4.2000	0.5200	8.9200	0.0000	0.0000
Prot. Cal/Total Cal	0.3068	0.1180	0.0050	0.1881	0.0000	0.0100
Unsat. FA/Total Fats	0.4700	0.4700	0.8000	0.4700	0.0000	0.0000
Isoleucine (mg)	779.0000	835.0000	103.7400	1772.8200	0.0000	16.2800
Leucine (mg)	1127.0000	1409.0000	141.9600	2991.5100	0.0000	23.6800
Lysine (mg)	859.0000	1253.0000	228.4800	2660.3000	0.0000	11.1000
Methionine (mg)	396.0000	339.0000	34.8600	719.7500	0.0000	5.1800
Cystine (mg)	309.0000	287.0000	37.8000	609.3400	0.0000	0.7400
Phenylalanine (mg)	717.0000	679.0000	84.8400	1441.6100	0.0000	13.3200
Tyrosine (mg)	494.0000	653.0000	25.2000	1386.4100	0.0000	41.4400
Threonine (mg)	622.0000	783.0000	94.5000	1662.4200	0.0000	17.0200
Tryptophan (mg)	218.0000	248.0000	30.2400	526.5400	0.0000	6.6600
Valine (mg)	900.0000	887.0000	110.0400	1883.2300	0.0000	22.9400

APPENDIX 5.1 (Continued): FOOD RAW MATERIAL COMPOSITIONS

Notes on Sources of Data:

1. Ngarmsak (1983): Banana, coconut milk, wheat flour, glutinous rice, sesame seeds, white sugar, brown sugar (from Vitamin B6 to Pantothenic acid, coconut sugar), glutinous flour (from Vitamin B6 to Valine, rice flour), pumpkin, cowpea flour, liver, and egg.

2. Anderson (1975): Peanuts (use 78% digestibility of sesame in Ngarmsak), and mungbean (except protein which is from Thai Public Health, 1973. And digestability of cowpea protein of 78% was used).

3. "Food Composition Table for Use in East Asia (1973)": Glutinous rice flour (from calories to Vitamin C except digestibility of protein - used that of rice flour, soybean oils (use that of vegetable oils), brown sugar (from Calories to Vitamin C except the digestibility of protein - used that of coconut sugar in Ngarmsak), and Vitamin B6 to Pantothenic acid).

4. Protein (g), protein digestibility (%), and digested protein (g):

Food	Protein (g)	Prot. Digest.(%)	Digested prot.(%)
Banana	1.00	85	0.90
Coconut milk	4.60	85	3.90
Flour, glutinous rice	6.60	84	5.60
Flour, wheat	8.60	89	7.70
Oils, soybean	0.00	-	0.00
Peanuts	4.77	78	3.70
Rice, glutinous	8.40	84	7.10
Sesame seeds, white	17.20	78	13.40
Sugar, brown	1.10	85	0.94
Sugar, white	0.00	-	0.00
Mungbean	24.40	78	19.032
Pumpkin	0.70	65	0.50
Flour, cowpea	27.30	78	21.30
Liver, beef	19.00	97	18.40
Liver, chicken	18.10	97	17.60
Egg, yolk	16.30	97	15.80
Egg, whole	12.90	97	12.90
Cassava starch	0.50	84	0.42

5. Prot. Cal/Total Cal: by calculation

6. Unsat. FA/Total fats: by calculation:

Food	Unsat. FA (g)	Tot. Fats (g)
Banana	-	-
Coconut milk	3.80	28.20
Flour, glutinous rice	1.10	1.80 (that of rice flour)
Flour, wheat	1.60	2.10 (that of wheat)
Oils, soybean	81.70	99.90 (that of vegetable oils)
Peanuts	14.10	19.40
Rice, glutinous	1.10	1.80
Sesame seeds, white	38.00	52.80
Sugar, brown	-	-
Sugar, white	-	-
Liver, beef	47.00	)
Liver, chicken	47.00	) That of animal fat
Egg (whole, yolk, yolk powder)	47.00	)

7. Cost: Wholesale price in Bangkok, 1982.

8. Cost of coconut milk:

Coconut shredd yield 65% coconut cream.

To make coconut milk, water should be added for the pressing process, app. a half of the cream obtained or app. 35.5%.

Therefore, the yield of coconut milk is app. 65 + 32.5 = 97.5/100 g coconut shredd.

The cost of coconut shredd = 8.71 B/Kg (wholesale price)

= 0.871 B/100 g

Coconut milk 97.5 g costs = 0.871 B

Coconut milk 100 g costs $= \frac{0.871 \times 100}{97.5} = 0.8933$ B

9. Cowpea flour cost was from Ngarmsak, 1983.

20% increase in cost was assumed.

10. Beef liver powder (LIVERBP): calculation from beef liver (Ngarmsak, 1983) based on moisture amount of 71.3% (Thai Public Health, 1970).

11. Chicken liver powder (LIVERCP): calculation from chicken liver, based on moisture content of 72.7% (Thai Public Health, 1970), for most of the nutrients. The exceptions were for VITB6, VITB12, FOLIC, PANTO, which were assumed to be the same amount of LIVERBP; and for all amino acids, which were assumed to be the same pattern of LIVERBP but in decreased amount based on the amount of PROTD it contained.

APPENDIX 5.1 (Continued): FOOD RAW MATERIAL COMPOSITIONS

12. The costs of LIVERBP and LIVERCP assumed to be the same and to be 400 Bahts/Kg or 40 B/100g. This figure was based on the following calculation.

    Liver cost = 50 B/Kg (assumed to be the same as beef or chicken)

    To make 100 g of liver powder, need fresh liver 350 g (based on 28-29% solid).

    The cost of which = 50 x 100/1000 x 350 = 17.50.

    Assume processing and marketing cost: raw material cost = 35 : 15

    Therefore, retailed price = 58.33

    Wholesale price = 58.33 x 67/100 = 39.08

    or = 40 B/100 g

13. Cost of glucose syrup ≃ 15 B/Kg

14. Calculation of cost and nutrients of coconut cream.

    Coconut shredd yield 65% coconut cream.

    Cost of coconut shredd = 8.71 B/Kg

    Coconut cream 65 g cost 0.871 B

    Coconut cream 100 g cost 0.871 x 100/65 = 1.34 B

    Since coconut milk is coconut cream : water = 2:1

    Thus, nutrients of coconut cream 100 = that of coconut mulk 150

    Therefore, 150/100 or 1.5 was used as the multiplier of nutrients in coconut milk to get nutrients for coconut cream.

15. Nutrients of egg yolk powder were calculated from egg yolk on the basis of 52.9% moisture of egg yolk (Thai Public Health). Thus, 100/47.1 was used as the multiplier for nutrients in egg yolk to get those of egg yolk powder.

    Cost of whole egg were from Sinthavalai (1984).

    Twenty percent increase in price was assumed.

    Since whole egg comprises of 31% egg yolk, the cost of egg yolk was assumed to be 100/31 of whole egg.

    As for egg yolk powder, the cost was NZ $9.81/Kg or 147.15 B/Kg (Assume NZ $1 = 15B). Twenty percent increase in price was assumed; thus, the cost was 176.58 B/Kg or 17.66 B/100g.

16. Glucose syrup composition from Food and Nutrition.

17. Cassava flour from Chittaporn, 1977.

18. Banana-syrup composition assumed that of 74% of sugar (since syrup concentration = 74%); Assumed no other composition other than those of sugar.

    However this syrup contains other compositions dissolved from banana.

19. Costs of synthetic nutrients were from Roche Price List, 1983.

Synthetic Nutrients and Costs

Synthetic Nutrients and Chemicals	Cost/Kg NZ$	Cost/Kg Bahts	Cost/100 g Bahts
Riboflavin	81.59	1223.85	122.39
Vitamin B12, crystal 100%	3700.00	55500.00	5550.00
Vitamin A palmetate type 500	24.26	363.90	36.39
Ascorbic acid	16.16	249.90	24.99
Folic acid	216.82	3252.30	325.23
Citric acid	2.35	35.25	3.53

Note: 1. Assume NZ $1 - 15 Bahts.
2. Vitamin A palmetate type 500: 500,000 IU/G
3. Source Roche Price List, 1983 (exception for citric, 1981)

APPENDIX 5.2a

IDENTIFICATION OF THE UNIT PROCESS AND DESCRIPTION OF THE PROCESSINGS

The flour, for the pastry type product, would be mixed with vegetable oil and water; and folded in the way that it would form a tender flaky pastry. After filling, the pastry would be cut into a square form.

The flour, for the pressed flour mixture would be in roasted form ready to be mixed with syrup and to form the thin layers for the sandwiching purpose.

The filling ingredients would be in the cooked form (boiling, roasting, deep syrup cooked, etc) and ready to be mixed with the vitamin mix to form an intermediate moisture or semimoisture filling mixture for the products.

The processes to be used for the products to be developed could be divided as follows:

1. Deep-Syrup Cooking of Bananas
   The banana would be deep-syrup cooked in the stainless steel jacket pan under controlled conditions of temperature, or in other words, of sugar concentration of the syrup. This could be classified under osmotic-dried process of banana. The colour of the product could be glossy yellow or glossy intense red for certain varieties of banana. Sulphuring, if needed, should be carried out by the use of solution of potassium metabisulphite. 0.04% of calcium chloride should be added to the cooking-syrup as firming agent.

   The raw materials The banana fruit should be bought green at the just-mature or a half full ripe stage to avoid mushiness of the finished product. If the banana bought is green under just-mature stage, ripening at the process plant should be taken from three to four days, after which the fruit would be ready for processing when it has acquired a yellow green colour and is still firm, with a sugar content of about 15-20%.

   Preparation After just-maturing, the bananas would be separated from the stems and the hands of fruits, washed thoroughly in tanks of clean water in order to remove and prevent any carry over during peeling.

   The bananas would be separated from the hands and peeled by hand with stainless steel knives, immediately after which they should be put in the calcium chloride solution or put in the cooking syrup, added 0.04% calcium chloride as firming agent. Sulphuring, if needed, should be carried out by dipping the banana in solution of potassium metabisulphite before deep-syrup cooking.

   Deep-Syrup Cooking The banana should be deep-syrup cooked immediately after sulphuring in a stainless steel jacket pan in which there is a sugar at 65 Brix (or a temperature of 102°C). The jacket pan must have a bottom drain with fittings so syrups can be pumped out the bottom and back to the top. A circular perforated aluminium or stainless steel sheet the diameter of the inside of the jacket pan should be positioned on top of the contents of the pan while cooking, weighted sufficiently to keep the banana immersed an inch or two below the surface, and secured in this position. Once in a while during the deep-syrup cooking process, the circulating pump should withdraw syrup from the bottom of the tank and discharge it to the surface of the syrup on top.

   During the operation, water would be withdrawn from the banana. Remedying the dilution of the syrup and increasing the rate of osmotic drying would be carried out by slowly raising the temperature of the syrup to the finished temperature of 108°C (or 72 Brix). The approximate deep-syrup cooking time would be 1½ - 2½ hours. The syrup would be decolourized with activated carbon, filtered, boiled down to 65 Brix and re-used for deep-syrup cooking.

   The deep-syrup cooked banana should be removed from the syrup and allowed to drain for about 20 minutes and would be ready to be mixed with other filling ingredients. The banana product should contain < 25% moisture and should have the water activity level under 0.80. It should, by subjective method, be glossy yellow or glossy red in colour, firm and chewy in texture and should have intense banana flavour.

2. Boiling and Roasting of Mungbean

   Boiling and roasting of mungbean should be done by the use of simple techniques of low cost. The finished product should be in the form of bursting fluffy whole mungbean with a well cooked aroma and taste.

   The raw material Whole kernel of unskinned green mungbean with moisture content of app. 13% would be used.

   Preparation The mungbean should be sorted by hand to remove the hard kernels and any other foreign substances. (Air separator could be used if available). The sorted mungbean should then be washed and soaked in water and left overnight or 10 hours at least.

APPENDIX 5.2a (Continued)

IDENTIFICATION OF THE UNIT PROCESS AND DESCRIPTION OF THE PROCESSINGS

Boiling of soaked mungbean The soaked mungbean should then be boiled in a jacket pan, in a limited amount of water to avoid the loss of nutrients, until well-cooked or kernel-bursting stage (Using mungbean 200g, or soaked mungbean 400g, and water 300-400g; boiling for approx. 30 minutes or until the cooked mungbean is approx. 260g). Or, it would be cooked in a steam cooker under 15 pounds of steam pressure in the cooker until thoroughly cooked. The lumps of the cooked mungbean coming from the cooker should then be drained, if necessary, and separated or spread on a pan; and it should then be roasted in an oven at 150°C for 10 minutes bottom heat and another 5 minutes top heat. The roasting time would be depending on: a) thickness of prepared mungbean, and b) the mungbean property desired for the product.

The fluffy roasted mungbean should have and maintain a moisture content of app. 15% to have the desired firm but tender texture. It should be, by subjective method, green for the skin part and light yellow for the bursting part. Its flavour should have creamy and well-cooked bean flavour and it should be firm and tender in texture.

3. Roasting of Peanuts

Roasting of peanuts should be done dry by radiant heat.

Raw Materials Peanuts of high grade and with less than three months of storage time is preferred.

Preparation Before roasting, the peanuts should be sorted by hand to remove shrunken, moldy, and discoloured kernels and any other foreign substances. (Air separator could be used if available).

Roasting The roasting process should be of batch type. Peanuts should be subjected to 450-500°F (230-260°C) air in an oven. The peanuts should be held at this temperature for 3 minutes using bottom heat and another 3 minutes using top heat. Revolving oven could also be used for this purpose. The roasted peanuts should be, by subjective method, evenly light brown in colour, tender crisp in texture, and rancidless cooked-nutty in flavour.

4. Roasting of White Sesame Seeds

Roasting of white sesame seeds should be done dry by radiant heat.

Raw Materials White sesame seeds of large size and with less than 3 months of storage time is preferred.

Preparation The white sesame seeds should be sorted by hand to remove any other foreign substances. The sorted white sesame seeds should then be washed to remove the dust and the remaining light foreign materials.

Roasting After washing, the white sesame seeds should be roasted by a batch type process. They should be subjected to 450-500°F (230-260°C) air in an oven and should be held at this temperature for 2 minutes using bottom heat and another 2 minutes using top heat.

The roasted white sesame seeds should be, by subjective method, light brown in colour, tender crisp in texture, and rancidless cooked-nutty in flavour.

5. Preparation of Coconut Milk

Coconut cream should be prepared by the use of low cost machine already in general use in food factory in Thailand. The process consists of two main steps - shredding and squeezing.

Raw Materials The coconut should be in fully mature stage, the kernel of which represents 60% and the water about 8% by weight. (The rest consist of a husk and the hard outer shell enclosing the coconut meat). It should be bought unhusked.

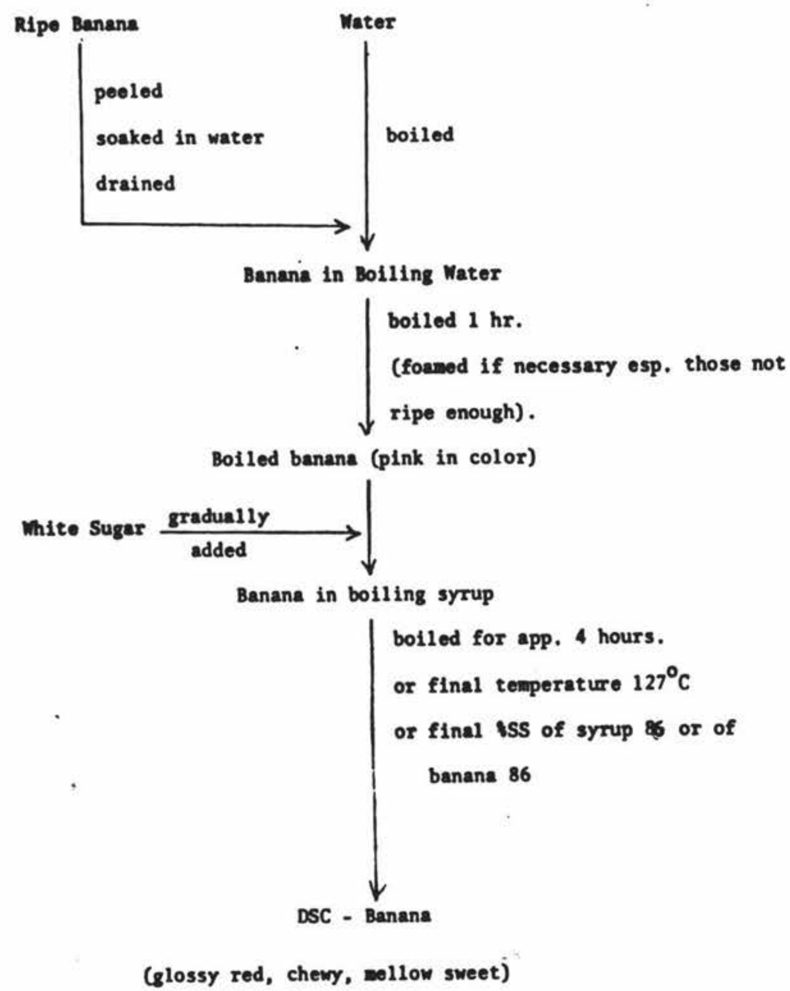
Preparation The fully mature coconut should be dehusked and shelled by hand using a stainless steel knife. The husk and shell could be used for fuel; and the watery fluid or coconut water could be used for lactic-acid fermentation purpose. Washing white coconut meat should be done in a tank having a bottom drain with fittings so that washed water could be pumped out.

Shredding and Squeezing The fresh coconut kernel should be grated in a comminuter, the blade of which is made from stainless steel. Squeezing should be done by a wedge/die plate mill consisting of a stainless steel knife-edged wedge rotating above a die-plate. Minced coconut kernel would be fed through the mill (without water added) and, the separation of the emulsion (coconut cream) from the cellulosic residue done by providing a perforated tray with the container for the cream at the bottom part of the machine, and another container for the discharged residue at one end. A certain amount of water should be added to the coconut residue; and the squeezing process should be repeated once more to take out the cream remaining from the first squeeze. (The coconut residue could be used for animal feed or for fuel).

Coconut cream which was found to be an oil in water emulsion would have the oil content of about 20-30%; and it should have the oil content of 10-15% when mixed with the second squeezing product. The coconut milk obtained from the above combining procedure should be, by subjective method, white in colour, fresh coconut or no rancid in flavour.

APPENDIX 5.2 b.

DSC - BANANA PROCESS



APPENDIX 5.3

DETAILED DESCRIPTIONS OF Z-ARM MIXER AND NID BAR-FORMING MACHINE

The Z-Arm Mixer (adapted by Sanitarium Health Food Factory)

Capacity	160 litres
Speed 1	28 rpm
Speed 2	48 rpm

The NID Bar Forming Machine (Australia)

Feed rollers
- fluted type
- roll in opposite directions
- pull product down

Forming rollers
- made of nylon
- constant mould size of bar
- thickness of the bar depends on speed of feed rollers and forming rollers, both of which should be matched.
  thickness applied: 32 mm width, 10 mm thick, flexible length.

Belt conveyer
- right speed needed
- separated card boards needed for the formed bar

Guillotine
- Speed determines length of bar
- 12.5 cm used
- Manually receiving the board needed after cutting the bars
- Trolley needed for board stacking to be ready for the transference to packaging department.

Conditions for bar-forming

Feed roller speed 1.25 rpm
(150 mm diameter)
surface speed 1.93 ft/min

Form roller speed 1.9 rpm
(150 mm diameter)
surface speed 2.94 ft/min

Conveyers
Surface speed 4.5 ft/min

Guillotine strokes/min 25

APPENDIX 5.4a

DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP1

The Yates Analyses For DSC-Banana.

