DEVELOPMENT OF
A MUTTON-BASED PROCESSED MEAT PRODUCT
FOR EXPORT FROM NEW ZEALAND TO THAILAND

A thesis
presented in partial fulfilment of
the requirements for the degree of
Doctor of Philosophy in Product Development
at Massey University

NINNART CHINPRAHAST

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ABSTRACT

There is a need for the development of processed meat products from New Zealand mutton so that marketing of the country's sheepmeats can be diversified and expanded, if possible to new overseas markets. Thailand, a country with a relatively big population, may be one of the importing countries for mutton-based processed meat products from New Zealand. However, there was a possibility that the Thai people might be unlikely to accept the products made from this unfamiliar meat with strong aroma and flavour.

There had never been research into the development of processed meat products made from New Zealand mutton for the Thais. Therefore, this thesis studied whether any product could be made acceptable to the target Thai consumers who were the middle and upper classes in the Bangkok area. The steps of the systematic product development process were followed to guide how such a product could be designed. In brief, the process started from surveying the Thai market for some suitable products, identifying the product (meatballs) to be developed using mutton, development of the formulation in New Zealand, improvement of the formulation in Thailand, and finally it ended with consumer testing of the developed product in the target market in Bangkok.

Different types of sensory panels were used at various stages of the development. These included: a laboratory panel (n=12) in Bangkok to identify important sensory attributes and the ideal profiles of some potential products in the Thai markets, a laboratory panel (n=8) to control the formulation development in New Zealand, a small household consumer panel (n=17) in New Zealand to test for acceptance of the intermediate product made by the selected formulation, a focus group panel (n=6) in Bangkok to optimise the formulation and a 'home use' consumer test panel (n=488) in Bangkok to test whether the final product was acceptable to the consumers.

The success of the development was believed to rely heavily on the formulation process which combined the use of appropriate experimental designs with the sensory evaluation methods. Experimental designs controlled by a laboratory taste panel using the ideal profile technique were used to formulate the meatball product. A mixture design was used to choose the appropriate kinds and levels of meat and meat fat to be mixed with mutton. A full

factorial design studied the texture development varying three ingredients - salt, phosphate and tapioca starch. Empirical equations relating the quantitative characteristics, determined either by subjective tests or objective tests, to the ingredient contents were derived so that the formulation could be directed systematically. A Plackett and Burman design was then used in the flavour development for screening of suitable spices. A quarter fractional factorial design was finally used to study the effects of the six ingredients, i.e. three texture improvers and three spices, on the sensory attribute acceptability of the product. An optimum formulation was selected and tested for acceptance by a small household consumer panel. This intermediate product was not highly acceptable.

A series of focus groups were therefore conducted in Thailand to optimise the formulation. The focus group panels provided valuable information as to how the product could be improved and, as a result, the prototype formulation was obtained and then used in a production trial to make the final product for a consumer test in Bangkok. The consumer test panel played its role at the final stage of this project to identify whether the developed product was acceptable.

The meatball product developed was acceptable to the target Thai consumers. It was believed that the product was successfully made by trimming of the mutton fat to reduce the strong aroma and flavour; this resulted in the high proportion (75%) of mutton which could be used with pork and pork fat (replacing mutton fat). Added ingredients also significantly improved the sensory characteristics of the product. Tapioca starch, sodium tripolyphosphate and particularly salt helped improve the texture and the spices, white pepper, garlic, onion and ginger, helped improve the aroma and flavour.

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CHAPTER 1
GENERAL OVERVIEW

The idea for this research project was to use New Zealand mutton to develop a processed meat product for the Thai people. In this chapter, the need for such a product in Thailand is discussed and the problems of making an acceptable processed meat product from mutton are outlined.

1.1 NEED FOR IMPORTED MEAT IN THAILAND

The problem of adequate protein supply is important for the population in many countries all around the world especially the underdeveloped and developing countries. Altschul (1967) stated that this problem has two parts, i) protein malnutrition and ii) the increasing demand for animal protein concurrent with increasing income in developing countries. Thailand, regarded as a developing country, has both problems.

According to the report prepared by the Sub-Committee for Developmental Planning for Food and Nutrition (1977), the average daily consumption of protein by Thai adults met the acceptable requirement, i.e. 0.9 g protein/kg of body weight. However, protein deficiency in the diets of infants, children and teenagers still existed, particularly for those in remote rural areas and in the slums of Bangkok. Approximately two-thirds of the protein consumed by the Thais is supplied by rice, grains and vegetables which may not provide good quality proteins to support development of the body during the periods which require high amounts of protein, i.e. pregnant women and children from infants to teenagers. Hence, in a product where the protein is contributed by meat, an improvement in good quality protein intake, i.e. providing essential amino acids, can be obtained and the Thais can gain advantage from such a product.

In 1986, meat products were less consumed than cereals and legumes, especially rice the staple food (see Appendix 1.1). Pork was the meat consumed in the largest quantities. Due to the increasing population and the high demand for meat, consumption of pork increased rapidly from 1973-1982 (Figure 1.1, detailed data in Appendix 1.2). Consumption of poultry meat also increased dramatically. However, consumption of beef and buffalo meat decreased significantly in the same period. This might be due to the increasing and very high prices of beef and buffalo meat when compared to that of pork, poultry and fish.

If the Thais wish to consume more red meat, then it will have to be imported, as the local production of beef did not increase during the years from 1982 to 1986 (Figure 1.2, detailed data in Appendix 1.3).

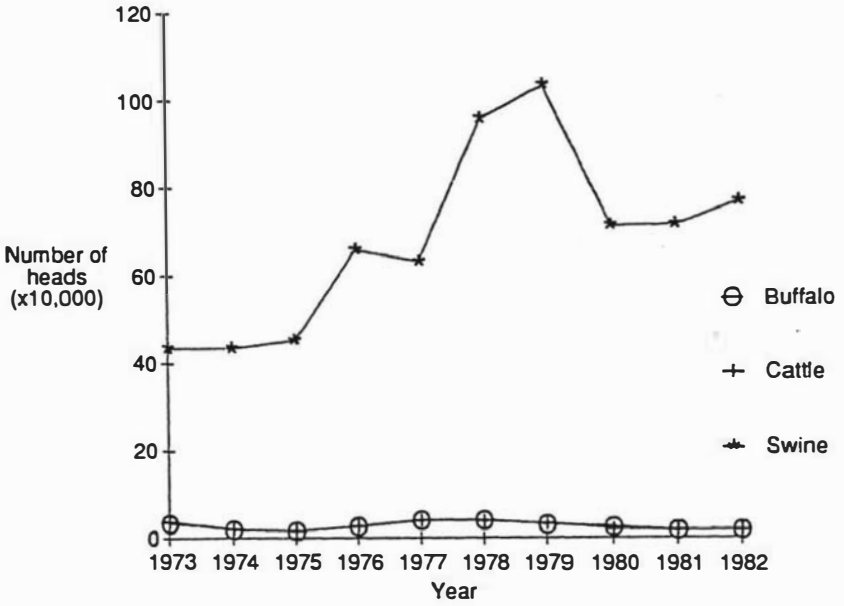


Figure 1.1 Number of buffalo, cattle and swine slaughtered in Bangkok, 1973-1982

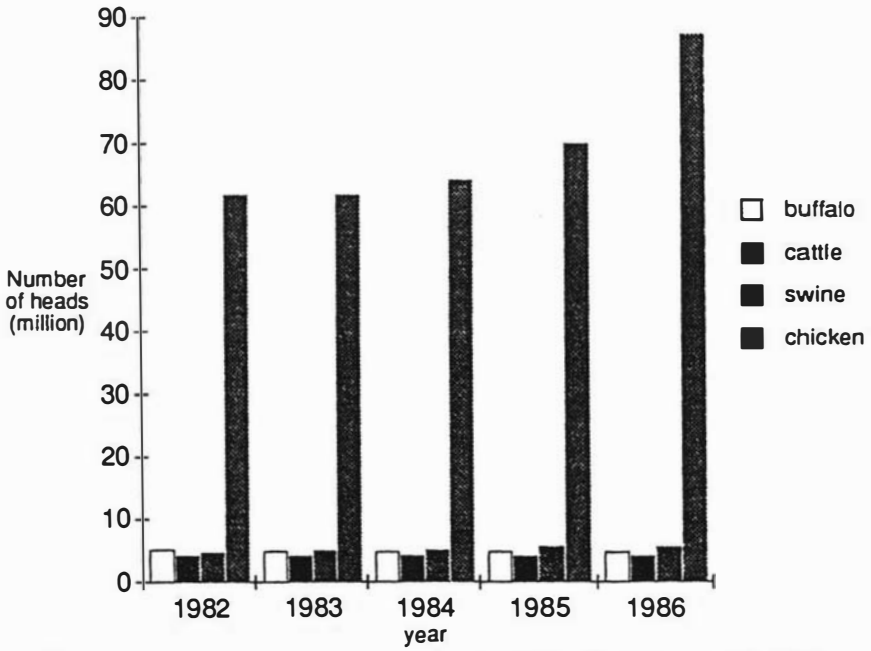


Figure 1.2 Number of buffalo, cattle, swine and chicken in Thailand, 1982-1986

Most of the frozen retail cuts are imported. These include New Zealand, Australian and American beef, lamb and mutton, and are usually consumed by foreigners.

Boneless beef is also imported for use in manufacturing. Sheepmeat could possibly be imported as a boneless meat for manufacturing, or as meat products for the general Thai population in Bangkok.

1.2 NEW ZEALAND SHEEPMEAT PRODUCTION AND EXPORTING

New Zealand has long been recognised as one of the major meat exporting countries. In particular, New Zealand is one of the major exporters of sheepmeats in the world. However, since the start of this project, the amount of sheepmeats produced and exported has, in general, decreased (see Table 1.1).

Table 1.1 Total New Zealand sheepmeat production and sheepmeat available for export, 1985-1987 (in thousand tonnes, bone in)

	1985	1986	1987
Total sheepmeat production			
lamb	500.9	464.7	407.3
mutton	227.4	146.7	199.0
Sheepmeat available for export			
lamb	491.0	445.4	392.6
mutton	160.8	83.3	123.0

Source: New Zealand Meat Producers Board (1986, 1987), 64th and 65th Annual Reports

It is obvious that the total sheepmeat production and the quantity of sheepmeat available for export dropped from the year 1985 to 1987 because of market difficulties and low prices. New Zealand normally exports sheepmeats as chilled or frozen lamb carcasses, mutton carcasses, lamb and mutton cuts and boneless mutton. Therefore, if new overseas markets could be established for sheepmeats or if sheepmeats could be used in production of processed meat products for export, New Zealand would earn substantially increased income from overseas trading.

Mawson (1985) stated that a number of commercial developments in the marketing of New Zealand sheepmeats had been established. These involved supplying both mass and specialty markets. The mass market for processed sheepmeat was required in the short term and could absorb the volume of meat from the former carcass commodity trade, but it should not be pursued as the permanent solution to sheepmeat marketing problems to the exclusion of specialty market development. Specialty market development offered the

potential for greater returns per unit raw material and, in spite of the greater difficulties in pursuing these markets and the possibility of high risk of failure, the effort should be made. In conclusion, the author suggested that specific techniques for the use of sheepmeats in processed products would have to be developed within the New Zealand meat and food industry.

1.3 NEW ZEALAND SHEEPMEAT EXPORTS TO THAILAND

Thailand has not been a major importing country for New Zealand's sheepmeats when compared to Singapore or Malaysia (see Table 1.2).

Table 1.2 Sheepmeat exports from New Zealand to ASEAN countries, 1985-1987 (in tonnes)

	Lamb			Mutton		
	1985	1986	1987	1985	1986	1987
Thailand	23	33	41	11	1	-
Philippines	9	10	1	-	-	-
Brunei	1	-	5	17	-	-
Indonesia	78	87	111	1	-	16
Malaysia	497	448	517	2371	2137	291
Singapore	936	909	935	637	796	272

Source: New Zealand Meat Producers Board (1987), 65th Annual Report

Sheepmeats are imported into Thailand normally as frozen cuts or boneless meat. There was not any processed sheepmeat product from New Zealand in the Thai markets at the beginning of this project which started in late 1984.

1.4 POSSIBLE MUTTON MEAT PRODUCTS FOR THAILAND

Fresh meat is normally used as raw material in Thai day-to-day cooking. However, there are some processed meat products being sold in the markets. These products may be categorised according to the methods of preservation as follows:

* dehydrated products such as shredded and dried pork (pork floss),sliced and dried spicy beef;
* cooked products, preserved by using additional methods of preservation, chilling or freezing, such as sausages (Western style: bologna, cocktail, vienna, frankfurter, salami; Thai style: moo yor), meatballs, bacon and ham;
* fermented products such as nam and sai krok priew;
* canned products such as beef curry, beef stew.

Furthermore, chilled or frozen retail meat cuts and beef patties also can be found in Thai supermarkets especially in the Bangkok area.

Mawson (1985) stated that the manufactured meat products which could be made from sheepmeats are limited only by the creativity and enthusiasm of the product development and marketing team. He suggested possible products for export:

* Sheepmeat in combination with non-meat ingredients: burgers, sandwiches, pizzas, filled tacos and pita breads, ethnic takeaways, pies, sausage rolls, hot dogs, corn dogs, prepared meals.
* Sausage products, especially dried, fermented and dried, products where sheepmeats offer functional advantages during processing.
* Ham products: lamb and mutton hams, bone-in or boneless, green, cooked or dried, or highly extended with non-meat protein.
* Roast meats: bone-in or boneless, smoked, flavoured, sliced with gravy.
* Restructured meats: sectioned and formed, chunked and formed, flaked and formed, cured, raw, precooked, flavoured, roasts, steaks, chops, schnitzels, fingers, balls, dices, battered and breaded.