Output Variables	Run	Results	1st col.	2nd col.	Mean Effect
1. %DSC-Banana Obtained	(1)	40.3	80.0	135.6	33.9
	a	39.7	55.6	-0.6	-0.30
	b	27.8	-0.6	-24.4	-12.20*
	ab	27.8	0.0	0.6	0.30
2. %B-Syrup Left	(1)	45.7	91.2	213.5	53.4
	a	45.5	122.3	1.5	0.8
	b	60.3	-0.2	31.1	15.6*
	ab	62.0	1.7	1.9	1.0
3. % Loss through foam	(1)	5.3	13.3	26.0	6.5
	a	8.0	12.7	5.4	2.7*
	b	5.0	2.7	-0.6	-0.3
	ab	7.7	2.7	0.0	0.0
4. % SS, DSC-Banana and Syrup	(1)	77.0	154.0	310.0	77.5
	a	77.0	156.0	0.0	0.0
	b	78.0	0.0	2.0	1.0*
	ab	78.0	0.0	0.0	0.0
5. Aw, DSC-Banana	(1)	0.802	1.625	3.360	0.840
	a	0.823	1.735	0.066	0.033*
	b	0.845	0.021	0.110	0.055*
	ab	0.890	0.045	0.024	0.012
6. Aw, B-Syrup	(1)	0.802	1.573	3.193	0.798
	a	0.771	1.620	-0.011	-0.006
	b	0.800	-0.031	0.047	0.024*
	ab	0.820	0.020	0.051	0.026*
7. pH, DSC-Banana	(1)	4.90	9.73	19.36	4.84
	a	4.83	9.63	0.00	0.00
	b	4.78	-0.07	-0.10	-0.05
	ab	4.85	0.07	0.14	0.07
8. pH, B-Syrup	(1)	4.88	9.69	19.32	4.83
	a	4.81	9.63	0.00	0.00
	b	4.78	-0.07	-0.06	-0.03
	ab	4.85	0.07	0.14	0.07
9. Force, 1st chew.	(1)	9.5	17.8	35.6	8.9
	a	8.3	17.8	-0.2	-0.10
	b	8.4	-1.2	1.2	0.60
	ab	9.4	1.0	2.2	1.10*
10. Force, 2nd chew.	(1)	5.8	11.1	25.6	6.4
	a	5.3	14.5	1.0	0.50
	b	6.5	-0.5	3.4	1.70*
	ab	8.0	1.5	2.0	1.00
11. Red R. Mean	(1)	1.0	1.8	2.9	0.725
	a	0.8	1.1	-0.7	-0.35*
	b	0.8	-0.2	-0.7	-0.35*
	ab	0.3	-0.5	-0.3	-0.15
12. Chewy R. Mean	(1)	1.2	2.2	3.6	0.9
	a	1.0	1.4	0.0	0.0
	b	0.6	-0.2	-0.8	-0.4*
	ab	0.8	0.2	0.4	0.2
13. Ban Flav R. Mean	(1)	0.6	1.2	3.3	0.825
	a	0.6	2.1	0.1	0.05
	b	1.0	0.0	0.9	0.45*
	ab	1.1	0.1	0.1	0.05
14. y-value, DSC-Banana	(1)	0.32	0.64	1.29	0.323
	a	0.32	0.65	0.01	0.005
	b	0.32	0.00	0.01	0.005
	ab	0.33	0.01	0.01	0.005
15. x-value, DSC-Banana	(1)	0.26	0.53	1.10	0.275
	a	0.27	0.57	0.02	0.01
	b	0.28	0.01	0.04	0.02*
	ab	0.29	0.01	0.00	0.00
16. y-value, B-Syrup	(1)	0.31	0.62	1.24	0.310
	a	0.31	0.62	0.00	0.000
	b	0.31	0.00	0.00	0.000
	ab	0.31	0.00	0.00	0.000
17. x-value, B-Syrup	(1)	0.24	0.48	1.01	0.253
	a	0.24	0.53	0.03	0.015
	b	0.25	0.00	0.05	0.025*
	ab	0.28	0.03	0.03	0.015

Notes: A = Initial Temp., 102 and 106;
B = Percent Solids (Ripeness), 17.5% and 23.0%.

y-value = chromaticity coordinate value identified the value (lightness) of the hue
x-value = chromaticity coordinate value identified the hue (chroma)

APPENDIX 5.4 b

DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP 2
The Yates' Analysis for DSC-Banana

EXP 2	(1)			a			b			ab		
	Rep 1	Rep 2	Average	Rep 1	Rep 2	Average	Rep 1	Rep 2	Average	Rep 1	Rep 2	Average
1.	29.560	28.220	28.890	26.440	26.000	26.220	32.220	33.330	32.775	28.670	29.330	29.000
2.	41.330	45.330	43.330	48.890	46.890	47.890	20.670	41.110	30.890	27.780	51.110	39.445
3.	78.000	77.000	77.500	76.500	78.000	77.250	78.000	78.000	78.000	76.500	77.000	76.750
4.	0.859	0.930	0.895	0.922	0.930	0.926	0.795	0.839	0.817	0.812	0.871	0.842
5.	0.820	0.820	0.820	0.864	0.828	0.846	0.820	0.816	0.818	0.797	0.836	0.817
6.	5.230	5.270	5.250	5.230	5.330	5.280	4.670	4.650	4.660	4.640	4.670	4.655
7.	0.390	0.650	0.520	0.740	0.890	0.815	0.790	0.930	0.860	1.020	0.930	0.975
8.	0.180	0.560	0.370	0.200	0.510	0.355	1.100	1.050	1.075	1.010	0.850	0.930
9.	0.450	0.580	0.520	0.430	0.550	0.490	0.820	0.750	0.785	1.020	0.820	0.920
10.	0.340	0.350	0.350	0.340	0.360	0.350	0.320	0.340	0.330	0.330	0.340	0.335
11.	0.390	0.410	0.400	0.390	0.410	0.400	0.460	0.440	0.450	0.440	0.410	0.425
12.	0.370	0.370	0.370	0.400	0.370	0.385	0.360	0.360	0.360	0.360	0.400	0.380
13.	0.420	0.460	0.440	0.540	0.540	0.540	0.470	0.430	0.450	0.570	0.540	0.555

APPENDIX 5.4 b : Continued

DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP 2
The Yates' Analysis for DSC-Banana

Output Variables	Run	Average Result	1st Column	2nd Column	Mean Effect	S.E.	t-ratio
1. % DSC-banana obtained	(1)	28.89	55.11	116.89	29.22	1.95	14.98
	a	26.22	61.78	-6.45	-3.23		-1.66
	b	32.78	-2.67	6.67	3.34		1.71
	ab	29.00	-3.78	-1.11	-0.56		0.29
2. % B-syrup left	(1)	43.33	91.22	161.56	40.39	6.72	6.01
	a	47.89	70.34	13.12	6.56		0.98
	b	30.89	4.56	-20.88	-10.44		1.55
	ab	39.45	8.56	4.00	2.00		0.30
3. % SS of DSC-banana/syrup	(1)	77.50	154.75	309.50	77.38	0.52	148.81
	a	77.25	154.75	-1.5	-0.75		1.44(*)
	b	78.00	-0.25	0.0	0.00		0.00
	ab	76.75	-1.25	-1.0	-0.50		0.96
4. Aw of DSC-banana	(1)	0.895	1.821	3.480	0.87	0.04	21.75
	a	0.926	1.659	0.056	0.028		0.70(*)
	b	0.817	0.031	-0.162	-0.081		-2.03(*)
	ab	0.842	0.025	-0.006	-0.003		0.08
5. Aw of B-syrup	(1)	0.820	1.666	3.301	0.825	0.02	41.25
	a	0.846	1.635	0.025	0.013		0.65
	b	0.818	0.026	-0.031	-0.016		-0.80
	ab	0.817	-0.001	-0.027	-0.014		-0.07
6. pH of DSC-banana/syrup	(1)	5.25	10.53	19.85	4.96	0.25	19.84
	a	5.28	9.32	0.03	0.02		0.08
	b	4.66	0.03	-1.21	-0.61		-2.44(*)
	ab	4.66	0.00	-0.03	-0.02		-0.08
7. Ratio-Mean: Red	(1)	0.52	1.34	3.16	0.79	0.15	5.27
	a	0.82	1.82	0.40	0.20		1.33(*)
	b	0.86	0.30	0.48	0.24		1.60(*)
	ab	0.96	0.10	-0.20	-0.10		-0.67
8. Ratio-mean: Chewy	(1)	0.37	0.73	2.74	0.685	0.28	2.45
	a	0.36	2.01	-0.16	-0.080		-0.29
	b	1.08	-0.01	1.28	0.640		2.29(*)
	ab	0.93	-0.15	-0.14	-0.070		-0.25
9. Ratio-mean: Banana flavour	(1)	0.52	1.01	2.72	0.68	0.16	4.25
	a	0.49	1.71	0.10	0.05		0.31
	b	0.79	-0.03	0.70	0.35		2.19(*)
	ab	0.92	0.13	0.16	0.08		0.50
10. y-value: DSC-banana	(1)	0.350	0.700	1.370	0.340	0.01	34.00
	a	0.350	0.670	0.005	0.003		0.30
	b	0.330	0.000	-0.030	-0.015		-1.50(*)
	ab	0.335	0.005	0.005	0.003		0.30
11. x-value: DSC-banana	(1)	0.400	0.800	1.675	0.419	0.02	20.95
	a	0.400	0.875	-0.025	-0.013		-0.65
	b	0.450	0.000	0.075	0.038		1.90(*)
	ab	0.425	-0.025	-0.025	-0.013		-0.65
12. y-value:	(1)	0.370	0.755	1.495	0.374	0.01	37.40
	a	0.385	0.740	0.035	0.018		1.80(*)
	b	0.360	0.015	-0.015	-0.008		-0.80
	ab	0.380	0.020	0.005	0.003		0.30
13. x-value: B-syrup	(1)	0.440	0.980	1.985	0.496	0.04	12.40
	a	0.540	1.005	0.205	0.103		2.58(*)
	b	0.450	0.100	0.025	0.013		0.33
	ab	0.555	0.105	0.005	0.003		0.08

APPENDIX 5.4c

DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP 3

Yates' Analysis for DSC-Banana

Output Variables	Treatment	Result	1st Column	2nd Column	Effect Mean	T-Score
1. BAN WT (SE= 3.0)	(1)	1,020	1,970	3,975	993.8	331.2
	a	950	2,005	-5	-2.5	-0.8
	b	970	-70	35	17.5	5.8**
	ab	1,035	65	135	67.5	22.5**
2. SY WT (SE= 4.0)	(1)	1,890	3,540	6,550	637.5	159.4
	a	1,650	3,010	-400	-200.0	-50.0**
	b	1,585	-240	-530	-265.0	-66.3**
	ab	1,425	-160	80	40.0	10 **
3. BSS DAYO (SE= 0.5)	(1)	50	99	215	53.8	107.5
	a	49	116	3	1.5	3.0*
	b	56	-1	17	8.5	17.0**
	ab	60	4	5	2.5	5.0**
4. BSS DAY 1 (SE= 0.5)	(1)	48	94	204	51.0	102.0
	a	46	110	0	0.0	0.0
	b	54	-2	16	8.0	16.0**
	ab	56	2	4	2.0	4.0*
5. BSS DAY 5 (SE= 0.5)	(1)	45	96	208	52.0	104.0
	a	51	112	16	8.0	16.0**
	b	51	6	16	8.0	16.0**
	ab	61	10	4	2.0	4.0*
6. BSYSS DAY 0 (SE= 0.0)	(1)	80	160	320	80.0	160.0
	a	80	160	0	0.0	0.0
	b	80	0	0	0.0	0.0
	ab	80	0	0	0.0	0.0
7. BSYSS DAY 1 (SE= 0.5)	(1)	72	148	301	75.3	150.5
	a	76	153	9	4.5	9.0**
	b	74	4	5	2.5	5.0**
	ab	79	5	1	0.5	1.0
8. BSYSS DAY 5 (SE= 1.0)	(1)	62	123	255	63.8	63.8
	a	61	132	1	0.5	0.5
	b	65	-1	9	4.5	4.5*
	ab	67	2	3	1.5	1.5
9. BINSY SS DAY 0 (SE= 0.5)	(1)	50	99	216	54.0	108.0
	a	49	117	2	1.0	2.0
	b	57	-1	18	9.0	18.0**
	ab	60	3	4	2.0	4.0*
10. BINSY SS DAY 1 (SE= 0.5)	(1)	51	106	223	55.8	111.0
	a	55	117	9	4.5	9.0**
	b	56	4	11	5.5	11.0**
	ab	61	5	1	0.5	1.0

APPENDIX 5.4c: Continued

Output Variables	Treatment	Result	1st Column	2nd Column	Effect Mean	T-Score
11. BINSY SS DAY 5 (SE= 0.5)	(1)	51	112	236	59.0	118.0
	a	61	124	22	11.0	22.0**
	b	56	10	12	6.0	12.0**
	ab	68	12	2	1.0	2.0
12. SINFRIGE DAY 0 (SE= 0.5)	(1)	80	160	320	80.0	160.0
	a	80	160	0	0.0	0.0
	b	80	0	0	0.0	0.0
	ab	80	0	0	0.0	0.0
13. SINFRIGE DAY 1 (SE= 1.5)	(1)	72	147	295	73.8	49.2
	a	75	148	9	4.5	3.0*
	b	71	3	1	0.5	0.3
	ab	77	6	3	1.5	1.0
14. SINFRIGE DAY 15 (SE= 1.0)	(1)	70	141	281	70.3	70.3
	a	71	140	3	1.5	1.5
	b	69	1	-1	-0.5	-0.5
	ab	71	2	1	0.5	0.5
15. BINRIGE DAY 15 (SE= 0.5)	(1)	44	93	195	48.8	97.5
	a	49	102	15	7.5	15.0**
	b	46	5	9	4.5	9.0**
	ab	56	10	5	2.5	5.0**
16. B MG (SE= 0.5)	(1)	3	8	21	5.3	10.5
	a	5	13	9	4.5	9.0**
	b	3	2	5	2.5	5.0**
	ab	10	7	5	2.5	5.0**
17. BINSY MG (SE= 1.0)	(1)	10	25	56	14.0	14.0
	a	15	31	16	8.0	8.0**
	b	10	5	6	3.0	3.0*
	ab	21	11	6	3.0	3.0*
18. COLOR (SE= 0.35)	(1)	18	27	136	34.0	9.7
	a	9	109	14	7.0	2.0
	b	43	-9	82	41.0	11.7**
	ab	66	23	32	16.0	4.6**
19. AROMA (SE= 0.2)	(1)	15	41	131	32.8	16.4
	a	26	90	57	28.5	14.3 **
	b	22	11	49	24.5	12.3 **
	ab	68	46	35	17.5	8.8 **
20. FLAVOUR (SE= 0.4)	(1)	28	41	131	32.8	8.2
	a	13	90	41	20.5	5.1**
	b	17	-15	49	24.5	6.1**
	ab	73	56	71	35.5	8.9**

APPENDIX 5.4c: Continued

Output Variables	Treatment	Result	1st Column	2nd Column	Effect Mean	T-Score
21. TEXTURE (SE= 0.25)	(1)	56	100	194	48.5	19.4
	a	44	94	48	24.0	9.6**
	b	17	-12	6	-3.0	-1.2
	ab	77	60	72	36.0	14.4**
22. ACCEPTABILITY (SE= 0.25)	(1)	35	50	168	42.0	16.8
	a	15	118	20	10.0	4.0*
	b	39	-20	68	34.0	13.6**
	ab	79	40	60	30.0	12.0**

t_4; 0.05 $\geq$ 2.77

t_4; 0.01 $\geq$ 4.60

Appendix 5.4c: Continued

Description of Output Variable Terms

	Terms	Descriptions
1.	BAN WT	Banana Weight
2.	SY WT	Syrup Weight
3.	BSS DAY 0	Banana Soluble Solids Day 0
4.	BSS DAY 1	Banana Soluble Solids Day 1
5.	BSS DAY 5	Banana Soluble Solids Day 5
6.	BSYSS DAY 0	Banana Syrup Soluble Solids Day 0
7.	BSYSS DAY 1	Banana Syrup Soluble Solids Day 1
8.	BSYSS DAY 5	Banana Syrup Soluble Solids Day 5
9.	B INSY SS DAY 0	Banana-in-Syrup Soluble Solids Day 0
10.	BINSY SS DAY 1	Banana-in-Syrup Soluble Solids Day 1
11.	BINSY SS DAY 5	Banana-in-Syrup Soluble Solids Day 5
12.	SINFRIGE SS DAY 0	Syrup-in-refrigerator Soluble Solids Day 0
13.	SINFRIGE SS DAY 1	Syrup-in-refrigerator Soluble Solids Day 1
14.	SINFRIGE SS DAY 15	Syrup-in-refrigerator Soluble Solids Day 15
15.	BINFRIGE SS DAY 15	Banana-in-refrigerator Soluble Solids Day 15
16.	B MG	Banana Mould Growth
17.	BINSY MG	Banana-in-Syrup **Mould Growth**
18.	COLOR	Colour of DSC-banana
19.	AROMA	Aroma of DSC-banana
20.	FLAVOUR	Flavour of DSC-banana
21.	TEXTURE	Texture of DSC-banana
22.	ACCPT	Acceptability of DSC-banana

Appendix 5.4c: Continued

Statistical Significance of Time, %SS, and Interect

	Time (A)	%SS (B)	Interact (AB)
BAN WT		**	**
SY WT	**	**	**
BSS DAY 0	*	**	**
DAY 1		**	*
DAY 5	**	**	*
BSYSS DAY 0	-	-	-
DAY 1	**	**	
DAY 5		*	
BINSY SS DAY 0		**	*
DAY 1	**	**	
DAY 5	**	**	
INFRIGE SS DAY 0	-	-	-
DAY 1	*		
DAY 15	-	-	-
BINFRIGE DAY 15	**	**	**
B MG	**	**	**
BINSY MG	**	*	*
COLOR		**	**
AROMA	**	**	**
FLAVOUR	**	**	**
TEXTURE	**		**
ACCPT	*	**	**

* = significant at 95% level

** = significant at 99% level

Appendix 5.4c: Continued

Summary Result of Effects of Time, %SS, and Interact on Output Variables

(by REGR Analysis)

Time	%SS	INTERACT
	BAN WT	BAN WT
SY WT	SY WT	SY WT
BSS DAY 0	BSS DAY 0	BSS DAY 0
	BSS DAY 1	BSS DAY 1
(BSS DAY 5)	(BSS DAY 5)	BSS DAY 5
	BSYSS DAY 1	
BSYSS DAY 1	BSYSS DAY 5	
	BINSY SS DAY 0	B INSY SS DAY 0
BINSY SS DAY 1	BINSY SS DAY 1	
BINSY SS DAY 5	(BINSY SS DAY 5)	
SINFRIGE DAY 1		
BINFRIGE SS DAY 15	BINFRIGE SS DAY 15	BINFRIGE SS DAY 15
B MG	B MG	B MG
BINSY MG	BINSY MG	BINSY MG
	COLOR	COLOR
FLAVOUR	FLAVOUR	(FLAVOUR)
TEXTURE		TEXTURE
ACCPT	(ACCPT)	ACCPT
AROMA	AROMA	AROMA

Notes: 1. The variables in parenthesis, though not statistically significant, had trends of significance.

APPENDIX 5.4d

DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP 4

Results of Plackett and Burman Experiment for BSE-Mungbean

Run No.	Wt.before Evap. (kg)	Wt. yield kg	Wt Loss g	Total Wt.	Wt/C	Color	Bottom burnt	Hot-stir* convenience	Texture** (grittiness)	Texture*** (fluffiness)	Stick-to-pan**** (hard-to clean)	Moisture content %
1.	5.5	4.69	170	4.86	230	Y	yes	1	3	0.5		64.89
2.	2.2	1.69	100	1.79	120	YY	yes	2+	1	2		54.07
3.	2.14	1.58	30	1.61	100	YY	yes	3	3	3		45.73
4.	2.18	1.57	70	1.64	100	Sl.GY	hard flakes	3	3	3		47.87
5.	5.8	5.19	90	5.28	225	YY	yes	1	3	1		66.90
6	2.2	1.72	30	1.75	120	GY	easy-to-losen flake	2	1	2		49.39
7.	4.89	4.05	280	4.33	210	Sl.GY	yes	1	3	1	1	63.77
8.	4.86	3.82	150	3.97	130	YY	yes	1	2	1		57.58
9	2.11	1.48	30	1.51	105	GY	yes	3	3	3		42.47
10.	4.08	3.77	300	4.07	160	Sl.GY	yes (strong)	2	3	1	1	61.24
11.	4.71	3.29	140	3.43	125	Sl.GY	yes (strong)	2	3	2	2	57.66
12.	2.0	1.65	50	1.70	110	YY	yes	3	2	3		49.66

* 1 = hardest; 3 = easiest.
** 1 = most gritly; 3 = least gritty
*** 1 = least fluffy; 3 = most fluffy.
**** 1 = hardest; 3 = easiest.

Modified results of Plackett and Burman Experiment for BSE-Mungbean

Run No.	Yield %	Yield[1] %	Yield %	Loss	Sp. Vol.[3]	M.C[4]	Handling[5] Score	Texture[6] Score
	Loss excluded	LOSS included	based on mungbean & water	based on mungbean used				
1.	234.5	243.0	63.95	8.5	1.02	64.89	1	3
2.	169.0	179.0	47.11	10.0	1.97	54.07	2	1
3	158.0	161.0	48.79	3.0	2.36	45.73	3	3
4	157.0	164.0	43.16	7.0	2.36	47.87	3	3
5	259.5	264.0	69.47	4.5	1.05	66.90	1	3
6	172.0	175.0	46.05	3.0	1.97	49.39	2	1
7	202..5	216.5	65.61	14.0	1.13	63.77	1	3
8	191.0	198.5	60.15	7.5	1.82	57.58	1	2
9	148.0	151.0	45.76	3.0	2.25	42.47	3	3
10	188.5	203.5	53.55	15.0	1.48	61.24	2	3
11	164.5	171.5	51.97	7.0	1.89	57.66	2	3
12	165.0	170.0	51.52	5.0	2.15	49.66	3	2

1 Based on mungbean used; Loss included because this was to be compared with the calculated yield and that no loss was assumed. Mungbean 1 kg (M.C 12) ⟶ HS-Mung 1.08 kg (M.C. 20%) or ≃ 1.1 kg.

2 Loss based on raw mungbean. The scorched part was as dry as raw mungbean and that this part was assumed to be 12 % in M.C.