Traditionally, sheepmeats have found limited use in processed meats, but no fundamental technical reasons exist for not finding greater application in these products. Sheepmeats may not be the easiest meats to market, but there are worldwide opportunities for them. An example, in ASEAN (Association of South East Asian Nations), is Singapore which has consumed processed sheepmeat products from New Zealand (Berryman, 1985).

1.5 REASONS FOR DEVELOPING A MUTTON-BASED PROCESSED MEAT PRODUCT FOR THE THAIS

From an investigation by the author, there were some basic ideas supporting development of a mutton-based processed meat product for Thai people.

* A need for imported red meat.
* A lack of New Zealand sheepmeat exports to Thailand.
* There were not yet any processed meat products made from mutton in the Thai markets at the time when this research started in late 1984. The imported mutton either from New Zealand or other countries chiefly included frozen boneless mutton or mutton cuts and were normally consumed by foreigners. Mutton, in spite of having inferior functionalities for processing requirements in processed meat products, may be blended with other kinds of meat or used with modification to produce processed meat products with required sensory attributes.
* The exporting trend of New Zealand's sheepmeats, especially mutton, has declined in the past few years. A surplus amount of mutton may be confronted in the future. If

mutton can be used for production of processed meat products, the market for sheepmeats, could expand in the ASEAN region, from the Singapore market to other markets such as Thailand.

* Mutton, as one kind of meat, may be regarded as a nutritional food and a source of good quality protein. Mutton is a good source of essential amino acids and, to a lesser extent, of certain minerals. Therefore, a mutton-based processed product can provide proteinaceous food for the Thai people.
* Conventional ways of living for some Thais have been changing in recent years. These people are absorbing the styles of living of the people in the western world. They go to supermarkets or groceries to buy every-day-needed foods and also buy some convenience foods instead of buying fresh foods and spending time cooking every-day meals. Therefore, if processed meat products made from mutton could be easily prepared for consumption, they may suit the needs of this type of Thai consumer.

The major reason against a mutton product is that mutton has a strong flavour which is not familiar to the Thais who may consider this flavour as disagreeable or obnoxious. There ought to be some possibilities for disguising mutton flavour if some processed meat products are made suitable for the Thai palates.

Therefore, there were some reasons why a processed meat product using New Zealand mutton should be developed for the Thai consumers, especially the middle and upper classes in Bangkok who buy processed meat products from supermarkets. To develop such a product successfully, a product development process should be closely followed. In addition, since mutton, a major raw material used in this research, was not familiar to the Thai people, inputs from the consumers were also important in guiding the development of an acceptable product in terms of its sensory attributes.

CHAPTER 2
PRODUCT DEVELOPMENT AND THE PROJECT

This chapter discusses the product development process and consumer inputs used in the product development process. The method of product development used in this research is outlined and the overall aim and objectives of the project are also defined.

2.1 PRODUCT DEVELOPMENT AND CONSUMERS

Product development is the applied industrial research which exploits knowledge in the basic sciences of chemistry, physics, and mathematics with knowledge in the social sciences in order either to produce new products or to modify existing products for a market. As it has become an increasingly important activity in industry, due to a competitive and changing environment, so too has the research into developing and refining the techniques for product development. The product development process can be utilised in many different situations. In the least complicated situation, the product is developed for a local market and for only one target market segment. However, there are more complicated situations which may involve the following factors:

* a necessity for the product to be acceptable to a specific group of consumers who may be unacquainted with raw materials or ingredients in the product,
* introduction of new technology either in processing or packaging,
* conforming to governmental regulations, and safety standards.

This thesis was a study of the product development process in an extraordinary situation. The project was the development of a mutton-based processed meat product acceptable to Thai consumers, who belong to the middle and upper classes in the Bangkok area, and who are not accustomed to mutton odour and flavour.

2.1.1 Food Product Development

Although the principles of product development can be applied to different industries, there are specific requirements in the food industry which may be different from other industries. These may include seasonality and properties of raw materials, special dietary needs, restrictions imposed by food regulations, the microbiological standards of food and the great differences in food acceptability between specific groups of consumers, especially for those with different ethnic backgrounds and cultures. In this project, the focus was on food product development, albeit many of the techniques used were also relevant to product development in other industries.

Wilkinson (1985) pointed out that systematic food product development is even more important now than thirty years ago when the number of food products for sale was small in comparison with today. At Massey University, there has been a continuing programme of research into systematic and quantitative methods for new food product development, initiated by Dr. W. Edwardson in 1969 (Anderson, 1975). Earle (1985) outlined the product development system which was partly used as a guideline for this project (see Figure 2.1).

In this project, the aim was only to develop an acceptable product, not to launch the product on the market. Therefore only the early stages of this product development process were used, that is "Definition of Project Aims" to "Final Evaluation of Marketing and Production".

2.1.2 Consumer Inputs in Product Development

The fate of a newly developed food product has always been dependent on acceptance by the consumers, therefore formal studies of consumer preference are needed to identify whether that product will survive in competition for the consumers' food money. Traditionally, in food product development, input from consumers was considered necessary at three major stages. These were the initial market research, sensory testing and the final market test (Lai, 1987). However, due to the nature of the major raw material, mutton, used in this study, input from consumers was extensively studied in the sensory testing stage.

Sensory evaluation, using various types of consumers, is an essential tool in food product development. Both consumer preference panels and a laboratory type sensory panel have been used by investigators in order to attain a measure of the probable relative acceptance of products having varying degrees of differences. There has been considerable research on the reliability of these two methods of sensory testing. Peryam and Haynes (1957) stated that the various types of testing of foods could be classified according to whether testing was done in "artificial" or "natural" situations. The "artificial" situations covered laboratory testing under controlled conditions whereas the "natural" situations included those which were more related to actual conditions of consumption. The laboratory method can frequently be used for selection or rejection of food items. Nevertheless, there has been a tendency not to rely only on laboratory results but to require additional testing in the field using the representative consumers in the population of interest. Amerine et al. (1965) pointed out that laboratory or expert panels were used to determine the differences between samples, and the direction of differences while consumer panels were used to evaluate the acceptance or preference of foods. Dethmers (1968) also noted that the use of experienced laboratory judges to determine direction of preference appeared to be valid. Sather (1968) concluded that although there was some indication that the home panel had a slightly greater ability to detect flavour differences, generally both home and laboratory panel results were in good agreement.