3 Sp.Vol. by measuring in a cup (236.6 ml.); Then Vol./WT.; To find the possible control method for cottage factory; From previous study, HS-mung with M.C. ≃ 22% would have Sp.Vol. ≃ 2 ± 0.05 ($236.6/_{115-120}$ = 1.97-2.06)

4 by oven method.

5 by the operator; 3 = the best.

6 by sensory evaluation; 3 = the best (without grittiness)

APPENDIX 5.4d (Continued): DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP 4

Summary Tables for variable and effects. for BSE-Mungbean

Code	Variable: Name	Levels: Low (-)	Levels: High (+)	Loss: Effect(-)to (+)	Loss: Relative significance, t-test		Specific Volume: Effect(-)to (+)	Specific Volume: Relative significan t-test		Moisture Cent: Effect	Moisture Cent: Rel.Sig (t-test)	
A	Water/Mung ratio	2.3	2.8	1.41	1.01	60%	-0.29	-3.91	app. 97%*	4.59	2.67	app. 94%*
B	Boiling time (min)	20	40	-3.58	-2.56	94%*	0.07	0.93	60%	-1.70	-0.99	60%
C	Hot-Stirring time (min)	20	30	1.92	1.37	70%	0.51	6.8	99%*	-2.15	-1.25	70%
D	Hot-Stirring speed (rpm)	38 (sp.1)	66 (sp.2)	3.25	2.32	92%*	0.17	2.27	91%	0.52	0.30	<50%
E	Evaporating time (min)	20	30	-1.58	-1.13	65%	0.06	0.8	50%	-1.52	-0.88	55%
F	Batch size (kg)	1	2	4.25	3.04	95%*	-0.78	-10.4	99%*	13.81	8.03	>99%*
G	Type of pan	SS	Brass	1.75	1.25	70%	0.12	1.6	80%*	-2.74	-1.59	80%*
H	Dummy			-2.58			0.07			-2.43		
I	Dummy			0.75			-0.05			0.68		
J	Dummy			-0.25			-0.02			-0.46		
K	Dummy			-0.75			-0.12			2.30		

	Handling Score: Effect	Handling Score: Rel. Sig.	(t-test)	Texture Score: Effect	Texture Score: Rel.Sig.	(t-test)	% Yield: Effect	% Yield: Rel.Sig.	(t-test)
A	-0.34	-1.17	app. 65%	-0.34	-2	app. 88%*	-0.09	-0.05	app. <50%
B	0.34	1.17	65%	1	5.88	99%*	-0.18	-0.10	<50%
C	0.34	1.17	65%	0	0		-6.27	-3.65	97%*
D	0.00	0.00		0.34	2	88%*	0.41	0.24	<50%
E	-0.34	-1.17	65%	-0.66	-3.88	98%*	-2.85	-1.66	80%*
F	-1.34	-4.62*	99%	0.66	3.88	98%*	13.71	7.97	99%*
G	0.34	1.17	65%	0.34	2	88%*	-5.81	-3.38	97%*
H	0.00			0			0.08		
I	-0.34			0			2.57		
J	-0.34			0			1.39		
K	-0.34			-0.34			1.81		

APPENDIX 5.4e

DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP 5

Results of 2^2 Factorial Experiment for BSE-Mungbean

Run	After H-S process					After Evap. process						Evap.			
	Whole Wt.	Loss Wt.	Wt/C	Loss Wt.	H-ST	Whole Wt.	Yield Wt.	Loss Wt.	Wt/C	Sp.Vol.	M.C.	Evap. Time	Handling Score	Texture Scpre	Color Score
	kg				h/min						%	h/min	1-10	1-10	1-10
1	3.75	0.05 (2.5%)	202	10	1	2.35 (117.5%)	2.35 (117.5%)	9	129	1.97	18.3	1	8	8.4	9.0
a	8.80	0.23 (5.75%)	201	20	2	4.70	4.90 (122.5%)	0	128	1.85	22.4	2/18	4.5	3.3	3.6
b	4.10	0.13 (6.5%)	196	10	1/10	2.50	2.55 (127.5%)	0	120	1.97	21.0	1.05	7.5	7.5	8.2
ab	8.70	0.30 (7.5%)	204	20	2/40	-	4.25 (106.25%)	-	130	1.82	22.0	2/15	5.0	5.0	6.0

Run	Batch kg	H-S speed rpm
1	2	38
a	4	38
b	2	66
ab	4	66

APPENDIX 5.4e (Continued):

The Yates' Analysis of Response Variables

Response	Run	Results	1st Col.	2nd Col.	Mean Effect	t= Effect / S.E.	For Prediction
1. H-S time	1	1.00	3.00	6.84	1.71	6.84	1.71
	a	2.00	3.84	2.50	1.25	5.0**	0.63
S.E. 0.25	b	1.17	1.00	0.84	0.42	1.68	0.21
	ab	2.67	1.50	0.50	0.25	2.08	0.13
2. % Yield	1	117.50	240.00	473.75	118.47	13.54	118.47
	a	122.50	233.75	-16.25	-8.13	-0.96	-4.06
S.E. 8.75	b	127.50	5.00	- 6.25	-3.13	-0.36	-1.56
	ab	106.25	-21.25	-26.25	-13.13	-1.50	-6.56
3. % Loss	1	2.50	8.25	22.25	5.56	8.83	5.56
	a	5.75	14.00	4.25	2.13	3.38*	1.06
S.E. 0.63	b	6.50	3.25	5.75	2.88	4.57*	1.44
	ab	7.50	1.00	-2.25	-1.13	1.79	-0.56
4. Sp.vol.	1	1.97	3.82	7.61	1.90	23.75	1.90
	a	1.85	3.79	-0.27	-0.14	-1.75	-0.07
S.E. 0.08	b	1.97	-0.12	-0.03	-0.02	-0.25	-0.01
	ab	1.82	-0.15	-0.03	-0.02	-0.25	-0.01
5. M.C.	1	18.3	40.7	83.7	20.93	14.43	20.93
	a	22.4	43.0	5.1	2.55	1.75	1.28
S.E. 1.45	b	21.0	4.1	2.3	1.15	0.79	0.58
	ab	22.0	1.0	-3.1	-1.55	-1.06	-0.78
6. Evap. time	1	1.00	3.30	6.60	1.65	3.59	1.65
	a	2.30	3.30	2.50	1.25	2.72(*)	0.63
S.E. 0.46	b	1.05	1.30	0.00	0.00	0.00	0.00
	ab	2.25	1.20	-0.10	-0.05	-0.11	-0.03
7. Evap. score	1	8.0	12.5	25.0	6.25	25.0	6.25
	a	4.5	12.5	-6.0	-3.00	-12.0**	-1.50
S.E. 0.25	b	7.5	-3.5	0.0	0.00	0.0	0.00
	ab	5.0	-2.5	1.0	0.50	2.0	0.25
8. Texture score	1	8.4	11.7	24.2	6.05	40.33	6.05
	a	3.3	12.5	-7.6	-3.80	-25.33**	-1.90
S.E. 0.15	b	7.5	-5.1	.8	0.40	2.67(*)	0.20
	ab	5.0	-2.5	2.6	1.30	8.67**	0.65
9. **Colour** score	1	9.0	12.6	26.8	6.70	67.00	6.70
	a	3.6	14.2	-7.6	-3.80	-38.00**	-1.90
S.E. 0.10	b	8.2	-5.4	1.6	0.80	8.00**	0.40
	ab	6.0	-2.2	3.2	1.60	16.00**	0.80

Note: 1. a = batch size; b = H-S speed

2. $t_4 \geq 2.77$ $(P \leq 0.05)$; $t \geq 4.60$ $(P \leq 0.01)$

3. * Statistically different at 95% level

** Statistically different at 99% level

(*) Nearly statistically different at 95% level

APPENDIX 5.4e (Continued): DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP 5

Standard error calculation

From 2 Reps of run 'a'

	Response variables	Rep. 1	Rep. 2	s^{n-1}	S.E.
1.	H-S Time	1.50	2.00	0.3536	0.25
2.	% Yield	105.00	122.50	12.3744	8.75
3.	% Loss	4.50	5.75	0.8839	0.63
4.	Sp. Vol.	1.69	1.85	0.1131	0.08
5.	% Moisture content	19.50	22.40	2.0506	1.45
6.	Evap. time	1.33	2.25	0.6505	0.46
7.	Evap. score	4.00	4.50	0.3536	0.25
8.	Texture score	3.00	3.30	0.2121	0.15
9.	Colour score	3.40	3.60	0.1414	0.10

Formula: $s^2 = \frac{\Sigma(x_i - \bar{x})^2}{n-1}$

$$s = \sqrt{s^2}$$

$$s_{\bar{y}} = \frac{s}{\sqrt{n}}$$

$\sqrt{n} = \sqrt{2} = 1.414$

Predictive equations were derived for selected response variables as below

1. H-S Time: $\hat{Y} = 1.71 + 0.63\ X_1$

   Uncoded: $\hat{Y} = -0.18 + 0.63\ X_1$

2. % Loss: $\hat{Y} = 5.56 + 1.06\ X_1 + 1.44\ X_2$

   Uncoded: $\hat{Y} = -2.96 + 1.06\ X_1 + 0.10\ X_2$

3. Evap. Time: $\hat{Y} = 1.65 + 0.63\ X_1$

   Uncoded: $\hat{Y} = -0.24 + 0.63\ X_1$

4. Evap. score: $\hat{Y} = 6.25 - 1.5\ X_1$

   Uncoded: $\hat{Y} = 10.75 - 1.5\ X_1$

5. Texture Score: $\hat{Y} = 6.05 - 1.9\ X_1 + 0.65\ X_1X_2$

   Uncoded: $\hat{Y} = 18.98 - 4.31\ X_1 - 0.14\ X_2 + 0.05\ X_1X_2$

6. Colour Score: $\hat{Y} = 6.7 - 1.9\ X_1 + 0.4\ X_2 + 0.8\ X_1X_2$

   Uncoded: $\hat{Y} = 19.82 - 4.87\ X_1 - 0.14\ X_2 + 0.06\ X_1X_2$

Uncoding:

Formula: $X_1 = \frac{X_1 - \frac{hi + lo}{2}}{\frac{hi - lo}{2}}$

$X_1 = X_1 - 3$

$X_2 = 0.07\ X_2 - 3.71$

$X_1X_2 = -3.71\ X_1 - 0.21\ X_2 + 0.07\ X_1X_2 + 11.13$

X_1 = batch size (2,4 kg)

X_2 = H-S speed (38,66 rpm)

APPENDIX 5.4 f

DETAILED RESULTS OF PROCESS DEVELOPMENT EXPERIMENTATION: EXP 6

Yates Analysis for MP-Snack   A = min. mix;   B = lbs. press

		1st Column	2nd Column	Mean Effect	For Prediction
	COL				
(1)	5.2	11.4	21.8	5.45	5.45
a	6.2	10.4	3.0	1.50*	0.75
b	4.2	1.0	-1.0	-0.50	-0.13
ab	6.2	2.0	1.0	0.50	0.13
	COH				
(1)	5.2	10.6	21.2	5.3	5.3
a	5.4	10.6	0.8	0.4(*)	0.2
b	5.0	0.2	0.0	0.0	0.0
ab	5.6	0.6	0.4	0.2(*)	0.1
	GRIT				
(1)	5.0	9.8	19.4	4.85	
a	4.8	9.6	-0.2	-0.1	
b	4.8	-0.2	-0.2	-0.1	
ab	4.8	0.0	0.2	0.1	
	MS				
(1)	3.7	7.0	12.3	3.08	3.08
a	3.3	5.3	-0.9	-0.45(*)	-0.23
b	2.9	-0.4	-1.7	-0.85(*)	-0.43
ab	2.4	-0.5	-0.1	-0.05	-0.03
	Handling Scores				
(1)	6	16	31	7.75	7.75
a	10	15	5	2.50(*)	1.25
b	7	4	-1	-0.5	-0.25
ab	8	1	-3	-1.5(*)	-0.75
	Sticking to the mould				
(1)	8	18	36	9.0	9.0
a	10	18	2	1.0(*)	0.5
b	9	2	0	0.0	0.0
ab	9	0	-2	-1.0(*)	-0.5
	%SS Before Press				
(1)	80.5	161.5	323.0	80.8	80.80
a	81.0	161.5	1.0	0.5	0.25
b	80.5	0.5	0.0	0.0	0.00
ab	81.0	0.5	0.0	0.0	0.00
	%SS After Press				
(1)	80.5	162.5	325.0	81.3	81.30
a	82.0	162.5	3.0	1.5(*)	0.75
b	80.5	1.5	0.0	0.0	0.00
ab	82.0	1.5	0.0	0.0	0.00

Note: Acceptability was excluded in analysing stage because of the wild data obtained from the nut-dislike panelist.

APPENDIX 5.5

PREDICTED SENSORY ATTRIBUTE SCORES AT VARIOUS MIXING TIME

Mixing time (min)	Sensory Scores			Handling Score
	Colour	Cohesive	Sweetness	
1	4.70	5.25	3.95	5.37
2	4.95	5.27	3.87	6.15
3	5.20	5.29	3.79	6.93
4	5.45	5.31	3.71	7.71
5	5.70	5.33	3.63	8.49
6	5.95	5.35	3.55	9.27
7	6.20	5.37	3.47	10.05

Ideals: Colour = 4.3; Cohesive = 5.2; Sweetness = 3.7; Handling Score = 10

Uncoding:

X_1 = mixing time (1,7 min); X_2 = pressing force (5000, 1000 lbs/sq in)

$$X_1 = \frac{X_1 - \frac{hi + lo}{2}}{\frac{hi - lo}{2}} = \frac{X_1 - \frac{7+1}{2}}{\frac{7-1}{2}} = \frac{X_1 - 4}{3} = 0.33\,X_1 - 1.33$$

$$X_2 = \frac{X_2 - \frac{5000 + 1000}{2}}{\frac{5000-1000}{2}} = \frac{X_2 - 3000}{2000} = 0.0005\,X_2 - 1.5$$

$$X_1X_2 = (0.33\,X_1 - 1.33)\,(0.0005\,X_2 - 1.5)$$

$$= 1.995 - 0.495\,X_1 - 0.000665\,X_2 + 0.000165\,X_1X_2$$

(1) $\hat{Y}$ (Colour) $= 5.45 + 0.75\,X_1$

Uncoded: $= 5.45 + 0.75\,(0.33\,X_1 - 1.33)$

$= 4.45 + 0.25\,X_1$

(2) $\hat{Y}$ (Cohesive) $= 5.3 + 0.2\,X_1 + 0.1\,X_1X_2$

Uncoded: $= 5.3 + 0.2\,(0.33\,X_1 - 1.33) + 0.1\,(1.995 - 0.495\,X_1 - 0.000665\,X_2 + 0.000165\,X_2X_2)$

$= 5.23 + 0.02\,X_1$

(3) $\hat{Y}$ (MS) $= 3.08 - 0.23\,X_1 - 0.43\,X_2$

Uncoded: $= 3.08 - 0.23\,(0.33\,X_1 - 1.33) - 0.43\,(0.0005\,X_2 - 1.5)$

$= 4.03 - 0.08\,X_1$

(4) $\hat{Y}$ (H-Score) $= 7.75 + 1.25\,X_1 - 0.75\,X_1X_2$

Uncoded: $= 7.75 + 1.25\,(0.33\,X_1 - 1.33) - 0.75\,(1.995 - 0.495\,X_1 - 0.000665\,X_2 + 0.000165\,X_1X_2)$

$= 4.59 + 0.78\,X_1$

Note: Values of X_2 and X_1X_2 in (2), (3) and (4) were so small that they were neglected in the prediction equation. The inclusion of pressing force - 1000, 2000, 3000, 4000, 5000 lbs/ ½ $inch^2$ in the calculation of the predicted sensory attribute indicated that 2000 lbs/½ $inch^2$ or 4000 lbs/sq inch was more suitable for pressing the developed snack bar than the other pressing force levels. Thus, it was chosen for further use.

APPENDIX 5.6

PROCEDURE FOR MEASURING PRESSING FORCE
- APPLIED ON DEVELOPED PRESSER AND CUTTER

1. Mark at the plunger rod when the plunger was lowered down and touched the base plate, and also when it was measured 7/16 inches (which was thickness of the snack bar) from the first mark.

2. Filled in the mould with snack product (from snack bar of the same surface area size as that of the plunger). Punch the plunger down until the second mark was reached.

3. Read on the gauge the pressing force applied.

Below is the results of 2 replications of measuring the three snack bars.

Snack Bar	Rep	Bar size: Area (w x 1) inch x inch	Bar size: Height inch	Bar size: Weight g	Mould size: Area $inch^2$	Mould size: Height inch	Mould size: Weight g	Pressing Force applied lbs/sq inch
1	1	$3\frac{3}{4} \times 1\frac{1}{2}$	$\frac{7}{16}$	39	0.50	0.38	7.1	4000
	2	$3\frac{3}{4} \times 1\frac{7}{16}$	$\frac{7}{16}$	43	0.38	0.41	7.9	4000
2	1	$3\frac{3}{4} \times 1\frac{1}{2}$	$\frac{7}{16}$	47	0.50	0.38	7.1	4000
	2	$3\frac{13}{16} \times 1\frac{7}{16}$	$\frac{7}{16}$	41	0.38	0.34	6.6	4000
3	1	$3\frac{3}{4} \times 1\frac{1}{2}$	$\frac{7}{16}$	43	0.50	0.38	7.1	4000
	2	$3\frac{15}{16} \times 1\frac{5}{8}$	$\frac{7}{16}$	48	0.38	0.38	7.7	4000

* Pressing force in lbs/sq inch was obtained from the reading value of 2000 lbs/0.497 $inch^2$; the calculated value of 4024 lbs/sq inch was rounded off into 4000 lbs.

APPENDIX 5.7

SENSORY EVALUATION OF FACTORY PRODUCT

A profile test was conducted on the factory product by 4 lab panelists, 2 males and 2 females, using category scales (9, 7, 5, 3, 1) on 4 important product attributes: colour, grittiness, cohesiveness, and sweetness. **Ideal score was 5.**

Panelists	Category Scales: Colour	Gritty	Cohesiveness	Sweet	Verbatim Comments
1	5	7	3	7	
2	5	5	3	5	Appearance improved
3	5	5	5	5	Appearance, texture, & flavour improved
4	3	5	5	3	Colour - less appeal
Mean	4.5	5.5	4.0	5.0	
S.D.	1.0	1.0	1.15	1.6	

<u>T-test:</u> Factory sample vs Ideal

	t-score
Colour	-1.00
Gritty	1.00
Cohesive	-1.73
Sweet	0.00

Thus, factory sample was not statistically significant different from the ideal.