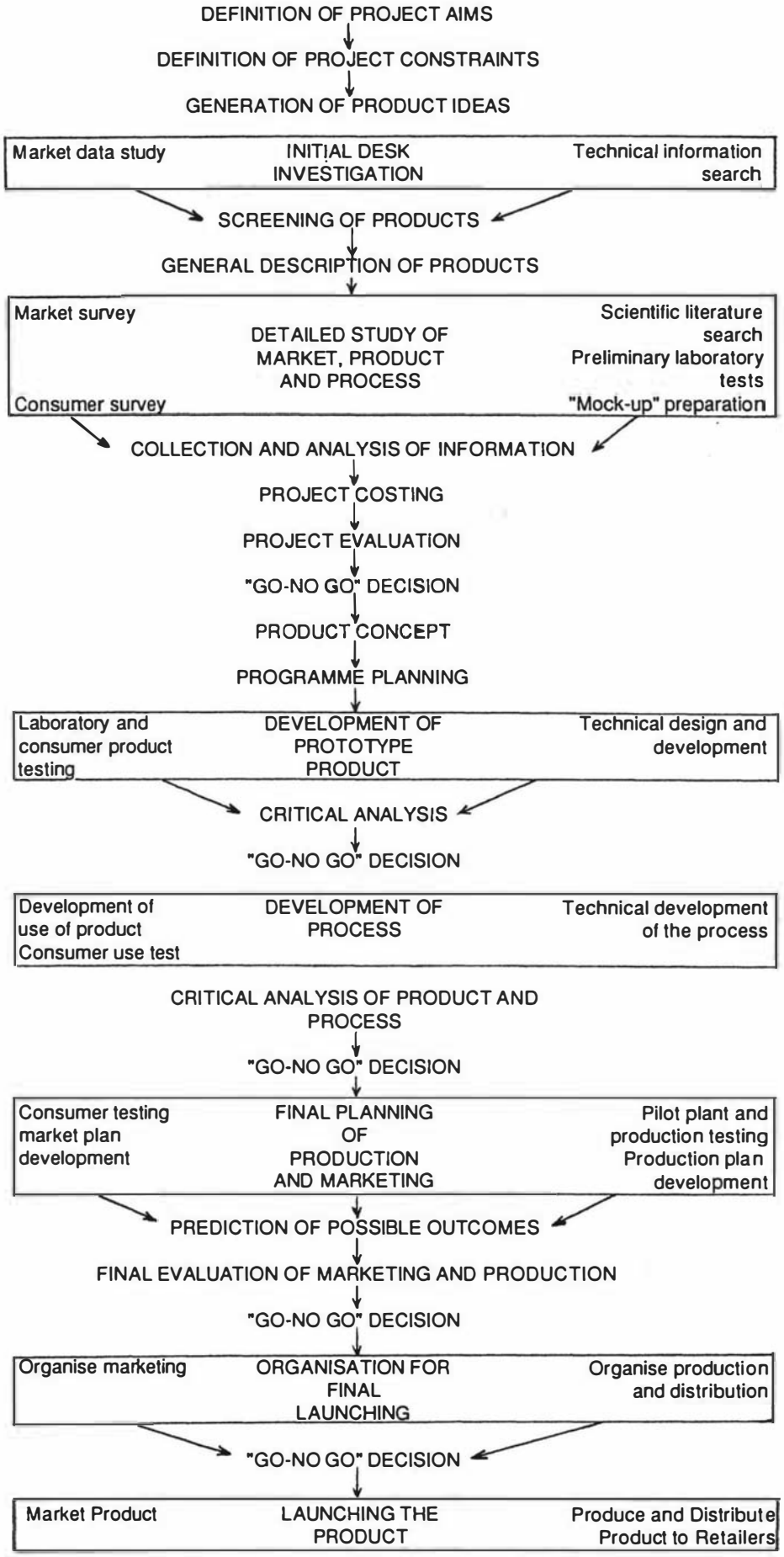


Figure 2.1 A systematic process for product development

Gatchalian (1981) referred to Martin (1973) and Stone and Sidel (1978) as considering consumers as naive, not even capable of performing simple sensory evaluation tasks. She noted that consumers are untrained evaluators who based their judgement mainly on their own feelings and perceptions. The consumer impressions and judgement may be entirely different from those of trained laboratory panelists (Cross et al., 1978; Klemmer, 1968 and Pangborn and Russell, 1976). Moskowitz (1985) characterised expert and consumer panels for product research noting that while market researchers work absolutely with consumers, sensory analysts have preferred to use expert panels. The author also stated that with the growing sophistication of product developers and the increasing interest of market researchers in the early stages of the product development process, guidance by consumer panels has frequently replaced the more traditional expert panels.

Gatchalian (1981) outlined the flow of product development activities which involves judgements from a small expert panel, to a group of laboratory panelists and then to untrained individuals, possibly belonging to the manufacturing firm or to a group of people known to represent the potential consumers. Afterwards, the flow involves two types of consumer acceptance tests known as the field and home-use tests. Finally, the results are analysed and later used as the basis for the manufacturer's decisions either to produce the product on a commercial scale or to make further improvements for increased product acceptance (see Figure 2.2).

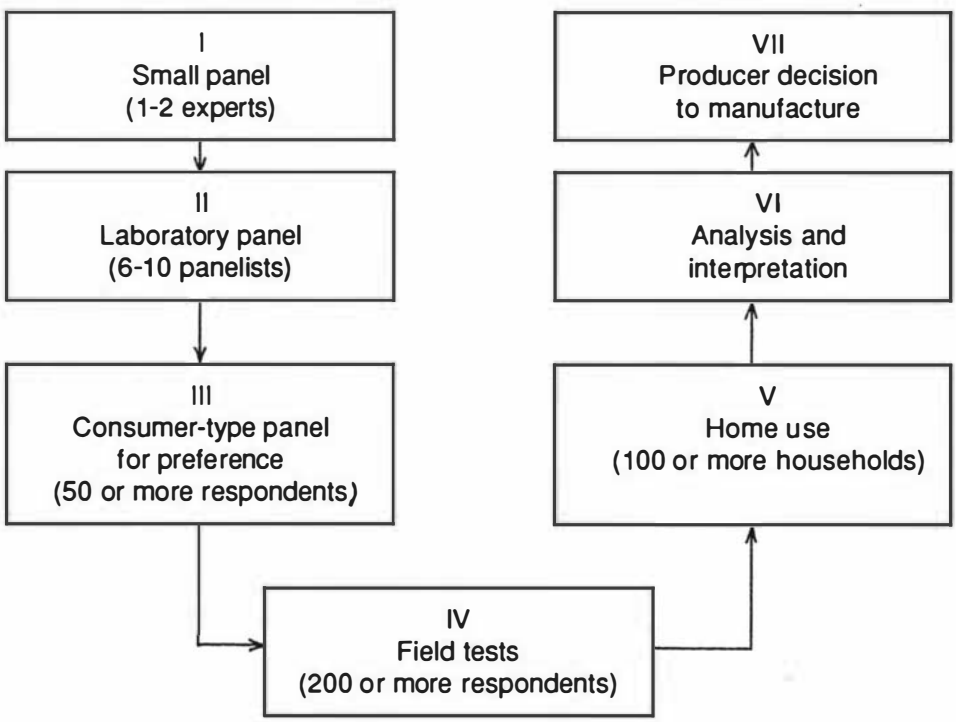


Figure 2.2 Product development and acceptance test flow

Anderson (1981) gave an example of the application of consumer panels throughout the full course of the product development process which demonstrated the relative importance of accurate information and of panel size (see Figure 2.3).

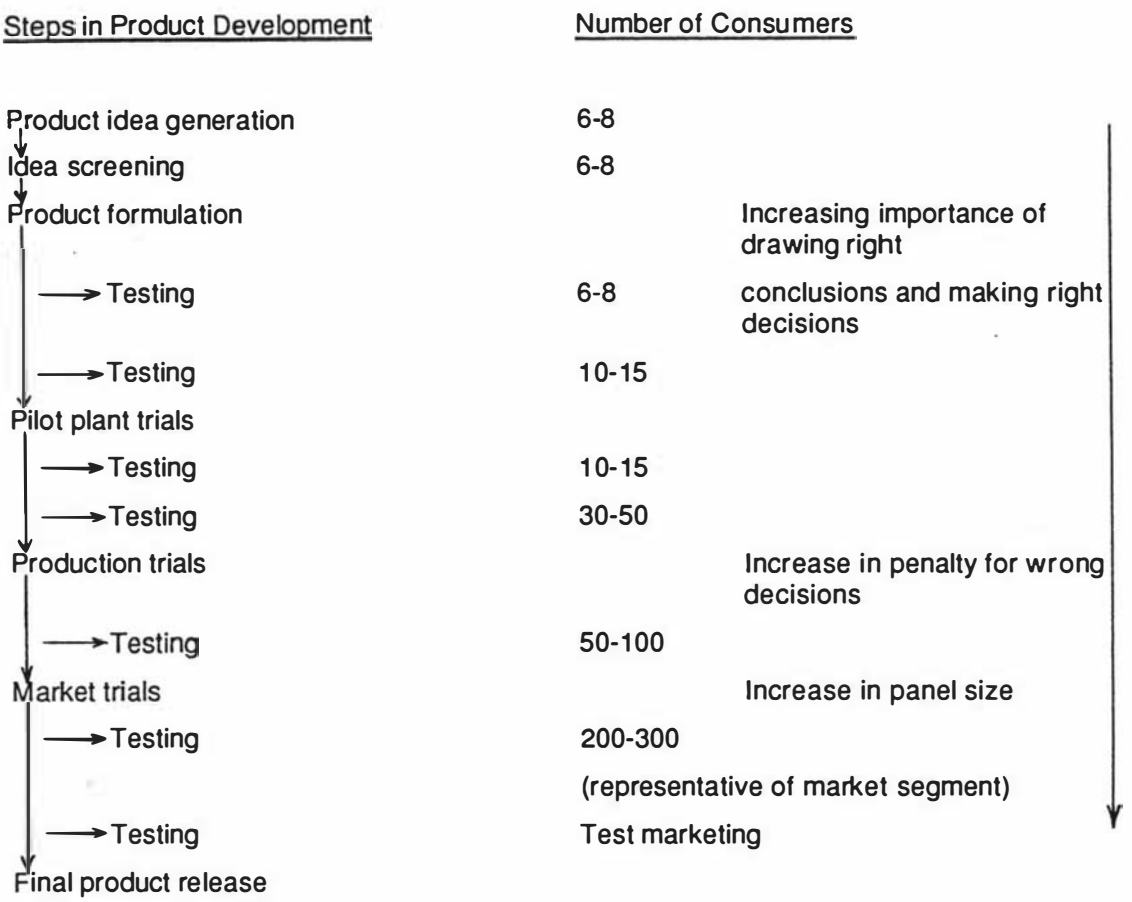


Figure 2.3 Consumer panels in product development (adapted from Anderson, 1981)

As the product development process proceeds towards the final launching of the new product, so the importance of correct decision-making increases. The penalty or cost of a wrong decision increases with every step of the process, and accordingly panel size should increase.

Consumer panel definitions as regarded by Anderson (1981) broaden, from a small group of 6 to 10 consumers gathering around a table for an informal discussion about some new product concepts to the full scale consumer survey of several hundred people to evaluate the potential of a new product formulation. Ideally the consumer panel should be a statistically random representation of the entire market segment or population of interest. However, this ideal condition is rarely fulfilled since it will normally involve a large number of consumers and result in high costs and considerable delays in data collection and analysis. Under these circumstances a trade-off will usually be made between the cost and speed of data collection and the accuracy of the results.

Earle (1981) stated that selection of a consumer panel depended on the market, for example, housewives for the general food market, teenagers for snack foods, restaurant and hotel managers and cooks for catering foods, food processors for processing raw materials. The author also noted that in choosing a consumer panel

* it must be representative of the people in the market,
* the panel must not be more knowledgeable than the other consumers and
* the panel must not be biased in any way.

Training of a consumer panel should be minimal. It is the spontaneous reaction from the consumer that is wanted, so training is only on how to fill in forms or the other mechanics of the test.

2.2 THE METHOD OF PRODUCT DEVELOPMENT IN THE PROJECT

The stages of the product development process used in this project are shown in Figure 2.4.

Country	Project Stage	Types of Consumer Input and Sensory Methods Used
	STAGE I IDENTIFYING THE PRODUCT	
Thailand	Preliminary identification of some potential products by a market survey and preliminary experiments concerning these products	Laboratory panel using ideal profile testing
New Zealand	Idea generation of the mutton-based products with added flavours for Thai consumers	Idea generation by small consumer panel using brainstorming
New Zealand	Screening of the product ideas	Screening techniques supported by ranking with small consumer panel
	STAGE 2 DEVELOPMENT OF THE PRODUCT	
New Zealand	Preliminary formulation of the selected product	Laboratory panel using triangle testing, descriptive category scaling and ideal profile testing
	STAGE 3 TESTING OF THE PRODUCT	
New Zealand	Testing of the optimum product from the formulation process	Household consumer panel using hedonic scaling
Thailand	Optimisation of the formulation to improve the product's attributes	Focus groups using ideal profile testing
Thailand	Production trial, consumer testing by household distribution	Consumer test panel using hedonic scaling

Figure 2.4 Stages of product development process and consumer inputs using sensory evaluation in the research project

The project started in Thailand with an initial market survey and preliminary experiments to identify some potential processed meat products. The survey revealed some product ideas with good potential.