APPENDIX 5.8 a

PREDICTION EQUATIONS FROM THE TWO STATISTICAL ANALYSIS METHODS

(1st line = coded; 2nd line = uncoded)

Output Variables	Yates' Method	Stepwise Regression Method
EXP 1: DSC-Banana		
1. % DSC-Banana obtained	$\hat{Y} = 33.9 - 6.1\ X_2$ $\hat{Y} = 78.8 - 2.2\ X_2$	$\hat{Y} = 32.9 - 6.0\ X_2$ $\hat{Y} = 78.06 - 2.16\ X_2$
2. % B-syrup left	$\hat{Y} = 53.4 + 7.8\ X_2$ $\hat{Y} = -4.01 + 2.81\ X_2$	$\hat{Y} = 51.6 + 7.78\ X_2 + 3.44\ X_1X_2$ $\hat{Y} = 1311.40 - 12.66\ X_1 - 62.24\ X_2 + 0.62\ X_1X_2$
3. % Loss through foam	$\hat{Y} = 6.5 + 1.4\ X_1 - 0.2\ X_2$ $\hat{Y} = 64.828 + 0.7\ X_1 - 0.072\ X_2$	$\hat{Y} = 7.08 + 1.49\ X_1 - 1.10\ X_1X_2$ $\hat{Y} = -491.60 + 4.79\ X_1 + 20.80\ X_2 - 0.20\ X_1X_2$
4. % SS DSC-banana/syrup		$\hat{Y} = 78.0 + 0.500\ X_2 - 0.865\ X_1X_2$ $\hat{Y} = -256.90 + 3.18\ X_1 + 16.54\ X_2 - 0.16\ X_1X_2$
5. Aw: DSC-banana	$\hat{Y} = 0.840 + 0.016\ X_1 + 0.028\ X_2$ $\hat{Y} = 0.198 + 0.008\ X_1 + 0.01\ X_2$	$\hat{Y} = 0.838 + 0.0165\ X_1 + 0.0275\ X_2$ $\hat{Y} = -0.2144 + 0.0081\ X_1 + 0.0099\ X_2$
6. Aw: B-syrup	$\hat{Y} = 0.798 + 0.012\ X_2 + 0.013\ X_1X_2$ $\hat{Y} = 5.6875 - 0.0478\ X_1 - 0.2415\ X_2 + 0.0023\ X_1X_2$	$\hat{Y} =$ — $\hat{Y} =$ —
7. Red R. Mean	$\hat{Y} = 0.725 - 0.175\ X_1 - 0.175\ X_2$ $\hat{Y} = 11.11 - 0.088\ X_1 - 0.064\ X_2$	$\hat{Y} =$ — $\hat{Y} =$ —
8. Chewy R. Mean	$\hat{Y} = 0.9 - 0.2\ X_2$ $\hat{Y} = 2.372 - 0.072\ X_2$	$\hat{Y} = 0.807 - 0.200\ X_2 + 0.188\ X_1X_2$ $\hat{Y} = 74.266 - 0.692\ X_1 - 3.627\ X_2 + 0.0338\ X_1X_2$
9. Flavour R. Mean	$\hat{Y} = 0.825 + 0.225\ X_2$ $\hat{Y} = -0.831 + 0.081\ X_2$	$\hat{Y} = 0.727 + 0.225\ X_2 + 0.191\ X_1X_2$ $\hat{Y} = 72.207 - 0.703\ X_1 - 3.53\ X_2 + 0.034\ X_1X_2$
EXP 6: MP - Snack		
1. Colour Score	$\hat{Y} = 5.45 + 0.75\ X_1$ $\hat{Y} = 4.45 + 0.2475\ X_1$	$\hat{Y} = 4.56 + 0.25\ X_1$ $\hat{Y} = 4.2275 + 0.0825\ X_1$
2. Mellow-sweet score	$\hat{Y} = 3.08 - 0.23\ X_1 - 0.43\ X_2$ $\hat{Y} = 4.0309 - 0.0759\ X_1 - 0.0002\ X_2$	$\hat{Y} = 3.98 - 0.075\ X_1 - 0.0002\ X_2$ $\hat{Y} = 4.08 - 0.02575\ X_1 - 0.0000001\ X_2$
3. % SS of snack after press	$\hat{Y} = 81.3 + 1.5\ X_1$ $\hat{Y} = 79.31 + 0.495\ X_1$	$\hat{Y} = 80.2 + 0.25\ X_1$ $\hat{Y} = 79.87 + 0.0825\ X_1$

Note: 1. Calculation for factors used for uncoding: uncoded value = $\dfrac{X - \dfrac{hi + lo}{2}}{\dfrac{hi - lo}{2}}$

2. Uncoded values for X_1, X_2, X_1X_2 respectively:

EXP 1: $0.5\ X_1 - 52$; $0.36\ X_2 - 7.36$; $0.18\ X_1X_2 - 3.68\ X_1 - 18.91\ X_2 + 382.91$

EXP 6: $0.33\ X_1 - 1.33$; $.0005\ X_2 - 1.5$; $1.995 - 0.495\ X_1 - 0.000665\ X_2 + 0.000165\ X_1X_2$

APPENDIX 5.8b

CALCULATIONS FOR SELECTED ESTIMATED OUTPUT VARIABLE VALUES

Examples for EXP 6:

Uncoded value: $$\frac{X - \frac{hi + lo}{2}}{\frac{hi - lo}{2}}$$

Uncoding for X_1:

$$\frac{X_1 - \frac{7 + 1}{2}}{\frac{7 - 1}{2}} = 0.33\ X_1 - 1.33$$

Uncoding for X_2:

$$\frac{X_2 - \frac{5000 + 1000}{2}}{\frac{5000 - 1000}{2}} = 0.0005\ X_2 - 1.5$$

Uncoding for X_1X_2:

$$(0.33\ X_1 - 1.33)(0.000\ \ X_2 - 1.5)$$

$$= 1.995 - 0.495\ X_1 - 0.000665\ X_2 + 0.000165\ X_1X_2$$

Equation Uncoding

From Yates' Analysis:

Coded: $\hat{Y}_{SSA} = 81.3 + 1.5\ X_1$

Uncoded: $\hat{Y}_{SSA} = 81.3 + 1.5\ (0.33\ X_1 - 1.33)$
$= 79.31 + 0.495\ X_1$

From Regression Analysis:

Coded: $\hat{Y}_{SSA} = 80.2 + 0.25\ X_1$

Uncoded: $\hat{Y}_{SSA} = 80.2 + 0.25\ (0.33\ X_1 - 1.33)$
$= 79.87 + 0.0825\ X_1$

(Note: SSA = % SS of snack after press)

APPENDIX 6.1a

TASTE PANEL FORM FOR 1ST IDEAL PRODUCT PROFILE GENERATION

PROFILE TEST FOR SNACK PRODUCT (KANOM)

Date ____ Name ____

You have 1 sample of a snack product made of nut, fruit and bean. Please evaluate for all of these attributes and include your 'ideal score' for each attribute where asked for.

Example

Weakly salty ——I——S—— Strongly salty

Meaning: sample is rather salty. Ideal should be less salty.

1. COLOUR Is the colour acceptable?

☐ Yes

☐ No (please describe): ____________

2. SIZE Please rank the samples according to their size.

1 = most preferred size

3 = least preferred size

	Sample no.
1 =	____
2 =	____
3 =	____

3. ODOUR

Not sweet (กลิ่นไม่หอมหวาน) ____ Very sweet (กลิ่นหอมหวานมาก)

Weakly Nutty (กลิ่นถั่วอ่อน ๆ) ____ Strongly Nutty (กลิ่นถั่วจัด)

4. TEXTURE

Soft (นุ่ม) ____ Firm (hard) (แข็ง)

Crumbly (ร่วน) ____ Cohesive (จับกันแน่น)

5. MOUTHFEEL

Not gritty (ไม่เป็นเม็ด ๆ) ____ Very gritty (เป็นเม็ด ๆ มาก)

Dry (แห้ง) ____ Juicy (ชุ่ม)

6. FLAVOUR

Weakly nutty (มีรสถั่วอ่อน ๆ) ____ Strongly nutty (มีรสถั่วจัด)

Weak Sesame seed flavour (มีรสงาอ่อน ๆ) ____ Strong Sesame seed flavour (มีรสงาจัด)

Mellow Sweet (หวานกลมกล่อม) ____ Sharp sweet (หวานแหลมจัด)

Weakly fruity (มีรสผลไม้อ่อน ๆ) ____ Strongly fruity (มีรสผลไม้จัด)

Weak hot-stirred mungbean flavour (มีรสถั่วกวนอ่อน ๆ) ____ Strong hot-stirred mungbean flavour (มีรสถั่วกวนอย่างจัด)

7. ACCEPTABILITY

Like extremely	☐
Like moderately	☐
Like slightly	☐
Neither like nor dislike	☐
Dislike slightly	☐
Dislike moderately	☐
Dislike extremely	☐

8. COMMENTS

____

____

____

____

APPENDIX 6.1b

TASTE PANEL FORM FOR 2ND IDEAL PRODUCT GENERATION

(in Thai)

แบบทดสอบการยอมรับแห่งถั่วอนามัย

16 สิงหาคม 2527 ชื่อ ชั้น อายุ

ท่านได้รับตัวอย่างแห่งถั่วอนามัย 1 ตัวอย่าง แห่งถั่วนี้ทำจากถั่วและผลไม้เป็นหลัก ให้ท่านชิมตัวอย่างดังกล่าว และให้ข้อคิดเห็นเกี่ยวกับลักษณะต่าง ๆ ของแห่งถั่ว ตามความรู้สึกของท่าน

ตัวอย่าง (ท = ตัวอย่างขนม ; ค = ลักษณะที่อยากให้เป็น)

อ่อนเค็ม ———ค———ท——— เค็มจัด

1. สี
สีอ่อน —————— สีคล้ำ

2. ขนาด
ขนาดเล็ก —————— ขนาดใหญ่

3. กลิ่น
กลิ่นถั่วและงาอ่อน ๆ —————— กลิ่นถั่วและงาจัด

4. เนื้อสัมผัสเมื่อจับต้อง
นุ่ม —————— แข็ง
ร่วน —————— จับกันแน่น

5. เนื้อสัมผัสเมื่อกิน
ไม่เป็นเม็ด ๆ —————— เป็นเม็ด ๆ มาก
แห้ง —————— ชุ่ม

6. รสชาติ
มีรสถั่วลิสงอ่อน ๆ —————— มีรสถั่วลิสงจัด
มีรสงาอ่อน ๆ —————— มีรสงาจัด
หวาน[illegible] —————— หวานแหลมจัด
มีรสผลไม้อ่อน ๆ —————— มีรสผลไม้จัด
มีรสถั่วกวนอ่อน ๆ —————— มีรสถั่วกวนจัด

7. ความชอบ (การยอมรับ)

ชอบอย่างมาก ☐
ชอบปานกลาง ☐
ชอบเล็กน้อย ☐
เฉย ๆ ☐
ไม่ชอบเล็กน้อย ☐
ไม่ชอบปานกลาง ☐
ไม่ชอบอย่างมาก ☐

8. ข้อวิจารณ์

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APPENDIX 6.1 c

PROFILE TEST FOR DEEP-SYRUP COOKED BANANA

You have 5 samples of deep-syrup cooked bananas. Please evaluate for all of these attributes against the ideal scores.

1. COLOUR

Light red ________________________I______ Dark red

Uneven _________________________________I Even

2. TEXTURE

A. Fingerfeel:

Mushy ______________I____________________ Firm

B. Mouthfeel:

Not chewy ______________I________________ Very chewy

Not sandy I_______________________________ Very sandy

3. FLAVOUR

Not sweet _______________________I_______ Very sweet

Weak banana flavour _______________________I_______ Strong banana flavour

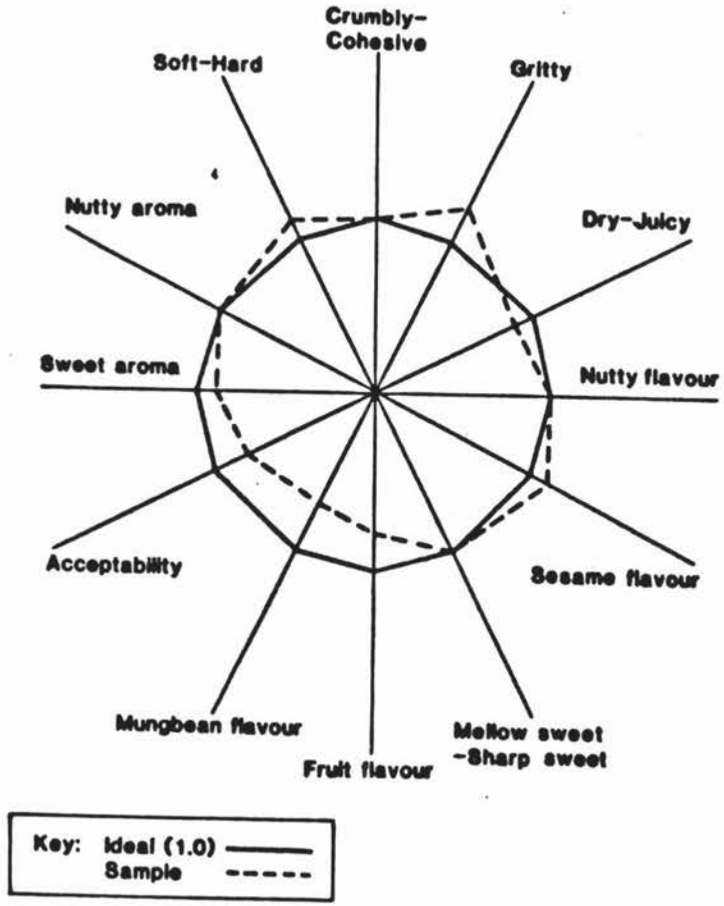
Other flavour: Weak ________I_______________________ Other flavour: Strong

Specify the other flavours found: ____________________

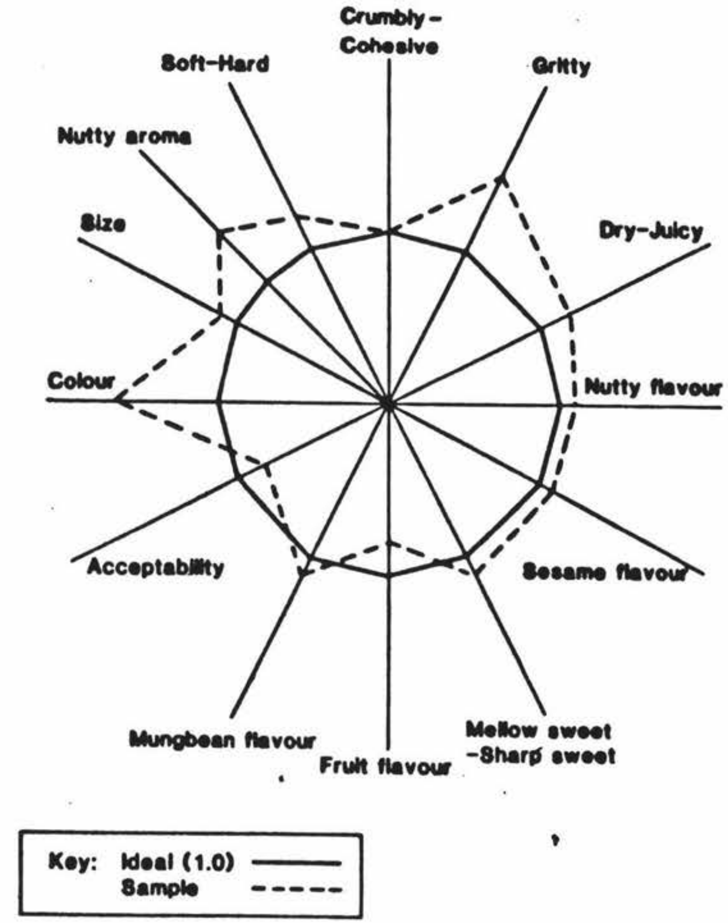
Whether it is acceptable? ____________________

If yes, whether it improves or is detrimental to the product? __________

COMMENTS: ____________________



Appendix 6.2a: Ratio Mean Profile of LP Reformulated Product by 1st Lab Panel.



Appendix 6.2b: Ratio Mean Profile of 1st Consumer Test Product by Child Consumer Panel

APPENDIX 6.3

POSSIBLE WAYS FOR THE ATTRIBUTE READJUSTMENT OF THE PRODUCT

Attributes and intensity	Ways for Readjustment	Decision
1. **Colour** (+)**	Use white sugar syrup instead of B-syrup	x
	Press force adjustment	✓
2. Nutty aroma (+)**	Nut decreased	x
	Press force adjustment	✓
	Fruit flavour addition	x
3. Gritty (+)**	Mincing the mixture	x
	Press force adjustment; splitted peanut **retained its shape**	✓
	Carefully prepared HS-mungbean	✓
4. Nutty flavour (+)*	Nut decreased	x
	Press force adjustment	✓
	Fruit flavour addition	x
5. Mungbean flavour (+)*	Mungbean decreased	x
	Fruit flavouring to cover	x
	Mung preparation change	✓
6. Acceptability (-)**	Readjustment of the above	✓

APPENDIX 6.4a

DESCRIPTIVE TASTE PANEL FORM FOR PRELIMINARY TEST OF STORED PRODUCT

You have samples of snack bars. Please evaluate for all of these attributes and fill in the blanks.

	Sample No.	Sample No.	Sample No.
1. Colour			
2. Mouthfeel			
3. Texture			
4. Flavour			

APPENDIX 6.4b

TASTE PANEL FORM FOR STORED PRODUCTS

Name Date

Mark in all samples plus reference sample.

Flavour Descriptions

Sweetness ____ ____ ____ ____ ____
not present strong

Rancidity ____ ____ ____ ____ ____
not present strong

Texture Descriptions

Dryness ____ ____ ____ ____ ____
not present strong

Hardness ____ ____ ____ ____ ____
not present strong

Acceptability

____	____	____	____	____
Unacceptable	Slightly Unaccpt	Slightly Accpt	Accpt	Very Accpt

Comments ________________

APPENDIX 6.5

T-TEST CALCULATION FOR COMPARISON BETWEEN LAB PANEL AND CONSUMER PANEL

	1ST PANEL					2ND PANEL				
	Lab (N_1=6)		Consumer (N_2=13)		t-value	Lab (n_1=5)		Consumer (N_2=30)		t-value
	$\bar{X}$	S.D.	$\bar{X}$	S.D.		$\bar{X}$	S.D.	$\bar{X}$	S.D.	
Colour	1.2	0.3	1.0	0.3	1.3507636	1.1	0.3	1.6	0.8	-1.3670301
Size	1.0	0.0	1.0	0.1	0.0	1.0	0.0	1.1	0.5	-0.4416717
Sweet aroma	0.8	0.1	0.9	0.3	-0.7858793	-	-	-	-	-
Nut aroma	1.0	0.2	1.0	0.2	0.0	1.0	0.3	1.4	0.9	-1.1457694
Soft-Hard	1.1	0.3	1.0	0.4	0.5426513	1.4	0.1	1.2	0.7	0.6300735
Crumbly-Cohesive	1.0	0.1	1.0	0.4	0.0	1.0	0.2	1.0	0.3	0.0
Gritty	1.3	0.4	1.2	0.4	0.5065363	1.4	0.1	1.5	0.6	-0.3673567
Dry-Juicy	0.9	0.1	1.0	0.2	-1.1475117	0.8	0.2	1.2	1.0	-0.8809168
Nutty Flavour	1.0	0.1	0.9	0.2	1.1475114	1.0	0.3	1.1	0.6	-0.3618735
Sesame Flavour	0.8	0.2	0.7	0.3	0.7383972	1.3	0.2	1.1	0.5	0.8737547
Mellow-Sharp sweet	1.0	0.1	0.9	0.3	0.7858792	1.3	0.2	1.1	1.1	0.4006075
Fruity Flavour	0.9	0.3	0.6	0.3	2.0261454	0.8	0.3	0.8	0.7	0.0
Mungbean flavour	1.1	0.4	1.0	0.2	0.7519	1.2	0.2	1.1	0.5	1.0856205
Acceptability	0.7	0.2	0.8	0.2	-1.0130727	0.8	0.1	0.8	0.2	0.0

$t_{17} \geq 2.110$ ($P<0.05$); $t_{17} \geq 2.898$ ($P<0.01$)

$t_{33} \geq 2.035$ ($P<0.05$); $t_{33} \geq 2.734$ ($P<0.01$)

APPENDIX 6.6a

PROFILES OF 1ST CONSUMER PRODUCT BY 1ST LAB PANEL USING THREE METHODS FOR ANALYSING DATA (FIXED-IDEAL DATA)

Sensory Attribute	Product Profiles		
	Score Mean	Ratio Mean	Interval Mean
Colour	6.0	1.2	1.0
Size	5.0	1.0	0.0
Sweet aroma	4.3	0.8	-0.9
Nut aroma	5.0	1.0	-0.2
Soft-hard	5.4	1.1	0.6
Crumbly-cohesive	6.0	1.0	-0.1
Gritty	5.3	1.3	1.2
Dry-juicy	5.2	0.9	-0.6
Nutty flavour	6.4	1.0	0.1
Sesame flavour	4.6	0.8	-1.0
Mellow-sharp sweet	4.2	1.0	-0.2
Fruity flavour	3.3	0.9	-0.3
Mungbean flavour	4.9	1.1	-0.3
Acceptability	5.2	0.7	-1.8

APPENDIX 6.6b

PROFILES OF 1ST CONSUMER PRODUCT BY 2ND LAB PANEL* USING **TWO** METHODS FOR ANALYSING DATA (FIXED-IDEAL DATA)

Sensory Attributes	**Product Profiles**	
	Ratio Mean	Interval Mean
Colour	1.1	0.4
Size	1.0	0.0
Sweet aroma	-	-
Nut aroma	1.0	0.0
Soft-hard	1.4	1.5
Crumbly-cohesive	1.0	0.2
Gritty	1.4	1.6
Dry-juicy	0.8	-1.3
Nutty flavour	1.0	-0.2
Sesame flavour	1.3	1.2
Mellow-sharp sweet	1.3	1.3
Fruity flavour	0.8	-1.1
Mungbean flavour	1.2	1.0
Acceptability	0.8	-1.4

* using ideal of child consumer panel

APPENDIX 6.6c

PROFILES OF LP FORMULATED PRODUCT BY 1ST LAB PANEL USING THREE METHODS FOR ANALYSING DATA (MOVING-IDEAL DATA)

Sensory Attributes	PROFILES BY THREE METHODS		
	Score Mean	Ratio Mean	Interval Mean
Colour	-	-	-
Size	-	-	-
Sweet aroma	4.5	0.9	-0.8
Nut aroma	5.1	1.0	-0.0
Soft-hard	4.5	1.1	-0.3
Crumbly-cohesive	3.5	0.6	-2.7
Gritty	5.8	1.4	1.7
Dry-juicy	6.1	1.1	0.4
Nutty flavour	5.8	1.0	-0.5
Sesame flavour	5.0	0.9	-0.6
Mellow-sharp sweet	4.1	0.9	-0.4
Fruity flavour	1.6	1.0	-2.0
Mungbean flavour	6.6	1.3	1.4
Acceptability	5.2	0.7	-1.8

APPENDIX 6.6d

PROFILES OF 1ST CONSUMER TEST PRODUCT BY 2ND LAB PANEL* USING THREE METHODS FOR ANLAYSING DATA (MOVING-IDEAL DATA)