The next stage was the generation by a brainstorming group of flavour variations of the product ideas suitable for Thai consumers. A large number of ideas were generated. Qualitative and quantitative screening techniques were then used to reduce the number of ideas. The final product was selected for development.

A systematic formulation method, using experimental designs, was used to formulate the product. The selected optimal formulation was tested using a household consumer panel of Thais. The results revealed that the sensory characteristics of the product made by the selected formulation were not highly acceptable.

In Thailand, consumer input using focus groups was therefore employed to investigate how to alter the formulation and optimise the product's sensory attributes. The prototype formulation obtained was used in a production trial. Finally, to evaluate the acceptability of the product, consumer testing was done by distributing the final product to the target consumers in the Bangkok area.

The importance of consumer input was highly recognised and it was therefore incorporated at various stages of development of the product in this study. Sensory evaluation, using different types of consumer panels, was utilised to help in guiding the development of the product until it was acceptable to the Thai consumers. Four major types of sensory panels were used to achieve the important goal of this study. The laboratory panel helped to create the preliminary formulation of the product. The household consumer panel helped to determine whether the product made by the selected optimal formulation was acceptable to the Thai consumers. The focus group panels then helped in alteration of the formulation and optimising the product's characteristics. Finally, the consumer test panel helped to identify whether the developed product was acceptable to the target Thai consumers.

2.3 OVERALL AIM AND OBJECTIVES OF THE RESEARCH PROJECT

The Thai people are not accustomed to mutton flavour. However, there might be some possibilities of disguising or alleviating the mutton flavour so that a mutton-based processed meat product could be developed for the Thai consumers.

Therefore, the overall aim of this study was to develop a processed meat product from New Zealand mutton which was acceptable, in terms of its sensory characteristics especially odour and flavour, to the target Thai consumers who belonged to the middle and upper

classes in the Bangkok area. An attempt was made to introduce a strikingly new product to the market so that the product would not be compared directly with present local products made from pork or beef.

In this project, consumer acceptance of the product was the vital key to its success. Although consumers have been used in various situations in product development, there has been no investigation into the stages where their input is useful in developing a product from a raw material with a drawback in its important characteristics, i.e. odour and flavour. Therefore, the relevance of consumer inputs in this research project was very important. As the technology for making processed meat products is well established, no major processing technology was involved.

The objectives of this thesis were to:

* investigate sensory evaluation methods using consumers to guide the formulation of the product by experimental design techniques.
* study the use of the objective methods in the texture development process and also their relationships to the subjective methods.
* study the use of a focus group technique to improve the product's characteristics.
* test the final product among the target Thai consumers for the evaluation of its acceptability.

CHAPTER 3
IDENTIFYING THE PRODUCT TO BE DEVELOPED USING MUTTON

3.1 INTRODUCTION

This chapter discusses the selection of the processed meat product to be developed using mutton. The selection was started in Thailand by conducting a market survey on local Thai processed meat products. This identified four processed meat products as suitable for manufacture from New Zealand mutton. Some of these commercial products were tested among a group of Thai consumers to determine the important sensory attributes and the ideal profiles for the products. The products were prepared using mutton as the basic meat raw material and the responses of the Thai consumers to the sensory characteristics of the mutton-based products were determined. Three groups of processed meat products were chosen for further investigation.

In New Zealand, a final screening was performed to select the product which would be developed. Ideas for variations of the three product types were created through brainstorming among a group of consumers. The number of product ideas were reduced using different screening techniques. Three experimental products were made using mutton to compare the Thai consumers' acceptance of each type of product. Finally, a decision was made on the Thai meat product to be developed using mutton as a major meat, taking into consideration such information as market potential and flavour acceptance.

3.2 PRELIMINARY IDENTIFICATION OF SOME POTENTIAL PRODUCTS IN THAILAND

A retail survey was conducted in Bangkok to identify the most popular Thai processed meat products which could be processed from mutton. In addition, technical information concerning these products was collected. The most suitable products were made in the laboratory at Chulalongkorn University and tested by a laboratory panel. As a result, three groups of products were maintained for further investigation.

3.2.1 A Market Survey and Technical Information about the Thai Processed Meat Products

A retail market survey determined the sales of processed meat products in 17 supermarkets in Bangkok. The data were collected by personal visits to supermarkets and also by mailing questionnaires to the managers. The approximate sales in individual supermarkets are shown in Appendix 3.1.

Meatballs made from beef and pork were very popular and were bought quite often by the Thai consumers. Among sausages, vienna and cocktail sausages had the highest monthly

sales volumes. Ham and also dried meat were popular and their monthly sales volumes were quite high. Traditional Thai processed meat products such as sai krok priew (fermented product) and moo yor (Thai style emulsion sausage) had lower monthly sales volumes. There were quite a large number of canned products available but the monthly sales volumes, although they varied among the supermarkets, were generally low.

The most suitable products were chosen according to sales volume, wholesale and retail prices and the product characteristics. The four main groups of products were meatballs, sausages, dried meat and ham. The sales volumes and also the wholesale and retail prices of these four groups of products were quite high and further sales also looked promising, therefore they were retained for further investigation.

Meatballs are normally consumed by Thai people. They originated from the Chinese people who cook and eat meatballs with noodles. Also, there are street vendors all around the country, selling roasted meatballs, on bamboo skewers, with sweet and sour chilli sauce. Processed meatballs normally include such products as beef and pork meatballs. However, when considering poultry and fish products, it is evident that Thai people also eat a lot of chicken, fish and shrimp balls in much the same way as they eat meatballs made from beef or pork. In the survey through the supermarkets, meatballs (not including poultry and fish products) were for sales the third ranked product, with maximum sales of approximately 480 kg/month in an individual supermarket. This figure did not include the sales of meatballs by street vendors nation-wide as mentioned previously.

There are many types of sausages on the market. The Western style sausages include cocktail, vienna, frankfurter, bologna. The Thai style sausages include moo yor (emulsion type) and sai krok priew (fermented product with coarse texture). According to the sales quantity, sausages were sold as the first ranked product. The Western style sausages were sold with maximum sales quantity of 545 kg/month for supermarkets whereas for the Thai sausages the sales were approximately 150 kg/month as a maximum. When considering the popularity of sausages especially the Western style, only the Thais who are the middle and high income classes seem to consume these kinds of products rather than those in the low income class.

Dried meat is consumed by Thai people nation-wide. There are many kinds of dried meat products in markets in Thailand, both in fresh markets and supermarkets. Also, there are street vendors who sell dried meat products throughout the country. Dried meat products normally consumed by the Thais include: sliced and dried salty beef (nua kem, in Thai), sliced and dried spicy beef (nua sawan), shredded and sweetened beef (nua warn), pork floss (moo yong), sliced and dried roasted pork (moo pan), and chinese sausage (kun

chieng). According to the survey through the supermarkets in Bangkok, dried meat products have the second highest sales with maximum sales quantity of approximately 510 kg/month in an individual supermarket. This figure did not include the sales of sliced and dried salty beef which is traditionally sold in fresh markets or by street vendors.

Hams are also eaten by Thai people and pressed-ham is another kind of processed meat product which is also consumed. The maximum sales quantity of pressed-ham sold in an individual supermarket was approximately 100 kg/month.

Information concerning packing of these four groups of products was also collected.

Meatballs are conventionally sold in open glass cabinets in foodshops and on street vendors' trolleys. However, there are some meatballs packed in plastic bags and sold in display chillers in supermarkets. Sausages are normally packed in plastic bags. However, they are frequently sold loose in trays within display chillers in supermarkets. Normally, dried meat products are sold unpacked in fresh markets, or by street vendors. However, there is such a product as sliced and dried spicy beef which is packed in plastic bags. Pressed-ham is normally sold as slices in trays within display chillers in supermarkets.

Promotion of all the previously mentioned products is not extensive. In Thailand, there were some brands of sausages (Western style) promoted on television in the past. At the present time, it seems that such a promotion is not suitable since its cost is exceptionally expensive. However, some popular brands of sausages and meatballs are occasionally advertised in some leading newspapers in Thailand. Dried meat is not advertised at all out of the shops. In-store promotion is likely to be used most often for processed meat products in Thailand. This can be in the form of special and large display stands and posters. These attract the customer's attention by standing out. Free samples and live stands with personnel using the products are other methods of promotion within stores. This type of promotion is aimed to introduce the products to the consumers.

In addition to the market information described previously, technical information concerning the four groups of products was also collected and it included processing and regulations. The processing steps required for production of the four groups of processed meat products are shown in Appendix 3.2.

As far as meat is concerned, it seems that as of now there are no Ministerial Regulations governing various kinds of processed meat products except for those packed in "completely sealed containers". The Food and Drug Administration, Ministry of Public Health, a directly responsible government organisation, is now collecting some data and information in order

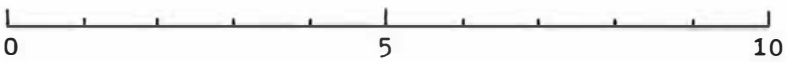
to produce Ministerial Regulations for some processed meat products such as sausages with the purpose of controlling the production for sale, importation for sale, or sale of this kind of food.

There are Ministerial Regulations governing use of food additives in food products. Normally, the maximum amount of each food additive allowed to be used in foods according to the Ministerial Regulation is adopted from the Codex (Joint Committee between the Food and Agricultural Organisation and the World Health Organisation) standards. As previously mentioned, there is not yet Ministerial Regulation governing processed meat products as "controlled foods". However, there are some regulations governing maximum amount of food additives to be used in meat products. These are shown in Appendix 3.3.

3.2.2 Preliminary Experiments on the Four Groups of Products

3.2.2.1 An Investigation on Sensory Properties of Commercial Products

The sensory properties of commercial cocktail and vienna sausages and meatballs were tested by a sensory panel comprised of twelve staff members and postgraduate students at the Department of Food Technology, Chulalongkorn University, Bangkok. The purpose was to determine perceptions of the Thai consumers of the important sensory attributes of some of the chosen commercial products and concurrently to determine their ideal profiles for use in further development. Two brands of each of the chosen products, namely cocktail and vienna sausages and meatballs, were randomly purchased from supermarkets. The products were cooked in boiling water for 2 min, coded with three digit random numbers and randomly presented to the panelists. The panelists gave the sensory attributes they thought were important to the products. A discussion was then held so that all the panelists agreed upon the proposed attributes. The twelve panelists were then asked to assess these sensory attributes of the products using the ideal profile testing. An example of the line scale used for evaluating the product's characteristics is given below (see the detailed questionnaire in Appendix 3.4).



extremely soft extremely firm

The panelists were requested to give both the sample score and their ideal score for each sensory characteristic. The ideal ratio score was determined by dividing the sample score by the ideal score. The results are shown in Figure 3.1.