Sensory Attributes	PROFILES BY THREE METHODS		
	Score Mean	Ratio Mean	Interval Mean
Colour	6.7	1.7	2.5
Size	5.1	1.0	0.0
Aroma	5.4	1.1	0.3
Soft-hard	4.7	1.1	0.3
Crumbly-cohesive	6.0	1.2	0.8
Gritty	7.0	1.5	2.1
Dry-juicy	5.1	1.0	-0.4
Nutty flavour	5.0	1.1	-0.3
Sesame flavour	5.0	1.4	1.0
Mellow-sharp sweet	3.4	1.2	0.2
Fruity flavour	1.2	0.2	-3.7
Mungbean flavour	4.9	1.2	0.5
Acceptability	4.7	0.7	-2.3

* using their own ideal

APPENDIX 6.7a

CORRELATION COEFFICIENTS OF SENSORY ATTRIBUTES OF THE 1ST CONSUMER TEST PRODUCT USING RATIO AND INTERVAL DATA BY ADULT CONSUMER PANEL IN NEW ZEALAND (N = 13)

RATIO

	R.COLOR	R.SIZE	R.SWARO	R.NUTARO	R.SOFT	R.COHES	R.GRIT	R.JUICY	R.NUTTY	R.SESAM	R.MSWEET	R.FRUIT	R.MUNG
R.SIZE	-0.273												
R.SWARO	-0.423	0.387											
R.NUTARO	-0.183	0.323	0.290										
R.SOFT	-0.419	-0.055	0.132	0.020									
R.COHES	-0.303	0.204	0.342	0.396	0.577								
R.GRIT	0.084	-0.046	-0.494	0.072	0.105	-0.314							
R.JUICY	-0.045	0.464	0.114	0.159	-0.754	-0.371	-0.047						
R.NUTTY	0.037	0.435	0.274	0.724	0.069	0.625	-0.038	-0.015					
R.SESAM	-0.175	-0.121	-0.119	0.039	0.387	0.603	-0.247	-0.342	0.347				
R.MSWEET	-0.278	0.461	0.662	0.189	0.223	0.271	-0.189	0.128	0.278	0.068			
R.FRUIT	-0.043	0.039	-0.017	-0.150	-0.052	0.165	-0.521	0.075	0.032	0.676	0.093		
R.MUNG	0.005	0.216	0.065	-0.385	-0.256	-0.249	-0.546	0.225	-0.216	-0.029	0.044	0.328	
R.ACCPT	-0.084	-0.156	0.189	0.081	0.288	0.204	-0.245	-0.427	0.032	0.184	0.020	0.093	0.118

INTERVAL

	I.COLOR	I.SIZE	I.SWARO	I.NUTARO	I.SOFT	I.COHES	I.GRIT	I.JUICY	I.NUTTY	I.SESAM	I.MSWEET	I.FRUIT	I.MUNG
I.SIZE	-0.273												
I.SWARO	-0.423	0.387											
I.NUTARO	-0.183	0.323	0.290										
I.SOFT	-0.419	-0.055	0.132	0.020									
I.COHES	-0.303	0.204	0.342	0.396	0.577								
I.GRIT	0.084	-0.046	-0.494	0.072	0.105	-0.314							
I.JUICY	-0.045	0.464	0.114	0.159	-0.754	-0.371	-0.047						
I.NUTTY	0.037	0.435	0.274	0.724	0.069	0.625	-0.038	-0.015					
I.SESAM	-0.175	-0.121	-0.119	0.039	0.387	0.603	-0.247	-0.342	0.347				
I.MSWEET	-0.278	0.461	0.662	0.189	0.223	0.271	-0.189	0.128	0.278	0.068			
I.FRUIT	-0.043	0.039	-0.017	-0.150	-0.052	0.165	-0.521	0.075	0.032	0.676	0.093		
I.MUNG	0.005	0.216	0.065	-0.385	-0.256	-0.249	-0.546	0.225	-0.216	-0.029	0.044	0.328	
I.ACCPT	-0.084	-0.156	0.189	0.081	0.288	0.204	-0.245	-0.427	0.032	0.184	0.020	0.093	0.118

r table .05 ≥0.553
.01 ≥0.684

APPENDIX 6.7b

CORRELATION COEFFICIENTS OF SENSORY ATTRIBUTES OF THE 1ST CONSUMER TEST PRODUCT USING RATIO AND INTERVAL DATA BY ADULT LAB PANEL IN THAILAND (N = 5)

RATIO	COL	ARO	SOFT	COH	GRIT	JUI	NUT	SES	MS	FRUIT	MUNG
ARO	0.663										
SOFT	-0.882*	-0.236									
COH	-0.843	-0.900*	0.551								
GRIT	0.328	-0.020	-0.482	-0.173							
JUI	-0.847	-0.900*	0.554	0.949*	-0.378						
NUT	-0.227	-0.864	-0.231	0.683	0.228	0.635					
SES	0.783	0.946*	-0.438	-0.929*	0.298	-0.988**	-0.719				
MS	0.852	0.473	-0.824	-0.642	0.751	-0.790	-0.046	0.720			
FRUIT	-0.578	-0.976**	0.125	0.801	0.177	0.803	0.857	-0.873	-0.353		
MUNG	0.714	0.611	-0.512	-0.510	0.330	-0.698	-0.208	0.715	0.768	-0.633	
ACC	0.384	-0.297	-0.687	-0.088	0.284	0.086	0.531	-0.216	0.174	0.375	-0.198
INTERVAL											
ARO	0.666										
SOFT	-0.876	-0.231									
COH	-0.849	-0.905*	0.551								
GRIT	0.334	-0.004	-0.493	-0.190							
JUI	-0.850	-0.902*	0.553	0.952*	-0.387						
NUT	-0.225	-0.863	-0.240	0.677	0.221	0.629					
SES	0.776	0.948*	-0.422	-0.928*	0.309	-0.987**	-0.720				
MS	0.848	0.474	-0.821	-0.649	0.760	-0.792	-0.042	0.716			
FRUIT	-0.580	-0.976**	0.117	0.807	0.162	0.807	0.857	-0.877	-0.355		
MUNG	0.712	0.609	-0.502	-0.523	0.333	-0.702	-0.204	0.716	0.766	-0.633	
ACC	0.386	-0.292	-0.692	-0.085	0.026	0.083	0.531	-0.228	0.172	0.372	-0.196

fixed ideal data

r table .05 > 0.878

.01 > 0.959

APPENDIX 6.8a

CORRELATION COEFFICIENTS OF SENSORY ATTRIBUTES OF THE 1ST CONSUMER TEST PRODUCT USING RATIO AND INTERVAL DATA BY ADULT LAB PANEL IN THAILAND (N = 6)

RATIO	R.COLOR	R.SIZE	R.SWARO	R.NUTARO	R.SOFT	R.COHES	R.GRIT	R.JUICY	R.NUTTY	R.SESAM	R.MSWEET	R.FRUIT	R.MUNG
R.SIZE													
R.SWARO													
R.NUTARO	-0.17												
R.SOFT	0.42			-0.46									
R.COHES	0.43			0.46	0.37								
R.GRIT	0.75			0.29	0.33	0.49							
R.JUICY	-0.42			0.15	-0.42	0.32	-0.08						
R.NUTTY	-0.50			-0.35	-0.37	-0.44	-0.37	0.51					
R.SESAM	0.62			0.48	-0.09	0.27	0.50	-0.22	-0.81*				
R.MSWEET	-0.45			0.44	-0.85*	0.03	-0.25	0.79	0.34	0.10			
R.FRUIT	-0.28			-0.65	-0.02	-0.47	-0.80	0.02	0.17	-0.26	0.08		
R.MUNG	-0.46			-0.53	-0.39	-0.67	-0.57	0.37	0.94**	-0.75	0.29	0.46	
R.ACCPT	0.10			0.66	0.10	0.77	0.30	0.03	-0.80	0.69	0.14	-0.27	0.87*

INTERVAL	I.COLOR	I.SIZE	I.SWARO	I.NUTARO	I.SOFT	I.COHES	I.GRIT	I.JUICY	I.NUTTY	I.SESAM	I.MSWEET	I.FRUIT	I.MUNG
I.SIZE													
I.SWARO	-0.22												
I.NUTARO													
I.SOFT	0.35			-0.47									
I.COHES	0.17			0.60	0.29								
I.GRIT	0.87*			0.18	0.26	0.52							
I.JUICY	-0.24			0.13	-0.37	0.16	0.01						
I.NUTTY	-0.60			-0.095	-0.48	-0.47	-0.49	0.68					
I.SESAM	0.43			0.52	-0.01	0.65	0.49	-0.26	-0.80				
I.MSWEET	-0.42			0.56	-0.91	0.01	-0.18	0.68	0.56	0.03			
I.FRUIT	0.17			0.25	-0.24	-0.06	0.42	0.28	0.42	-0.35	0.23		
I.MUNG	-0.51			-0.29	-0.58	-0.69	-0.58	0.57	0.91*	-0.72	0.55	0.17	
I.ACCPT	0.99**			0.70	0.10	0.90*	0.36	-0.08	-0.63	0.86*	0.08	-0.29	-0.74

'moving ideal' data

r table .05 > 0.811
.01 > 0.917

APPENDIX 6.8b

CORRELATION COEFFICIENTS OF SENSORY ATTRIBUTES OF THE 1ST CONSUMER TEST PRODUCT USING RATIO AND INTERVAL DATA BY CHILD CONSUMER PANEL IN THAILAND (N = 30)

	COL	SIZE	ARO	SOFT	COH	GRIT	JUI	NUT	SES	MS	FRUIT	MUNG
RATIO												
SIZE	-0.147											
ARO	0.284	-0.053										
SOFT	-0.164	0.060	0.331									
COH	-0.024	0.180	0.271	0.492**								
GRIT	0.395*	0.345	0.568	0.191	0.179							
JUI	0.100	0.519**	-0.114	-0.046	-0.106	0.230						
NUT	0.308	0.395*	0.139	0.258	0.480**	0.408*	0.340					
SES	-0.211	0.423*	0.083	0.456	0.212	0.423*	0.243	0.472**				
MS	-0.200	0.049	-0.115	0.097	-0.008	0.129	0.103	0.073	0.536**			
FRUIT	-0.325	0.373	-0.273	0.113	0.043	0.010	0.411*	0.162	0.544**	0.605**		
MUNG	-0.110	0.127	-0.141	-0.030	0.293	0.050	0.217	0.305	0.374*	0.352	0.401*	
ACC	0.306	-0.026	0.090	-0.045	0.056	0.299	-0.200	0.395*	0.259	0.346	0.205	0.225
INTERVAL												
SIZE	-0.065											
ARO	-0.370*	-0.029										
SOFT	-0.035	0.015	0.140									
COH	-0.197	0.090	0.140	0.469**								
GRIT	0.315	0.179	0.420*	0.313	0.193							
JUI	0.041	0.216	-0.217	-0.090	-0.287	-0.146						
NUT	0.122	0.346	0.212	0.356	0.421*	0.586**	0.194					
SES	-0.160	0.408*	0.187	0.452*	0.221	0.500**	0.223	0.680**				
MS	-0.079	0.161	0.057	-0.109	0.035	0.162	0.130	0.438*	0.392*			
FRUIT	-0.307	0.137	-0.289	0.026	0.007	-0.176	0.504**	0.102	0.299	0.211		
MUNG	-0.171	0.003	-0.037	-0.166	0.138	-0.052	0.004	0.136	0.086	0.373*	0.323	
ACC	0.201	-0.035	0.104	0.147	0.134	0.387	-0.290	0.512**	0.333	0.555**	0.038	0.281

r. table .05 $\geq$ 0.361
.01 $\geq$ 0.463

'moving ideal' data

APPENDIX 6.9a

RATIO MEANS AND STANDARD DEVIATION FOR PRODUCT PROFILES BY CONSUMER PANEL (N=30) AND CALCULATION OF REFERENCE C.V. VALUES

Product Sensory Attributes	Data 1				C.V. (%)		Reference C.V. Values	Data 2				C.V. %		Reference C.V. Values
	EXP 1		EXP 2		EXP 1	EXP 2		EXP 1		EXP 2				
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}				$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}			
Colour	1.6	0.8	1.0	0.3	50	30	40	1.6	0.8	1.2	0.3	50.00	25.00	38
Size	1.1	0.5	1.0	0.1	45	10	28	-	-	-	-	-	-	-
Sweet aroma	-	-	0.9	0.3	-	33	33	-	-	-	-	-	-	-
Nut aroma	1.4	0.9	1.0	0.2	64	20	42	-	-	-	-	-	-	-
Soft-hard	1.2	0.7	1.0	0.4	58	40	49	-	-	-	-	-	-	-
Crumbly-cohesive	1.0	0.3	1.0	0.4	30	40	35	1.0	0.3	1.0	0.2	30.00	20.00	25
Gritty	1.5	0.6	1.2	0.4	40	33	37	1.5	0.6	1.1	0.2	40.0	18.18	29
Dry-Juicy	1.2	1.0	1.0	0.2	83	20	52	-	-	-	-	-	-	-
Nutty flavour	1.1	0.6	0.9	0.2	55	22	39	-	-	-	-	-	-	-
Sesame flavour	1.1	0.5	0.7	0.3	45	43	44	-	-	-	-	-	-	-
Mellow-sharp sweet	1.1	1.1	0.9	0.3	100	33	67	1.1	1.1	0.9	0.3	100.00	33.33	67
Fruity flavour	0.8	0.7	0.6	0.3	88	50	69	-	-	-	-	-	-	-
Mungbean flavour	1.1	0.5	1.0	0.2	45	20	33	-	-	-	-	-	-	-
Acceptability	0.8	0.2	0.8	0.2	25	25	25	-	-	-	-	-	-	-

APPENDIX 6.9b

RATIO MEANS AND STANDARD DEVIATION FOR PRODUCT PROFILES BY CONSUMER SURVEY (N=1094)

AND CALCULATION OF REFERENCE C.V. VALUES

Product Sensory Attributes	Data EXP 1 $\bar{x}$	n-1	C.V. %	Reference C.V. Values
Colour	1.2	0.3	25.00	25
Size	1.1	0.3	27.27	27
Texture (crumbly-cohesive)	0.9	0.4	44.44	44
Flavour (sweetness)	0.8	0.5	62.50	63
Preference	0.6	0.3	50.00	50

APPENDIX 6.9c

SCORE MEANS AND STANDARD DEVIATION FOR IDEAL PRODUCT PROFILE BY LAB PANEL AND CALCULATION OF REFERENCE C.V. VALUES

Product Sensory Attributes	Data (N = 6)				C.V.		Reference C.V. Values	Data (N=30)		C.V.	Reference C.V. Values
	EXP 1		EXP 2					EXP 1			
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	EXP 1	EXP 2					
Colour	-	-	4.2	1.2	-	28.57	29	4.4	1.7	38.64	39
Size	-	-	5.1	0.0	-	0.00	0	5.1	1.6	31.37	31
Sweet aroma	5.2	1.2	-	-	23.08	-	23	-	-	-	-
Nut aroma	5.1	1.4	5.0	1.1	27.45	22.00	25	4.5	1.8	40.00	40
Soft-hard	4.9	1.5	4.5	0.7	30.61	15.56	23	4.5	1.6	35.56	36
Crumbly-cohesive	6.1	1.4	5.2	1.2	22.95	23.08	23	5.1	1.5	29.41	29
Gritty	4.1	1.2	4.9	1.1	29.27	22.45	26	4.4	1.9	43.18	43
Dry-juicy	5.8	1.9	5.5	1.7	32.76	30.91	32	5.2	2.0	38.46	39
Nutty flavour	6.3	2.0	5.3	1.4	31.75	26.42	29	4.5	1.2	26.67	27
Sesame flavour	5.6	0.9	4.0	1.5	16.07	37.50	27	4.3	1.5	34.88	35
Mellow-sharp sweet	4.4	1.4	3.2	1.2	31.82	37.50	35	3.7	2.1	56.76	57
Fruity flavour	3.6	1.7	4.8	1.4	47.22	29.17	38	4.3	2.2	51.16	51
Mungbean flavour	5.2	1.7	4.4	2.2	32.69	50.00	41	4.3	1.5	34.88	35

APPENDIX 6.9d

RATIO MEANS AND STANDARD DEVIATION FOR 'STORAGE TEST PRODUCT' PROFILES BY LAB PANEL (N=6)

AND CALCULATION OF REFERENCE C.V. VALUES

Product Sensory Attributes	DATA										D.V.					Reference C.V. Values
	EXP 1		EXP 2		EXP 3		EXP 4		EXP 5		EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}						
Sweetness	1.0	0.0	0.8	0.1	0.9	0.1	1.0	0.1	0.9	0.1	-	12.50	11.11	10.00	11.11	11
Rancidity	1.0	0.0	1.0	0.1	1.2	0.2	1.3	0.2	1.5	0.3	-	10.00	16.67	15.38	20.00	16
Dryness	1.0	0.0	1.5	0.2	1.3	0.1	1.2	0.2	1.1	0.1	-	13.33	7.69	16.67	9.09	12
Hardness	1.0	0.0	1.4	0.3	1.3	0.1	1.0	0.2	1.2	0.2	-	21.43	7.69	20.00	16.67	16
Acceptability	1.0	0.0	0.8	0.1	0.9	0.1	0.9	0.1	0.8	0.1	-	12.50	11.11	11.11	12.50	12

APPENDIX 7.1

CALCULATION OF CHEMICAL SCORES BY 2 METHODS

Essential Amino Acids	Level suggested by FAO/WHO		Level in the Product		Chemical Scores		Limiting amino acids
	mg/g total protein	% of total	mg/g total protein	% of total	A/T	A/E	
Isoleucine	40	11.1	18	6.9	45*	62	Isoleucine
Leucine	70	19.4	55	21.2	79	109	
Lysine	55	15.3	40	15.4	73	101	
Methionine + cystine	35	9.7	20	7.7	57	79	
Phenylalanine + tyrosine	60	16.7	60	23.2	100	139	
Threonine	40	11.1	28	10.8	70	97	
Tryptophan	10	2.8	10	3.9	100	139	
Valine	50	13.9	28	10.8	56	78	
TOTAL	360		259				

APPENDIX 7.2a

CHANGES OF SENSORY ATTRIBUTES OF STORED PRODUCT

(1) **Sweetness**

Conditions	Day 0		Day 5		Day 9		Day 14		Day 21	
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}
PP										
1 25-75	3	0.6	2.8	1.2	3.0	0.9	2.7	0.8	2.8	0.8
2 25-95			2.8	1.0	2.7	0.8	2.8	0.8	2.5	1.0
3 35-85			3.3	0.8	2.5	1.2	2.8	0.8	2.8	0.8
4 45-75			2.5	1.0	2.5	1.0	2.3	1.0	2.3	1.2
5 45-95			2.8	0.8	2.8	1.0	2.7	1.0	2.5	1.0
6 35-75			3.5	0.8	3.2	0.8	2.3	1.0	2.3	1.0
7 RT-Amb			3.3	0.8	2.7	1.0	2.7	1.2	2.7	1.0
AF										
1 25-75			2.5	0.8	3.0	1.1	2.1	0.8	2.7	0.8
2 25-95			3.0	1.1	2.8	1.0	2.7	0.8	2.3	1.0
3 35-85			2.7	1.2	2.7	0.8	2.8	1.2	2.5	1.0
4 45-75			2.7	1.5	2.2	1.2	2.1	0.8	2.7	1.0
5 45-95			2.8	1.2	2.5	1.0	2.7	1.2	2.3	1.0
6 35-75			2.8	1.3	2.8	1.0	2.5	1.0	2.8	0.8
7 4-Amb			3.7	0.5	3.2	0.8	2.7	0.8	2.8	0.8

σ^{n-1} = S.D.

(2) **Rancidity**

Conditions,	Day 0		Day 5		Day 9		Day 14		Day 21	
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}
PP										
1 25-75	1.3	0.5	1.3	0.8	1.2	0.4	1.5	1.2	1.5	0.8
2 25-95			1.2	0.4	1.5	0.8	1.8	1.3	2.0	0.9
3 35-85			1.2	0.4	1.7	0.8	1.7	1.2	2.3	1.2
4 45-75			1.5	0.5	1.7	0.8	2.2	1.3	2.3	1.2
5 45-95			1.3	0.5	2.0	1.3	2.5	1.5	2.0	1.3
6 35-75			1.3	0.5	1.3	0.5	2.3	1.2	2.0	1.1
7 RT-Amb			1.2	0.4	1.7	1.0	2.0	1.3	1.3	0.8
AF										
1 25-75			1.0	0.0	1.3	0.8	1.3	0.5	1.3	0.5
2 25-95			1.2	0.4	1.5	1.2	1.3	0.8	1.8	1.3
3 35-85			1.3	0.5	1.7	0.8	2.0	1.5	1.7	1.2
4 45-75			1.5	1.2	1.8	1.3	1.8	1.3	2.2	1.3
5 45-95			1.2	0.4	1.7	1.0	2.2	1.6	2.7	1.2
6 35-75			1.7	1.2	1.2	0.4	1.8	1.6	1.8	1.3
7 4-Amb			1.3	0.8	1.3	0.5	1.5	1.2	1.3	0.5

APPENDIX 7.2a (Continued): CHANGES OF SENSORY ATTRIBUTES OF STORED PRODUCT

(3) Dryness

Conditions	Day 0		5		9		14		21	
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}
PP										
1 25-75	2.0	0.9	2.2	1.0	3.3	1.0	2.7	1.2	2.5	1.0
2 25-95			2.0	0.9	2.7	1.4	2.3	1.4	2.5	0.5
3 35-85			2.7	0.8	3.0	1.3	2.8	1.3	3.0	1.1
4 45-75			3.2	0.8	3.0	0.6	3.2	1.2	3.2	0.4
5 45-95			2.8	1.2	2.8	1.2	3.2	1.0	3.0	0.9
6 35-75			2.5	0.5	2.8	0.8	2.7	0.5	2.8	0.8
7 RT-Amb			2.5	0.5	2.5	0.8	3.0	1.3	3.2	1.3
AF										
1 25-75			2.5	1.0	2.5	1.0	1.8	0.8	2.8	1.2
2 25-95			2.2	1.2	2.7	1.2	2.3	1.0	2.8	0.8
3 35-85			2.8	1.5	2.3	1.4	2.3	1.2	3.3	0.5
4 45-75			2.5	1.0	3.3	1.2	2.8	1.5	3.3	0.5
5 45-95			2.2	0.8	3.0	0.9	3.3	1.0	3.0	0.0
6 35-75			2.7	1.0	3.3	0.8	2.8	1.2	2.5	1.0
7 4-Amb			1.7	0.5	2.2	0.4	2.2	1.2	2.7	1.2

σ^{n-1} = S.D.

(4) Hardness

Conditions	Day 0		5		9		14		21	
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}
PP										
1 25-75	2.2	1.0	1.8	0.8	3.0	1.1	2.7	1.0	1.8	0.8
2 25-95			2.0	0.6	2.5	1.2	2.0	0.6	2.2	1.0
3 35-85			2.5	0.8	2.5	0.8	2.8	0.8	2.3	0.8
4 45-75			3.5	0.5	2.8	0.8	3.5	1.4	3.3	1.2
5 45-95			2.5	1.2	2.8	1.6	2.3	0.5	2.5	0.5
6 35-75			2.5	0.8	2.5	0.8	2.7	0.8	2.7	0.8
7 RT-Amb			3.0	0.6	2.7	1.0	3.2	1.0	2.8	1.5
AF										
1 25-75			2.2	1.2	2.2	1.0	2.0	0.9	2.0	1.3
2 25-95			1.7	0.8	2.3	1.0	2.2	0.8	2.8	1.0
3 35-85			2.0	0.9	2.2	1.5	2.7	1.5	2.8	0.8
4 45-75			2.7	1.2	2.7	1.0	2.7	1.2	3.3	0.8
5 45-95			2.5	1.2	2.7	1.0	3.3	0.8	3.0	1.1
6 35-75			2.2	0.8	2.7	1.0	3.0	0.9	2.5	1.0
7 4-Amb			1.7	0.8	2.0	0.9	2.7	1.2	2.2	0.8

APPENDIX 7.2a (Continued): CHANGES OF SENSORY ATTRIBUTES OF STORED PRODUCT

(5) Acceptability

Conditions	Day									
	0		5		9		14		21	
	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}	$\bar{x}$	σ^{n-1}
PP										
1 25-75	4.2	0.8	4.0	0.6	3.5	0.5	3.7	0.8	3.7	1.2
2 25-95			3.7	1.0	3.7	1.0	3.7	1.2	3.0	1.4
3 35-85			4.0	0.6	3.3	0.5	3.3	1.0	2.8	1.5
4 45-75			3.2	1.0	3.0	0.6	2.7	1.5	2.5	1.6
5 45-95			3.5	1.0	3.0	1.1	2.7	0.8	2.8	0.8
6 35-75			3.8	0.8	3.5	0.8	3.0	1.1	3.2	0.8
7 RT-Amb.			3.0	0.9	3.3	1.0	3.0	0.9	3.2	1.0
AF										
1 25-75			3.7	1.5	3.5	0.8	3.7	0.8	3.7	1.0
2 25-95			3.3	1.0	3.8	1.0	3.7	1.2	3.3	1.0
3 35-85			3.5	1.2	3.5	1.0	3.0	1.4	2.8	1.2
4 45-75			2.7	0.5	2.8	0.8	3.0	1.3	2.7	1.4
5 45-95			3.2	1.2	3.0	0.6	3.2	0.8	2.5	1.6
6 35-75			3.8	0.8	3.2	0.4	3.5	1.2	3.5	1.0
7 4-Amb.			4.2	0.4	3.8	0.8	3.8	1.0	3.7	1.0

σ^{n-1} = S.D.

APPENDIX 7.2b

CHANGES OF MOISTURE CONTENT (%) OF STORED PRODUCTS

Conditions		Day 0	5	9	14	21
PP						
1	25-75	9.11	9.97	10.21	9.61	9.38
2	25-95	9.11	9.88	10.28	9.84	10.08
3	35-85	9.11	10.06	10.58	10.10	8.89
4	45-75	9.11	9.18	10.25	10.26	9.51
5	45-95	9.11	9.68	10.37	10.15	10.07
6	35-75	9.11	10.57	10.66	10.39	9.32
7	RT-Amb.RH	9.11	9.03	10.54	10.69	9.49
AF						
1	25-75	9.11	9.00	10.03	9.73	9.33
2	25-95	9.11	9.72	10.27	10.05	9.98
3	35-85	9.11	9.80	9.84	9.88	9.11
4	45-75	9.11	11.12	10.15	9.77	9.28
5	45-95	9.11	9.39	11.34	9.37	10.09
6	35-75	9.11	10.06	11.30	9.73	9.01
7	4-Amb.RH	9.11	9.77	9.73	11.02	9.16

APPENDIX 7.2C

CHANGES OF TOTAL PLATE COUNT OF STORED PRODUCTS

Conditions		Day 0	5	9	14	21
PP						
1	25-75	1.4×10^3	4.5×10^3	3.3×10^2	6.3×10^3	3.0×10^3
2	25-95	1.4×10^3	4.9×10^3	3.8×10^3	4.7×10^3	4.8×10^3
3	35-85	1.4×10^3	5.0×10^2	4.3×10^3	2.9×10^3	3.4×10^3
4	45-75	1.4×10^3	2.1×10^2	3.2×10^3	2.5×10^3	3.6×10^3
5	45-95	1.4×10^3	1.5×10^3	3.2×10^3	4.9×10^3	5.0×10^3
6	35-75	1.4×10^3	2.6×10^2	1.7×10^3	2.9×10^3	4.5×10^3
7	RT-Amb	1.4×10^3	1.7×10^3	1.4×10^2	3.6×10^2	3.7×10^2
AF						
1	25-75	1.4×10^3	3.8×10^2	2.2×10^3	3.8×10^3	2.0×10^3
2	25-95	1.4×10^3	1.6×10^3	1.6×10^3	4.2×10^3	6.3×10^3
3	35-85	1.4×10^3	1.5×10^3	3.9×10^3	3.1×10^3	5.1×10^3
4	45-75	1.4×10^3	1.7×10^2	2.3×10^3	2.1×10^3	3.0×10^2
5	45-95	1.4×10^3	1.8×10^3	3.9×10^3	2.1×10^3	2.8×10^3
6	35-75	1.4×10^3	4.1×10^2	3.4×10^3	5.9×10^3	3.2×10^2
7	4-Amb	1.4×10^3	9.4×10^3	3.2×10^3	3.8×10^3	7.0×10^3

APPENDIX 7.2d

DIAGRAMATICALLY SHOWN CHANGES OF PRODUCT ATTRIBUTES

DURING STORAGE AT DIFFERENT CONDITIONS

(Vertical = 25, 45°C; Horizontal = 75, 95% RH; Middlepoint = 35°C, 85% RH)
(References shown were at Day 5)

Sweetness (Day 0 = 3.0; Reference = 3.7)

	PP 45°C, 75% RH	PP 45°C, 95% RH	PP middle	PP 25°C, 75% RH	PP 25°C, 95% RH	AF 45°C, 75% RH	AF 45°C, 95% RH	AF middle	AF 25°C, 75% RH	AF 25°C, 95% RH
Day 5	2.5	2.8	3.3	2.8	2.8	2.7	2.8	2.7	2.5	3.0
Day 9	2.5	2.8	2.5	3.0	2.7	2.2	2.5	2.7	3.0	2.8
Day 14	2.3	2.7	2.8	2.7	2.8	2.7	2.7	2.8	2.7	2.7
Day 21	2.3	2.5	2.8	2.8	2.5	2.7	2.3	2.5	2.7	2.3

APPENDIX 7.2d (Continued): DIAGRAMATICALLY SHOWN CHANGES OF PRODUCT ATTRIBUTES DURING STORAGE AT DIFFERENT CONDITIONS

Rancidity

(Day 0 = 1.3; Reference = 1.3)

	PP top-left	PP top-right	PP centre	PP bottom-left	PP bottom-right	AF top-left	AF top-right	AF centre	AF bottom-left	AF bottom-right
Day 5	1.5	1.3	1.2	1.3	1.2	1.5	1.2	1.3	1.0	1.2
Day 9	1.7	2.0	1.7	1.2	1.5	1.8	1.7	1.7	1.3	1.5
Day 14	2.2	2.5	1.7	1.5	1.8	1.8	2.2	2.0	1.3	1.3
Day 21	2.3	2.0	2.3	1.5	2.0	2.2	2.7	1.7	1.3	1.8

Dryness

(Day 0 = 2.0; Reference = 1.7)

	PP top-left	PP top-right	PP centre	PP bottom-left	PP bottom-right	AF top-left	AF top-right	AF centre	AF bottom-left	AF bottom-right
Day 5	3.2	2.8	2.7	2.2	2.0	2.5	2.2	2.8	2.5	2.2
Day 9	3.0	2.8	3.0	3.3	2.7	3.3	3.0	2.3	2.5	2.7
Day 14	3.2	3.2	2.8	2.7	2.3	2.8	3.[illegible]	2.3	2.8	2.[illegible]
Day 21	3.2	3.0	3.0	2.5	2.5	3.3	3.0	3.3	2.8	2.8

APPENDIX 7.2d (Continued): DIAGRAMATICALLY SHOWN CHANGES OF PRODUCT ATTRIBUTES DURING STORAGE AT DIFFERENT CONDITIONS

Hardness

(Day 0 = 2.2; Reference = 1.7)

	PP top left	PP top right	PP centre	PP bottom left	PP bottom right	AF top left	AF top right	AF centre	AF bottom left	AF bottom right
Day 5	3.5	2.5	2.5	1.8	2.0	2.7	2.5	2.0	2.2	1.7
Day 9	2.8	2.8	2.5	3.0	2.5	2.7	2.7	2.2	2.2	2.3
Day 14	3.5	2.3	2.8	2.7	2.0	2.7	3.3	2.7	2.0	2.2
Day 21	3.3	2.5	2.3	1.8	2.2	3.3	3.0	2.8	2.0	2.8

Acceptability

Day,0 = 4.2; Reference = 4.2

	PP top left	PP top right	PP centre	PP bottom left	PP bottom right	AF top left	AF top right	AF centre	AF bottom left	AF bottom right
Day 0	3.2	3.5	4.0	4.0	3.7	2.7	3.2	3.5	3.7	3.3
Day 5	3.0	3.0	3.3	3.5	3.7	2.8	3.0	3.5	3.5	3.8
Day 14	2.7	2.7	3.3	3.7	3.7	3.0	3.2	3.0	3.7	3.7
Day 21	2.5	2.8	2.8	3.7	3.0	2.7	2.5	2.8	3.7	3.3

APPENDIX 7.2d (Continued): DIAGRAMATICALLY SHOWN CHANGES OF PRODUCT ATTRIBUTES DURING STORAGE AT DIFFERENT CONDITIONS

<u>Moisture Content</u>

Day 0 = 9.11; Reference = 9.77

	PP top-left	PP top-right	PP centre	PP bottom-left	PP bottom-right	AF top-left	AF top-right	AF centre	AF bottom-left	AF bottom-right
Day 5	9.18	9.68	10.06	9.97	9.88	11.12	9.39	9.80	9.00	9.72
Day 9	10.25	10.37	10.58	10.21	10.28	10.15	11.34	9.84	10.03	10.27
Day 14	10.26	10.15	10.10	9.61	9.84	9.77	9.37	9.88	9.73	10.05
Day 21	9.51	10.07	8.89	9.38	10.08	9.28	10.09	9.11	9.33	9.93

<u>Total Plate Count</u>

Day 0 = 1.4×10^3; Reference = 9.4×10^3

	PP top-left	PP top-right	PP centre	PP bottom-left	PP bottom-right	AF top-left	AF top-right	AF centre	AF bottom-left	AF bottom-right
Day 5	2.1×10^2	1.5×10^3	5.0×10^2	4.5×10^3	4.9×10^3	1.7×10^2	1.8×10^3	1.5×10^3	3.8×10^2	1.6×10^3
Day 9	3.2×10^3	3.2×10^3	4.3×10^3	3.3×10^2	3.8×10^3	2.3×10^3	3.9×10^3	3.9×10^3	2.2×10^3	1.6×10^3
Day 14	2.5×10^3	4.9×10^3	2.9×10^3	5.3×10^3	4.7×10^3	2.1×10^3	2.1×10^3	3.1×10^3	3.8×10^3	4.2×10^3
Day 21	3.2×10^3	5.0×10^3	3.4×10^3	3.0×10^3	4.8×10^3	3.0×10^2	2.8×10^3	5.1×10^3	2.0×10^3	6.3×10^3

APPENDIX 7.3a

SIGNIFICANT DIFFERENCE IN SENSORY ATTRIBUTES BETWEEN DAYS OF STORAGE BY t-TEST

	Day 0	Day 5	Day 9	Day 14
1. Sweetness				
Day 5	1.35			
Day 9	3.81**	1.69		
Day 14	7.45**	2.35*	0.79	
Day 21	7.68**	3.04**	1.52	1.17
2. Rancidity				
Day 5	-0.00			
Day 9	-3.77**	-3.02**		
Day 14	-5.59**	-5.73**	-3.57**	
Day 21	-5.41**	-5.49**	-3.40**	-0.34
3. Dryness				
Day 5	-5.81**			
Day 9	-9.55**	-2.64*		
Day 14	-5.87**	-1.48	1.38	
Day 21	-11.23**	-4.74**	-0.39	-1.70
4. Hardness				
Day 5	-1.40			
Day 9	-5.67**	-1.50		
Day 14	-3.77**	-2.83*	-1.01	
Day 21	-3.26**	-1.90	-0.22	
5. Acceptability				
Day 5	6.47**			
Day 9	10.55**	1.80		
Day 14	9.05**	2.22*	0.88	
Day 21	9.94**	3.90**	2.75*	2.22*
6. Moisture Content				
Day 5	-4.82**			
Day 9	-10.25**	-3.00**		
Day 14	-7.90**	-1.13	1.75	
Day 21	-3.32**	1.64	5.96**	3.16**
7. Total Plate Count				
Day 5	-0.95			
Day 9	-6.16**	-1.31		
Day 14	-6.75**	-2.56*	-1.94	
Day 21	-7.15**	-3.61**	-2.44*	-0.67

APPENDIX 7.3b

SIGNIFICANT DIFFERENCE IN SENSORY ATTRIBUTES BETWEEN CONDITIONS OF STORAGE BY T-TEST

(averaging from 5 days of storage; Day 0, 5, 9, 14, 21)

	PP+							AF++					
	1	2	3	4	5	6	7	1	2	3	4	5	6
Sweetness													
+PP 2	1.20												
3	-0.45	-0.97											
4	3.67*	2.95*	2.30										
5	1.58	0.00	0.88	-3.54*									
6	0.00	-0.45	0.09	-1.59	-0.90								
7	0.25	-1.12	-0.00	-2.71*	-1.12	-0.11							
++AF 1	1.37	-0.19	0.48	-2.41	-0.22	0.31	0.54						
2	0.85	0.00	0.88	-2.33	0.00	0.62	1.24	0.13					
3	1.50	1.00	1.00	-2.75*	0.53	0.51	1.12	0.45	0.25				
4	1.32	0.88	2.06	-1.06	0.75	0.67	1.62	0.69	0.60	0.09			
5	1.63	2.24	1.90	-1.61	1.58	0.92	2.16	0.82	1.58	1.37	0.00		
6	1.63	-0.21	0.75	-3.20*	-0.25	0.36	0.88	0.00	-0.16	-0.41	-0.91	0.97	
7	-1.26	-1.78	-1.32	-2.85*	-1.93	-2.16	-1.91	-1.32	-2.30	-1.73	-1.77	-2.30	-1.77

\+ PP 1-7 = Conditions of storage at 25/75, 25/95, 35/85, 45/75, 45/95, 35/75 °C/% RH and ambient temperature and relative humidity

++ AF 1-7 = Conditions of storage at 25/75, 25/95, 35/85, 45/75, 45/95, 35/75 °C/% RH and at 4°C and ambient relative humidity

APPENDIX 7.3b (Continued): SIGNIFICANT DIFFERENCE IN SENSORY ATTRIBUTES BETWEEN CONDITIONS OF STORAGE BY T-TEST

	PP							AF					
	1	2	3	4	5	6	7	1	2	3	4	5	6
Rancidity													
PP 2	-1.83												
3	-1.69	-1.09											
4	-2.93*	-3.54*	-1.55										
5	-2.26	-1.81	-0.98	-0.46									
6	-1.76	-0.69	0.00	1.73	1.33								
7	-0.93	0.36	0.63	1.63	2.50	0.78							
AF 1	1.63	2.58	2.39	3.40*	2.85*	2.03	1.96						
2	-0.58	1.43	2.16	2.48	1.85	1.07	0.41	-1.96					
3	-2.04	-0.43	0.27	1.83	2.27	0.31	-1.29	-3.21*	-1.29				
4	-2.79*	-2.36	-1.21	0.93	0.60	-0.48	-1.17	-3.36*	-3.59*	-1.04			
5	-1.93	-1.96	-1.62	-0.18	0.0	-1.13	-1.17	-2.29	-1.93	-1.09	-0.66		
6	-2.39	0.00	0.42	1.67	1.17	0.55	-0.31	-2.05	-0.89	0.27	1.09	1.09	
7	0.41	1.56	1.54	2.59	2.36	1.63	1.32	-1.58	0.64	2.41	2.46	1.77	1.90

	PP							AF					
	1	2	3	4	5	6	7	1	2	3	4	5	6
Dryness													
PP 2	2.06												
3	-1.04	-3.38*											
4	-1.61	-2.91*	-2.16										
5	-1.06	-2.55	-0.61	2.14									
6	-0.14	-2.80	3.50*	2.98*	2.11								
7	-0.40	-1.83	0.45	2.01	1.24	-0.64							
AF 1	0.84	-0.11	2.18	2.61	1.79	1.37	1.37						
2	0.88	-1.58	3.16*	2.76*	2.13	1.97	1.53	-0.61					
3	0.00	-1.00	0.85	1.96	1.05	0.10	0.59	-1.58	-0.76				
4	-1.60	-3.64*	-0.83	0.78	-0.12	-1.90	-0.81	-2.26	-3.56*	-1.05			
5	-0.95	-2.35	0.00	1.09	0.45	-0.95	-0.40	-1.23	-1.63	-0.53	0.51		
6	-1.24	-2.39	0.31	1.44	0.57	-0.77	-0.08	-1.39	-1.49	-0.40	0.69	0.20	
7	1.68	1.16	3.04*	3.04*	2.89*	2.64*	3.14*	0.81	2.23	1.82	3.44*	2.82*	1.92

APPENDIX 7.3b (Continued): SIGNIFICANT DIFFERENCE IN SENSORY ATTRIBUTES BETWEEN CONDITIONS OF STORAGE BY T-TEST

	PP							AF					
	1	2	3	4	5	6	7	1	2	3	4	5	6
<u>Hardness</u>													
PP 2	0.56												
3	-0.77	-1.76											
4	-1.98	-2.85*	-3.04*										
5	-0.70	-3.50*	0.00	2.17									
6	-0.86	-2.37	-0.69	3.04*	-0.54								
7	-1.68	-2.63*	-3.30*	2.75*	-1.78	-2.53							
AF 1	0.70	0.69	2.61*	3.35*	3.30*	2.98*	3.32*						
2	0.20	-0.37	0.96	2.55	1.14	1.69	2.05	-0.58					
3	-0.28	-1.04	0.47	2.75*	0.39	1.25	2.14	-1.27	-1.25				
4	-1.25	-2.75*	-1.34	1.80	-1.83	-1.85	0.35	-2.86*	-3.01*	-2.37			
5	-1.65	-2.44	-2.01	1.81	-1.34	-1.98	0.33	-2.63*	-2.50	-3.21*	-0.13		
6	-1.28	-1.98	-0.61	2.27	-0.35	0.00	1.77	-2.14	-1.45	-1.03	1.01	2.27	
7	0.60	0.40	1.98	3.11*	1.29	2.36	2.96*	-0.20	-0.44	1.98	2.35	3.88*	3.09*

	PP							AF					
	1	2	3	4	5	6	7	1	2	3	4	5	6
<u>Acceptability</u>													
PP 2	1.02												
3	1.79	1.06											
4	3.34*	3.31*	2.90*										
5	3.27*	2.26	2.26	-1.63									
6	2.01	0.75	-0.16	-3.38*	-3.59*								
7	2.71*	1.75	0.77	-1.44	-0.61	1.29							
AF 1	1.00	-0.65	-1.19	-3.03*	-2.69*	-1.38	-3.02*						
2	0.91	0.00	-0.61	-2.65*	-1.83	-0.61	-2.50	0.75					
3	2.30	2.23	0.97	-3.50*	-1.55	1.61	-0.41	1.94	1.59				
4	3.43*	3.08*	1.90	0.28	0.89	2.18	2.32	3.72*	3.57*	1.81			
5	3.04*	3.77*	2.18	-1.00	0.14	1.81	0.70	2.82*	2.60	1.45	-1.20		
6	3.67*	0.12	-0.75	-2.80*	-2.64*	-0.73	-1.83	1.63	0.11	-1.35	-3.01*	-2.41	
7	-2.06	-2.06	-2.75*	-3.81*	-3.74*	-3.07*	-3.04*	-1.80	-1.63	-3.19*	-3.52*	-3.50*	-3.00*

APPENDIX 7.3b (Continued): SIGNIFICANT DIFFERENCE IN SENSORY ATTRIBUTES BETWEEN CONDITIONS OF STORAGE BY T-TEST

	PP							AF					
	1	2	3	4	5	6	7	1	2	3	4	5	6
Moisture Content													
PP 2	-1.30												
3	-0.54	0.32											
4	-0.02	0.88	0.35										
5	-1.23	-0.46	-0.47	-1.62									
6	-2.14	-0.66	-2.67*	-1.26	-0.51								
7	-0.36	0.22	-0.08	-1.03	0.46	0.71							
AF 1	1.11	2.26	1.22	2.61*	3.29*	1.97	1.83						
2	-1.10	0.19	-0.30	-1.15	1.70	0.73	-0.22	-2.89*					
3	0.96	1.53	1.25	0.56	1.69	2.92*	0.78	-0.58	1.62				
4	-0.98	-0.15	-0.51	-0.52	-0.03	0.59	-0.22	-1.06	-0.17	-1.32			
5	-0.65	-0.08	-0.29	-0.61	0.06	0.37	-0.25	-1.44	-0.13	-0.79	0.05		
6	-0.77	-0.01	-0.53	-0.54	0.10	0.73	-0.19	-1.26	-0.05	-0.98	0.12	0.06	
7	-0.30	0.23	-0.03	-0.39	0.38	0.89	0.05	-1.04	0.22	-0.90	0.31	0.18	0.18

	PP							AF					
	1	2	3	4	5	6	7	1	2	3	4	5	6
Total Plate Count													
PP 2	-0.95												
3	0.42	1.65											
4	0.68	2.11	1.43										
5	-0.09	1.05	-1.25	-2.22									
6	0.79	2.14	0.57	0.07	2.94*								
7	2.14	3.84*	1.71	1.54	2.27	1.40							
AF 1	1.12	2.50	1.02	0.45	2.56	0.33	-1.40						
2	0.08	1.07	-0.56	-1.12	0.36	-2.25	-1.91	-1.24					
3	0.08	1.30	-1.33	-3.07*	0.48	-2.13	-2.22	-1.57	0.03				
4	1.50	2.97*	2.17	1.51	2.36	1.05	-0.69	1.71	1.51	2.16			
5	0.53	2.29	0.27	-0.52	1.13	-0.34	-2.25	-0.73	0.62	1.25	-2.32		
6	0.67	1.37	0.22	-0.10	0.92	-0.11	-1.18	-0.52	0.52	0.59	-1.43	0.11	
7	-1.36	-1.02	-1.36	-1.62	-1.09	-1.72	-3.04*	-1.70	-1.29	-1.27	-2.05	-1.69	-1.23

APPENDIX 7.4a

SIGNIFICANT EFFECTS AND SIGNIFICANT MODELS OF SENSORY ATTRIBUTES, MOISTURE AND TOTAL COUNT IN STORAGE by 'Yates Analysis'

Attributes		Significant MOdels
Sweet:	AF	$\hat{Y}(D9) = 2.63 - 0.28\ X_1$
		$\hat{Y}(D21) = 2.50 - 0.20\ X_2$
Rancid:	PP	$\hat{Y}(D9) = 1.60 + 0.25\ X_1$
		$\hat{Y}(D14) = 2.00 + 0.35\ X_1$
		$\hat{Y}(D21) = 1.95 + 0.20\ X_1 - 0.20\ X_1X_2$
	AF	$\hat{Y}(D14) = 1.63 + 0.35\ X_1$
		$\hat{Y}(D21) = 2.00 + 0.45\ X_1 + 0.25\ X_2$
Dry:	PP	$\hat{Y}(D5) = 2.55 + 0.45\ X_1$
		$\hat{Y}(D14) = 2.85 + 0.35\ X_1$
		$\hat{Y}(D21) = 2.80 + 0.30\ X_1$
	AF	$\hat{Y}(D9) = 2.88 + 0.28\ X_1$
		$\hat{Y}(D14) = 2.55 - 0.50\ X_1$
Hard:	PP	$\hat{Y}(D5) = 2.45 + 0.55\ X_1$
		$\hat{Y}(D14) = 2.63 - 0.48\ X_2$
		$\hat{Y}(D21) = 2.45 + 0.45\ X_1$
	AF	$\hat{Y}(D14) = 2.55 + 0.45\ X_1$
		$\hat{Y}(D21) = 2.78 + 0.38\ X_1$
ACC:	PP	$\hat{Y}(D5) = 3.60 - 0.25\ X_1$
		$\hat{Y}(D9) = 3.30 - 0.30\ X_1$
		$\hat{Y}(D14) = 3.20 - 0.5\ X_1$
		$\hat{Y}(D21) = 3.00 - 0.35\ X_1$

Appendix 7.4a: Continued

Attributes		Significant MOdels
	AF	$\hat{Y}(D5) = 3.23 - 0.28\ X_1$
		$\hat{Y}(D9) = 3.28 - 0.38\ X_1$
		$\hat{Y}(D14) = 3.40 - 0.30\ X_1$
		$\hat{Y}(D21) = 3.05 - 0.45\ X_1$
MC:	PP	$\hat{Y}(D14) = 9.97 + 0.24\ X_1$
		$\hat{Y}(D21) = 9.76 + 0.32\ X_2$
	AF	$\hat{Y}(D14) = 9.73 - 0.16\ X_1 - 0.18\ X_1X_2$
		$\hat{Y}(D21) = 9.67 + 0.37\ X_2$
TPC:	PP	$\hat{Y}(D5) = (2.8 \times 10^3) - (1.9 \times 10^3)\ X_1$
		$\hat{Y}(D14) = (4.6 \times 10^3) - (0.9 \times 10^3)\ X_1 + (0.9 \times 10^3) X_1X_2$
		$\hat{Y}(D21) = (4.1 \times 10^3) + (0.8 \times 10^3)\ X_2$
	AF	$\hat{Y}(D5) = (0.9 \times 10^3) + (0.7 \times 10^3)\ X_2$
		$\hat{Y}(D14) = (3.05 \times 10^3) - (0.95 \times 10^3)\ X_1$
		$\hat{Y}(D21) = (2.85 \times 10^3) + (1.3 \times 10^3)\ X_1 + (1.7 \times 10^3)\ X_2$

Notes: 1. Y = Predicted Attribute; D = Day; X_1 = Temperature; X_2 = Relative humidity

2. ( ) = Significant by 'Estimate' used in this study

APPENDIX 7.4b

SIGNIFICANT EFFECTS AND SIGNIFICANT MODELS OF SENSORY ATTRIBUTES MOISTURE AND TOTAL COUNT IN STORAGE by STEPWISE REGRESSION

Attributes		Significant Models
Sweet	AF	$\hat{Y}D9^{*} = 3.602 - 0.027 X_1$
		$\hat{Y}D21^{**} = 4.200 - 0.020 X_2$
Rancid	PP	$\hat{Y}D9^{**} = 0.698 + 0.0003 X_1X_2$
		$\hat{Y}D9^{**} = 0.345 + 0.005 X_2 + 0.0003 X_1X_2$
		$\hat{Y}D14^{*} = 0.722 + 0.0004 X_1$
	AF	$\hat{Y}D14^{*} = 0.528 + 0.0004 X_1X_2$
		$\hat{Y}D21^{*} = 0.305 + 0.0005 X_1X_2$
Dry	PP	$\hat{Y}D5^{*} = 1.005 + 0.045 X_1$
		$\hat{Y}D5^{*} = 1.005 + 0.082 X_1 - 0.0004 X_1X_2$
		$\hat{Y}D14^{*} = 1.615 + 0.035 X_1$
		$\hat{Y}D21^{*} = 1.790 + 0.030 X_1$
	AF	$\hat{Y}D14^{**} = 0.717 + 0.0006 X_1X_2$
		$\hat{Y}D14^{*} = 0.375 + 0.0047 X_2 + 0.0006 X_1X_2$
Hard	PP	$\hat{Y}D5^{**} = -6.690 + 0.310 X_1 + 0.085 X_2 - 0.003 X_1X_2$
	AF	$\hat{Y}D14^{**} = 0.971 + 0.0005 X_1X_2$
		$\hat{Y}D14^{*} = 1.005 - 0.0063 X_1 + 0.0006 X_1X_2$
		$\hat{Y}D21^{*} = -7.776 + 0.271 X_1 + 0.109 X_2 - 0.003 X_1X_2$
ACC	PP	$\hat{Y}D9^{**} = 4.35 - 0.03 X_1$
		$\hat{Y}D9^{*} = 3.925 - 0.03 X_1 + 0.005 X_1X_2$
		$\hat{Y}D9^{**} = 2.438 + 0.012 X_1 + 0.022 X_2 - 0.0005 X_1X_2$
		$\hat{Y}D14^{**} = 4.97 - 0.05 X_1$
	AF	$\hat{Y}D9^{*} = 4.633 - 0.038 X_1$
		$\hat{Y}D21^{*} = 4.496 - 0.0005 X_1X_2$
MC	PP	$\hat{Y}D14^{*} = 9.152 + 0.024 X_1$
	AF	$\hat{Y}D5^{**} = -7.836 + 0.565 X_1 + 0.189 X_2 - 0.006 X_1X_2$
TPC:	PP	$\hat{Y}D21^{*} = -2840 + 80 X_2$
	AF	$\hat{Y}D5^{*} = -4966 + 71.25 X_2$
		$\hat{Y}D14^{**} = 6385 - 95 X_1$
		$\hat{Y}D14^{*} = 5535 - 95 X_1 + 10 X_2$
		$\hat{Y}D14^{*} = 2560 - 10 X_1 + 45 X_2 - 1 X_1X_2$

Notes:

1 $\hat{Y}$ = Predicted attributes; D = Day; X_1 = Temperature; X_2 = Relative humidity

2 * = Significant at 95% level

** = Significant at 99% level

APPENDIX 7.5a

1ST SET DATA FOR SHELF-LIFE ESTIMATION: 75% RH; 25, 35, 45°C

Time (days)	25°C	35°C	45°C	25°C	35°C	45°C	25°C	35°C	45°C	25°C	35°C	45°C
	Polypropylene Packet						Laminated Aluminium Foil Packet					
	Rancidity			Acceptability			Rancidity			Acceptability		
0	1.3	1.3	1.3	4.2	4.2	4.2	1.3	1.3	1.3	4.2	4.2	4.2
5	1.3	1.3	1.5	4.0	3.8	3.2	1.0	1.7	1.5	3.7	3.8	2.7
9	1.2	1.3	1.7	3.5	3.5	3.0	1.3	1.2	1.8	3.5	3.2	2.8
14	1.5	2.3	2.2	3.7	3.0	2.7	1.3	1.8	1.8	3.7	3.5	3.0
21	1.5	2.0	2.3	3.7	3.2	2.5	1.3	1.8	2.2	3.7	3.5	2.7
			(2.5)* 32 days									
35	(1.6)	(2.3)	(2.6)	(3.5)	(2.9)	(1.9)*	(1.4)	(1.6)	(2.5)*	(3.5)	(3.3)	(2.2)
												(1.9)* 38 days
42	(1.7)	(2.4)		(3.3)	(2.6)		(1.5)	(1.8)	(2.8)	(3.3)	(3.1)	(1.7)
50	(1.8)	(2.5)*		(3.1)	(2.3)		(1.6)	(2.0)		(3.1)	(2.9)	
					(1.9)* 60 days			(2.5)* 68 days				
71	(2.1)			(2.5)			(1.9)	(2.6)		(2.5)	(2.3)	
											(1.9)* 85 days	
92	(2.4)			(1.9)*			(2.2)			(1.9)*	(1.7)	
99	(2.5)*						(2.3)					
							(2.5)* I13 days					

( ) = days extrapolated from the actual data

( )* = days at 'reject point'

APPENDIX 7.5b

2ND SET DATA FOR SHELF-LIFE ESTIMATION: 95% RH; 25, 45°C

Time (days)	25°C	45°C	25°C	45°C	25°C	45°C	25°C	45°C
	Polypropylene Packet				Laminated Aluminium Foil Packet			
	Rancidity		Acceptability		Rancidity		Acceptability	
0	1.3	1.3	4.2	4.2	1.3	1.3	4.2	4.2
5	1.2	1.3	3.7	3.5	1.2	1.2	3.3	3.2
9	1.5	2.0	3.7	3.0	1.5	1.7	3.8	3.0
14	1.8	2.5) 2.25) 0.95	3.7	2.7	1.3	2.2) 2.45) 1.15	3.7) 0.9)	3.2) 1.7)
21	2.0	2.0) 0.32	3.0	2.8	1.8	2.7) 0.38	3.3) 0.3	2.5) 0.57
35	2.4	(2.5)*26 days	(2.2)	(1.9)*28 days	(2.14)	(2.5)*22 days	(2.7)	(1.9)*28 days
42	(2.5)*38 days		(1.9)*40 days		(2.31)		(2.4)	
50					(2.48)*		(2.1)	
							(1.9)*55 days	
71								

( ) = days extrapolated from the actual data

( )* = days at 'reject point'

APPENDIX 7.6a

CALCULATION OF 'k' VALUES : 75% R.H.

Temperature °C	K	Quality No	N	ln (N/No)	=	kt	k (day^{-1})	1/T K^{-1}($x10^{-3}$)
(1) Rancidity : PP								
25	298.15	1.3	2.5	ln (2.5/1.3)	=	k(99)	0.66×10^{-2}	3.35
35	308.15	1.3	2.5	ln (2.5/1.3)	=	k(50)	1.31×10^{-2}	3.25
45	318.15	1.3	2.5	ln (2.5/1.3)	=	k(32)	2.04×10^{-2}	3.14
28	301.15							3.32
(2) Rancidity : AF								
25	298.15	1.3	2.5	ln (2.5/1.3)	=	k(105)	0.62×10^{-2}	3.35
35	308.15	1.3	2.5	ln (2.5/1.3)	=	k(68)	0.96×10^{-2}	3.25
45	318.15	1.3	2.5	ln (2.5/1.3)	=	k(35)	1.87×10^{-2}	3.14
(3) Acceptability : PP								
25	298.15	4.2	1.9	ln (1.9/4.2)	=	k(92)	-0.86×10^{-2}	3.35
35	308.15	4.2	1.9	ln (1.9/4.2)	=	k(60)	-1.32×10^{-2}	3.25
45	318.15	4.2	1.9	ln (1.9/4.2)	=	k(35)	-2.27×10^{-2}	3.14
(4) Acceptability : AF								
25	298.15	4.2	1.9	ln (1.9/4.2)	=	k(92)	-0.86×10^{-2}	3.35
35	308.15	4.2	1.9	ln (1.9/4.2)	=	k(85)	-0.93×10^{-2}	3.25
45	318.15	4.2	1.9	ln (1.9/4.2)	=	k(38)	-2.09×10^{-2}	3.14

APPENDIX 7.6b

CALCULATION OF 'k' VALUES: 95% R.H.

Temperature °C	K	Quality No	N	ln (N/NO)	=	kt	k (day^{-1})	1/T k^{-1} ($x 10^{-3}$)
(1) Rancidity : PP								
25	298.15	1.3	2.5	ln (2.5/1.3)	=	k(38)	1.72×10^{-2}	3.35
35	308.15	not investigated		-		-	-	3.25
45	318.15	1.3	2.5	ln (2.5/1.3)	=	k(26)	2.52×10^{-2}	3.14
28	301.15							3.32
(2) Rancidity : AF								
25	298.15	1.3	2.5	ln (2.5/1.3)	=	k(50)	1.31×10^{-2}	3.35
45	318.15	1.3	2.5	ln (2.5/1.3)	=	k(22)	2.97×10^{-2}	3.14
(3) Acceptability : PP								
25	298.15	4.2	1.9	ln (1.9/4.2)	=	k(40)	-1.98×10^{-2}	3.35
45	318.15	4.2	1.9	ln (1.9/4.2)	=	k(28)	-2.83×10^{-2}	3.14
(4) Acceptability : AF								
25	298.15	4.2	1.9	ln (1.9/4.2)	=	k(55)	-1.44×10^{-2}	3.35
45	318.15	4.2	1.9	ln (1.9/4.2)	=	k(28)	-2.83×10^{-2}	3.14

APPENDIX 7.7

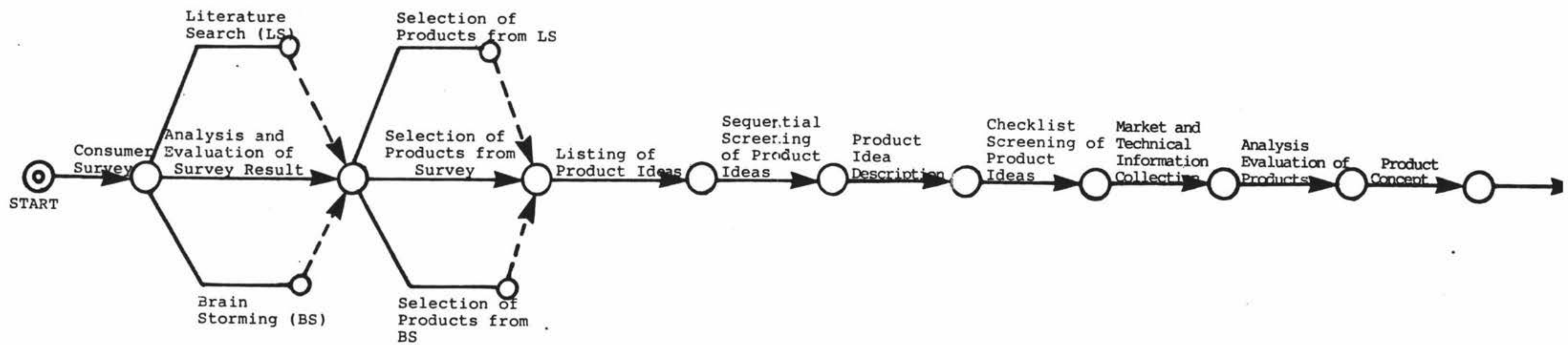
RESULTS OF FURTHER SENSORY INSPECTION OF STORED PRODUCTS

C = Colour; R = Rancidity; A = Acceptable

Storage Conditions °C/%RH	No Visible Mold	Characteristics								
		Day 35			Day 42			Day 50		
		C	R	A	C	R	A	C	R	A
PP 25/75										
25/95										
35/85		x			x	(x)	(x)	x	(x)	(x)
45/75		x	x	x	x	x	x	x	x	x
45/95		x	x	x	x	x	x	x	x	x
35/75						(x)	(x)		(x)	(x)
Room Condition									(x)	
AF 25/75										
25/95										
35/85		x			x			x	(x)	
45/75		x	x	x	x	x	x	x	x	x
45/95		x	x	x	x	x	x	x	-	-
35/75						(x)	(x)		(x)	x
AF=CAN: Cold Room									(x)	

X = obviously increased color intensity or rancid in flavour or not acceptable

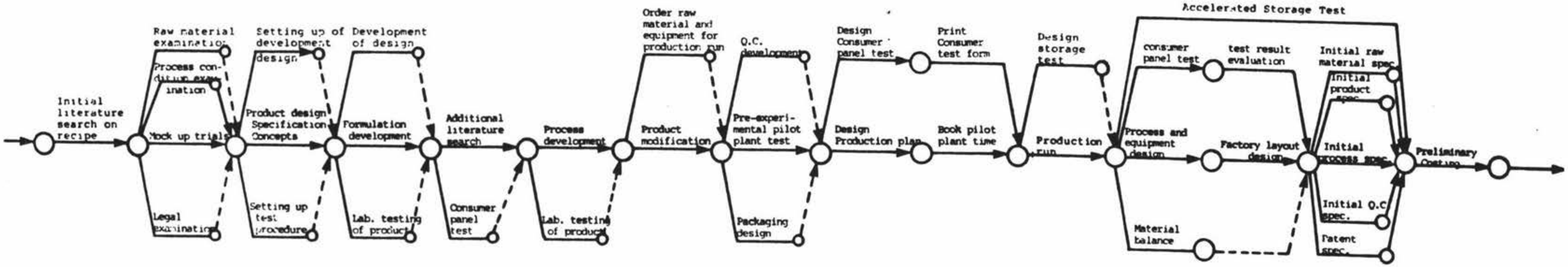
(x) = have trend of the x



APPENDIX 8.1: LOGIC DIAGRAM FOR THE DEVELOPMENT ACTIVITIES OF THE PRESENT NPD PROJECT FOR THAILAND
(Note: 'Market Test' which was excluded in this project is also shown in the diagram for use in complete NPD project)

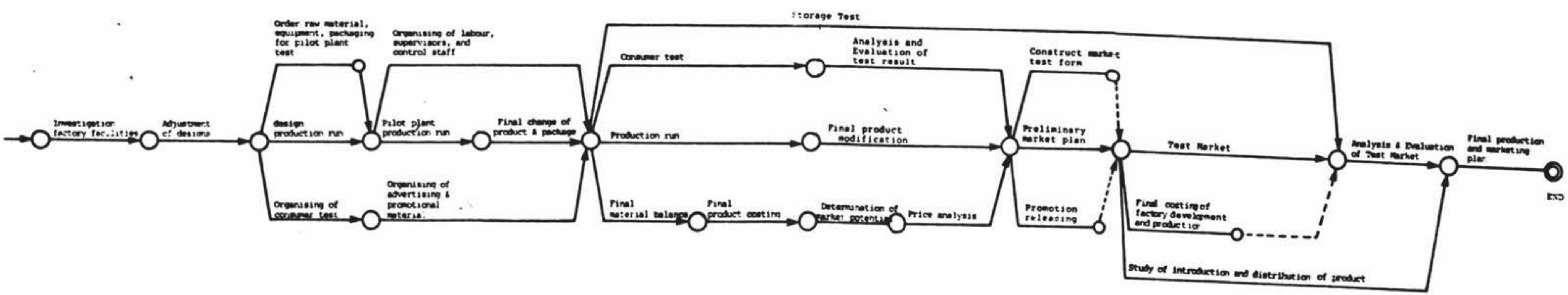
APPENDIX 8.1 (Continued): LOGIC DIAGRAM FOR THE DEVELOPMENT ACTIVITIES OF THE PRESENT NPD PROJECT FOR THAILAND

IN NEW ZEALAND



Appendix 8.1: Continued

IN THAILAND



Appendix 8.1: Continued

APPENDIX 8.2

MATERIAL BALANCE FOR THE BAR PRODUCTION

Material In	Weight	Operation	Material Out	Weight kg
1. Banana in hand	6.70	Peeling 1 h	Peeled Banana Loss (peel)	5.00 (74.6%) 1.70 (25.4%)
Total	6.70		Total	6.70
2. Banana, peeled White sugar Water	5.00 5.00 12.50	Deep-syrup Cooking 4½ h	DSC-banana B-syrup Loss (foam & evaporation)	3.80 (16.9%) 3.40 (15.1%) 15.30 (68.0%)
Total	22.50		Total	22.50
3. Peeled mungbean	10.00	Sorting 3 h	Sorted mungbean Loss (defects, impurities)	9.95 (99.5%) 0.05 (0.5%)
Total	10.00		Total	10.00
4. Sorted mungbean Water	4.00 8.00	Washing 1 sec	Washed mungbean Loss (waste water)	4.52 (37.7%) 7.48 (62.3%)
Total	12.00		Total	12.00
5. Washed munbean Water	4.52 10.00	Boiling ½ h	Boiled mungbean Loss (Evaporation)	8.00 (55.1%) 6.52 (44.9%)
Total	14.52		Total	14.52
6. Boiled mungbean	8.00	Hot-stirring 2 h	Hot-stirred mungbean (in dough form) Loss (evaporation & scorching)	5.40 (67.5%) 2.60 (32.5%)
Total			Total	8.00
7. Mungbean dough	5.40	Evaporation 1 h	BSE mungbean Loss (Evaporation)	4.40 (81.5%) 1.00 (18.5%)
Total			Total	
8. White Sesame Seeds (small size; if large size-no loss)	5.00	Sorting (Screening included) 3 h (if large size: ½ h)	Sorted Sesame Seeds Loss (stone grit, sand, lime grit)	4.90 (98%) 0.10 (2%)
Total	5.00		Total	5.00

APPENDIX 8.2: Continued

Material In	Weight	Operation	Material Out	Weight kg
9. Sorted sesame Seed	3.00	Roasting 25 min	Roated Sesame Seeds Loss	2.88 (96%) 0.12 (4%)
Total	3.00		Total	3.00
10. Peanuts	10.00	Sorting 1 h	Sorted peanuts Loss	9.98 (99.8%) 0.02 (0.2%)
Total	10.00		Total	10.00
11. Sorted Peanuts	3.00	Roasting 35 min	Roasted Peanuts Loss (Evaporat-ion	2.90 (96.7%) 0.10 (3.3%)
Total	3.00		Total	3.00
12. Roasted Peanuts	2.90	Skinning 15 min	Skinned Roasted peanuts Loss (skin)	2.80 (96.6%) 0.10 (3.4%)
Total	2.90		Total	2.90
13. G-syrup B-syrup	0.375 0.375	Warming in boiled water	Hot GB-syrup Loss(evaporation)	0.75 (100%) 0.00 (0%)
Total	0.750		Total	0.75
14. Ascorbic Acid Riboflavin Vitamin A Folic Acid	0.220 0.005 0.060 0.005	Mixing min	Vitamin mix Loss (sticking to bowl)	0.278 (96%) 0.012 (4%)
Total	0.290		Total	0.290
15. BSE mungbean Hot GB-syrup Vitamin Mix	1.250 0.750 0.029	Syrup impreg-nation of BSE mungbean and vitamin adding	Nutrified mungbean Loss(Evaporation, Scorching 0.15)	1.979 (97.5%) 0.050 (2.5%)
Total	2.029		Total	2.029
16. DCS-banana Nutrified mung R-sesame seeds RS-Peanuts	1.30 2.03 1.00 0.70	Mixing 4 min	Snack-bar mix (or snack dough) Loss(Evaporation)	4.93 (98%) 0.10 (2%)
Total	5.03		Total	5.03

APPENDIX 8.2 (Continued): MATERIAL BALANCE FOR THE BAR PRODUCTION

Material In	Weight	Operation	Material OUt	Weight kg
17. Snack dough	1.08	Pressing & Cutting and Packaging	Snack bars in packets	1.05 (97.2%)
			Loss(Evaporation and losing pieces)	0.03 (2.8%)
Total	1.08		Total	1.08

Yield

The yield obtained in the production run could be expressed in terms of all the ingredients except water present in each major pre-product of each batch as follows:

(1) DSC-Banana

Banana and white sugar used	10.00kg
DSC-Banana and B-syrup obtained	7.20kg

$$\therefore \text{Yield} = \frac{7.2 \times 100}{10.0} = 72\%$$

(2) BSE-Mungbean

Mungbean used	4.00kg
BSE-mungbean obtained	4.40kg

$$\therefore \text{Yield} = \frac{4.4 \times 100}{4} = 110\%$$

(3) R-Sesame Seeds

Sesame seeds used	3.00kg
R-sesame seeds	2.88 kg

$$\therefore \text{Yield} = \frac{2.88 \times 100}{3.0} = 96\%$$

(4) RS-Peanuts

Peanuts used	3.00kg
RS-Peanuts	2.76 kg

$$\therefore \text{Yield} = \frac{2.76 \times 100}{3.0} = 92\%$$

(5) Nutrified-mungbean

BSE-mungbean used	1.25 kg
Hot GB-Syrup used	0.75 kg
Vitamin Mix used	0.029 kg
Nutrified mungbean obtained	1.979 kg

$$\therefore \text{Yied} = \frac{1.979 \times 100}{(1.25 + 0.75 + 0.029)} = 98\%$$

APPENDIX 8.2 (Continued): MATERIAL BALANCE FOR THE BAR PRODUCTION

(6) Snack-bars

DSC-Banana used	1.30
N-mungbean used	1.98
R-sesame used	1.00
RS-Peanuts used	0.70
Snack-bars obtained	4.74 kg

$$\therefore \text{Yield} = \frac{4.74 \times 100}{(1.30 + 1.98 + 1.00 + 0.70)} = 95\%$$

(7) Overall Yield

The overall yield of nutritionally-balanced snack bars was determined for a 5 kg batch production. This was based on raw materials in (including peeling, sorting, roasting, boiling, hot-stirring, evaporating, mixing, pressing process losses). The calcualtion was as follows:

$$\text{Overall Yield} = \frac{\text{Weight of snack bars out} \times 100}{\text{Weight of raw materials* in}}$$

$$= \frac{4.74 \times 100}{\underset{BAN}{1.3} + \underset{BS}{0.375} + \underset{GS}{0.375} + \underset{MUNG}{1.25} + \underset{SES}{1.00} + \underset{PEA}{0.70} + \underset{VIT}{0.029}}$$

$$= \frac{4.74 \times 100}{5.029}$$

$$= 94\%$$

* Raw materials in prepared forms

The major losses occur during the evaporation of water and the separation of inedible parts. The former was desirable because as much water as possible was to be got rid of. The latter was also desirable because inedible parts were to be removed. Losses during sorting and other operation were small but nevertheless quite important in trying to get a maximum efficiency in output. These losses could be minimised by a careful operation especially for those losses through scorching to pan, and by a good quality control practice especially for those losses through impurities.

PROCESS YIELD (from Production Trials)

Unit operation	% Yield
Peeling banana	74.6
Deep-syrup cooking banana (16.9 + 15.1)	32.0
Sorting mungbean	99.5
Washing mungbean	
Boiling mungbean	55.1
Hot-stirring mungbean	67.5
Evaporating mungbean	81.5
Sorting white sesame seeds	98.0
Roasting white sesame seeds	96.0
Sorting peanuts	99.8
Roasting peanuts	96.7
Skinning peanuts	96.6
Warming glucose syrup & banana syrup	100.0
Mixing vitamins	96.0
Syrup-impregnating of BSE-mungbean	97.5
Final mix of all ingredients	98.0
Pressing & cutting & packing	97.2
Overall Yield* (on raw materials in; water excluded)	94.0%

APPENDIX 8.2 (Continued): MATERIAL BALANCE FOR THE BAR PRODUCTION

A note on Yield of DSC-Process for Banana

Batch size : 5 : 5 : 12.5 kg
Banana Sugar Water

DSC-banana obtain	3.75 kg ≃ 3.8 kg	(16.9%)
B-syrup obtain	3.45 kg ≃ 3.4 kg	(15.1%)
Loss (foam & evaporation	15.3 kg	(68.0%)

For each 5 kg batch for mixing:

(1)	The DSC-banana needed	= 1.3
	3 batches for mixing	= 3.9
(2)	The B-syrup needed	= 0.375
	3 batches for mixing	= 1.125
	∴ B-syrup left	= 3.43-1.125
		= 2.3 kg

APPENDIX 8.3

PRELIMINARY RAW MATERIAL SPECIFICATION

Split Peeled Mungbean

Freshly harvested mungbean
(under 3 months of storage)

NAM WA Banana

GLUOY SUAN NONTHABORI
or GLUOY SUAN BAN PAW
27-29% SS or very ripe

White Sesame Seed

Large Size
Freshly harvested (under 3 mos.)

Peanuts

CHOLBURI (Pink skin)
First grade
Freshly harvested (under 3 mos)

White Sugar

Good quality (Pure white grade)

Glucose Syrup

NOG GA YANG Brand
86% SS

Vitamin

Ascorbic Acid	- fine, white crystalline powder - assay = 99.0 - 100.5%
Riboflavin	- yellow to orange-yellow powder - assay = 98.0 - 102.0% (on dry material)
Vitamin A	- Dry Vitamin A acetate, Type 500 - light yellow, fine granular powder - content = min. 500,000 I.U./g
Folic Acid	- yellow to yellowish-orange crystalline powder - assay = 95.0 - 102.0% (on anhydrous material)

Packets

polypropylene film of 0.1 mm thickness
size 11.4 x 11.4 cm^2 (for 1 bar packet)

APPENDIX 8.4

PRODUCT COSTING

(and profit estimation)

MARKET SIZE

52% of the children interviewed were willing to buy the product (34% were not sure, and 14% would not buy) at the medium frequency. Suggestions were made on 'not to use the exact frequency in numbers for younger children', however, this could be estimated based on communication with selected children as follows:

high frequency = every day, every week
medium frequency = every 2 weeks, every month
low frequency = every 2 or 3 months

Since the average amount the 'will buy' children could eat at a time was 2 bars or 90 grams of product, $\frac{52}{2}$ wks x 2 bars = 52 bars or 26 packets (90g size) could be considered as the amount bought per head per year.

According to National Statistical Office of Thailand (1982), app. 10% of 5 million (500,000) of Bangkok populations are children age 7-15 years. Assuming that only 75% of the children who said that they would buy, would actually make the purchase.

Since this is non-special-group product, 2% of the other groups were assumed to be a part of the market potential.

$\therefore$ The total market potential is

$$\left\{\left(\frac{75}{100} \times \frac{52}{100} \times 500{,}000\right) + \left(\frac{2}{100} \times 4{,}500{,}000\right)\right\} \times 26 \times \frac{90}{1000 \times 1000} \text{ tonnes/year}$$

$$= (195{,}000 + 90{,}000) \times 26 \times \frac{90}{1000 \times 1000}$$

$$= 666.9 \simeq 667 \text{ Tonnes/year.}$$

Taking a pessimistic view that the company's share is only 5% of the market potential, then the maximum sales are:

$$\frac{5}{100} \times 667$$

33.4 Tonnes/year.

PRODUCT COSTING

The following items were considered in the costing of the product.

(1) Raw materials
(2) Packaging
(3) Direct operating cost
(4) Indirect operating cost
(5) General factory overhead
(6) Transport cost

The calculation was based on the cost incurred in the manufacture of 33.4 tonnes snack bars per annum. All calculations were done on Thai figures (while app. 13 Bahts = 1 N.Z. dollar).

(1) Raw Material Cost

Raw Materials	Quantity* Tonnes	Cost/Unit ฿/kg	Costs ฿
Banana (NAM WA)	8.95	4.00	35,800
Mungbean	7.59	11.00	83,490
White sugar	1.48(6.68)	12.00	80,160
B-syrup	2.51		
Glucose syrup	2.51	7.65(195/25.5kg)	19,201
White sesame seeds	7.11	23.00	163,530
Peanuts	5.08	20.00	101,000
Vitamin mix	0.00194	1348.34	2,612
	33.4		485,793

* Loss included; detail follows

If yield was only around 94% (at mixing and moulding step) as it was in the production run, then the raw material cost for 33.4 tonnes of product produced is:

$$\frac{฿\ 493{,}383}{.94} = ฿\ 524{,}875$$

APPENDIX 8.4 (Continued): Product Costing and Profit Estimation

Formula for 33.4 Tonnes Product:

	Tonnes	
DSC-Banana	8.684	- Banana 6.68-unpeeled 8.95 White sugar 6.68
BSE-Mungbean	8.350	- Mungbean 7.59 Water
G-Syrup	2.505	
B-Syrup	2.505	
R-Sesame seeds	6.680	- Sesame 7.11
RS-Peanuts	4.676	- Peanuts 5.08
Vitamin Mix	0.00194	Asc. 1.4696kg (370฿/kg) = 543 ฿ Rib. 0.0334kg (1650฿/kg) = 55 ฿ Vit.A 0.4008kg (4696฿/kg) = 1882 ฿ Folic 0.0334kg (3937฿/kg) = 132฿ 2612฿

(2) Packaging Cost

Cost = ฿ 0.12 per packet (฿ 36/300 pkts)

packets/years of sale = $\frac{33.4 \text{ Tonnes}}{90 \text{ gram}}$

= 371,111 packets

Total packaging cost = 371,111 x .12 ฿

= 44,533

5% loss included = $\frac{44,533 \times 105}{100}$

= 46,760 ฿

Label Cost

Cost = 3 ฿/100 labels

= 0.03 ฿/label

Total = 371,111 x 0.03 = 11,133 ฿/year

(3) Direct Operating Cost

(a) Labour cost Assume 10 workers : (1 x 1500) + (2 x 1000) + (7 x 700)

= 8,400 ฿/mo

∴ Labour cost = 8,400 x 12

= 100,800 ฿ per annum

However, this product was to be produced 33.4 Tonnes per year or $\frac{33.4}{52}$ = .642 Tonnes or 642 kg/wk. This could be produced in 2 days of a week (Similar to RIN factory situation, that is it produce GRAYASAHT 2 days a week at 400 kg. a day). Thus, the adjusted labour cost would be:

$$100,800 \times \frac{2}{6} = 33,600 \text{ ฿/year}$$

A Note on current lowest labour rate:

1.	Bangkok, Samutprakarn, Nonthaburi, Nakorn Patom, Ranong, Samutsakorn, Pangnga, Puket	70 ฿ per day
2.	Saraburi, Cholburi, Chiengmai	65 ฿ per day
3.	All the rest	59 ฿ per day

APPENDIX 8.4 (Continued): Product Costing and Profit Estimation

(b) Utilities

Water (assume 2.84 ฿/m^3)	=	฿ 500
Power (assume 1.93 ฿/kw.hr)	=	฿ 2000
Fuel (assume free of charge like RIN)	=	฿ 1000 (transportation charge)
∴ Utility cost	=	฿ 3500
Thus, total direct operating cost	=	฿ 37100

(4) <u>Indirect Operating cost</u>

Assume 10% depreciation rate on equipment and on building

∴ Indirect operating cost = ฿ 2,000

(5) <u>General Factory Overhead</u>

This was taken as 5% of direct costs

∴ overhead cost = ฿ 1,855

(6) <u>Transport Cost</u>

This was estimated at = ฿ 1,000

(7) <u>Tax</u> 10% of the wholesale price of product marketed = ฿ 103,911

(9% for trade tax 1% for local tax)

$\frac{33.4 \text{ Tonnes}}{90 \text{ gm}}$ = 371,111 packets

Wholesale price/packet = $4 \times \frac{70}{100}$ = 2.80 ฿

∴ Wholesale price/year = 371,111 x 2.80 = 1,039,110

10% for tax = 103,911 ฿

Total Cost per annum

		Cost ฿
1.	Raw material cost	506,034
2.	Packaging cost	44,533
	Label cost	11,133
3.	Direct Operating Cost	
	Labour cost	33,600
	Utilities cost	3,500
4.	Indirect operating cost	2,000
5.	General factory overhead	1,855
6.	Transport cost	1,000
7.	Tax	103,911
	Total	707,566

Since 371,111 packets are produced a day

Thus, cost per packet

= 707,566/371,111

= 1.91 ฿/packet

Assume 'turn back' products = 4.5%

∴ Cost per packet

$= 1.91 + \frac{4.5 \times 1.91}{100}$

= 1.91 + 0.09

= 2 ฿

Assume the price for consumer = 4 ฿

General price markup:

Processor ⟶ (10%) Wholesaler ⟶ (20%) Retailer ⟶ Consumer

Thus,

Processor —2.80 ฿→ Wholesaler —3.20 ฿→ Retailer —4 ฿→ Consumer

APPENDIX 8.4 (Continued): Product Costing and Profit Estimation

Thus, profit per packet for the processor:

$= 2.80 - 2.00 = 0.80$ ฿

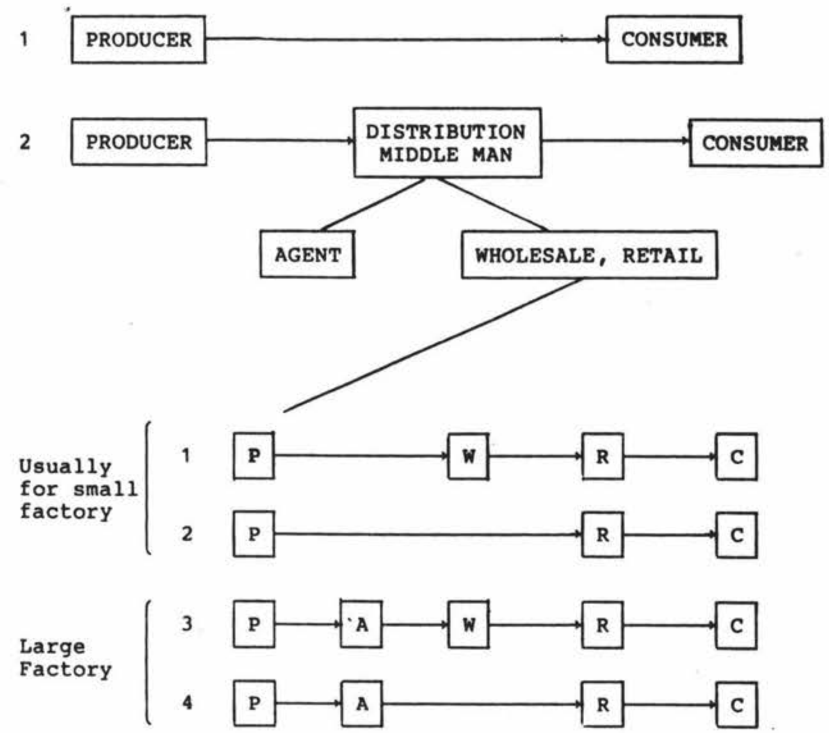
or $= \frac{0.80}{2.80} \times 100 = 28.57\%$

or $\simeq 30\%$ of cost

Note: At the beginning of the commercialization, profit might be lower than the value estimated because during this period there might be more 'turn back' products.

APPENDIX 8.5

DISTRIBUTION CHANNELS IN THAILAND



P = Producer
W = Wholesale
R = Retail
C = Consumer
A = Agency