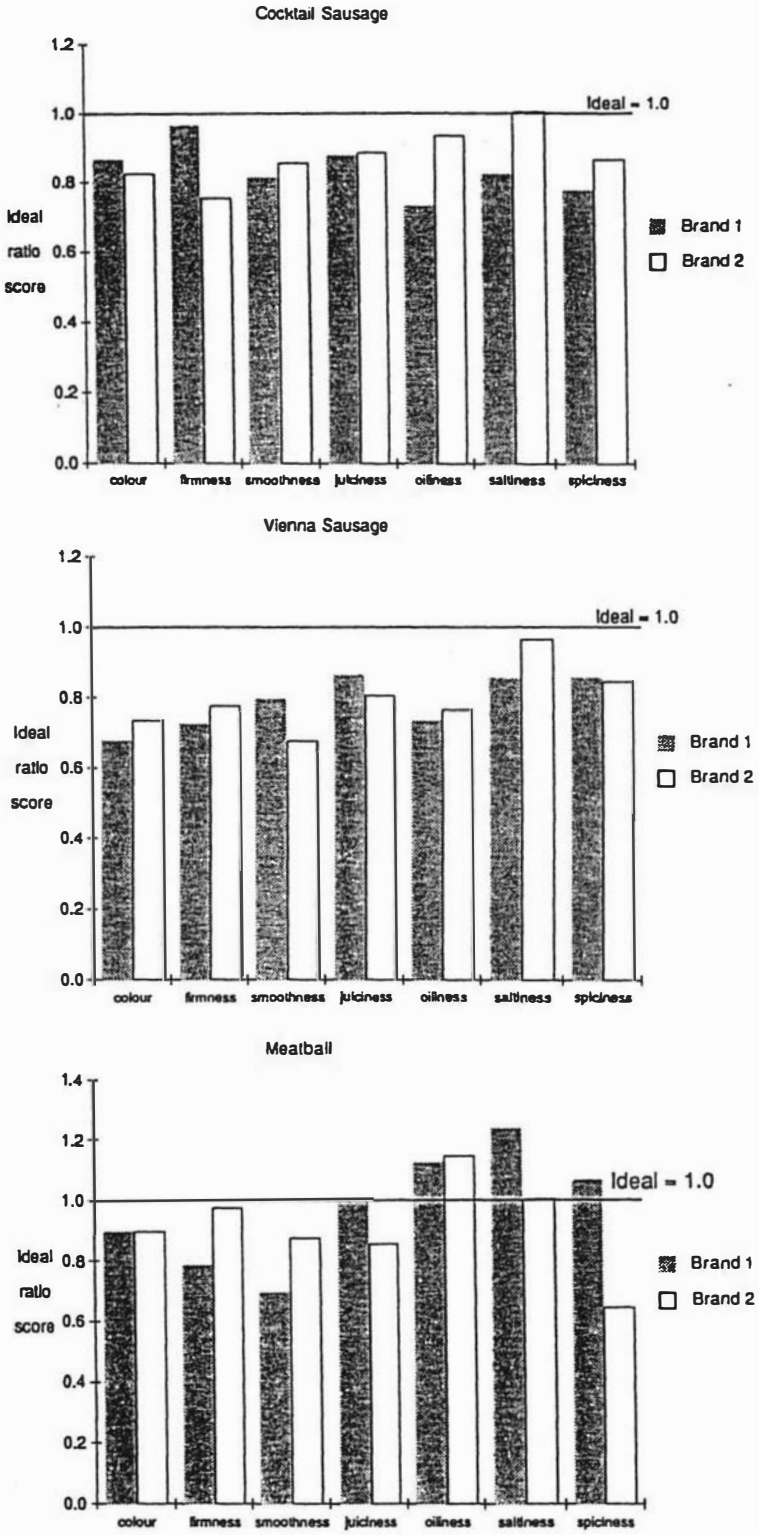


Figure 3.1 Sensory ideal ratio scores (sample score : floating ideal score) for two brands of commercial sausages and meatballs

In general, the commercial products had good sensory attributes with their ideal ratio scores relatively near 1, especially for cocktail sausages. The mean ideal absolute score of each sensory characteristic for these commercial meat products were also determined and are shown in Table 3.1.

Table 3.1 Mean ideal absolute scores for sensory attributes of commercial cocktail sausages, vienna sausages and meatballs

Product	Attribute						
	Colour	Firm-ness	Smooth-ness	Juici-ness	Oili-ness	Salti-ness	Spici-ness
Cocktail Sausage	8.2	8.3	8.2	6.7	6.4	5.5	6.0
Vienna Sausage	8.0	8.3	8.1	7.0	6.9	6.3	6.7
Meatball	7.8	8.0	8.2	6.1	4.3	5.6	3.9

It was interesting to note that the Thai consumers liked products with firm and smooth texture and with quite intense colour. The products should not be too juicy or oily; especially for the meatball, it should have mild oiliness. Saltiness was also another important sensory attribute. In general, the products should be mildly salty. Meatballs should not have too much spicy flavour. The mean ideal absolute score of each characteristic of the meatball was used as the "fixed" ideal for further development.

3.2.2.2 An Investigation on the Effects of Using Mutton on the Four Groups of Products

Another experiment was performed to investigate the effects of using various proportions of mutton together with other kinds of meats to make the four groups of processed meat products. Details of formulations and methods are in Appendix 3.5. The same twelve panelists were asked to assess the sensory characteristics of these products by using the ideal profile testing. The results are shown in Figures 3.2, 3.3 and 3.4.

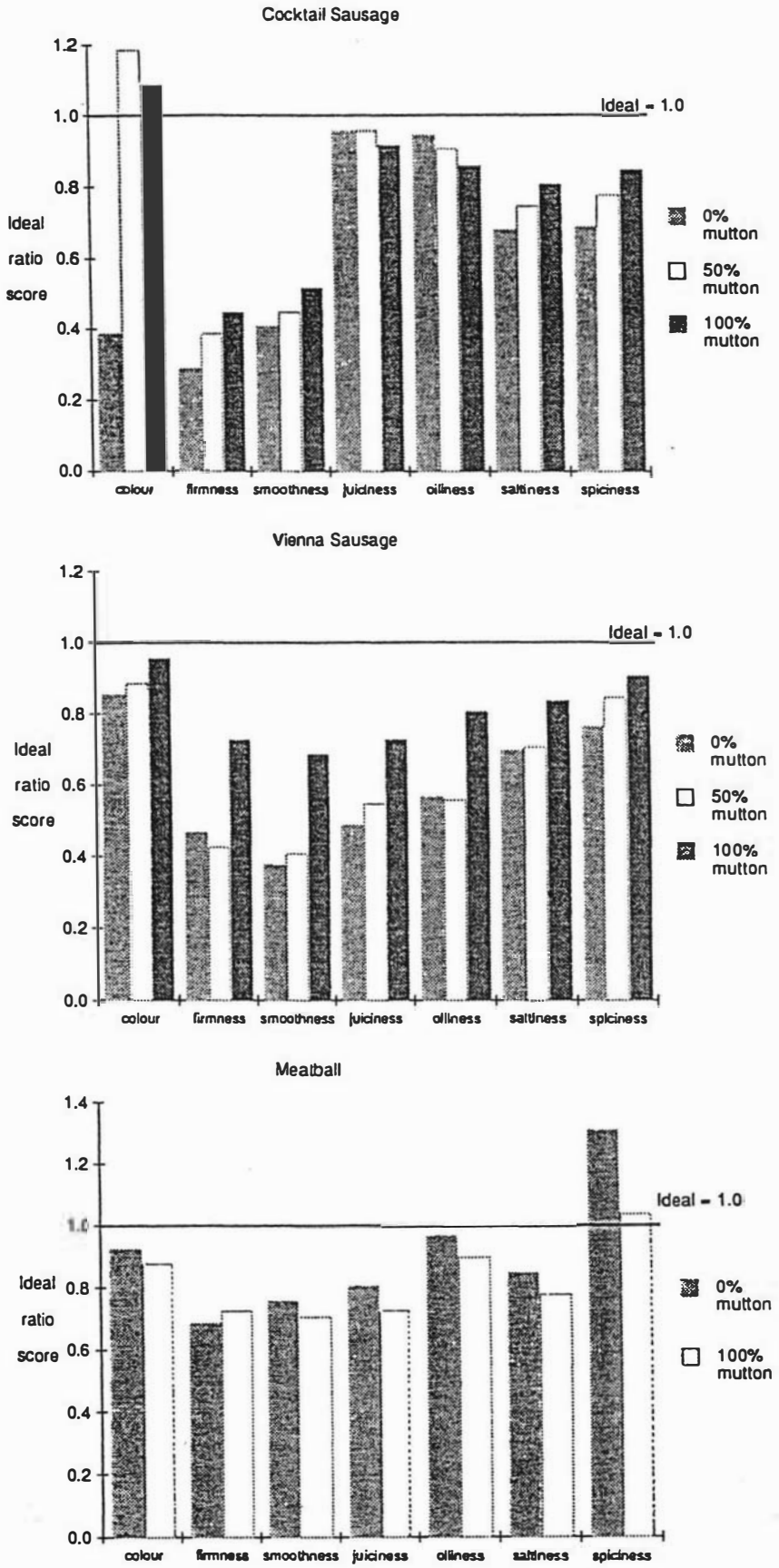


Figure 3.2 Sensory ideal ratio scores(sample score: fixed ideal score) for experimental cocktail sausages, vienna sausages and meatballs made with varying amounts of mutton

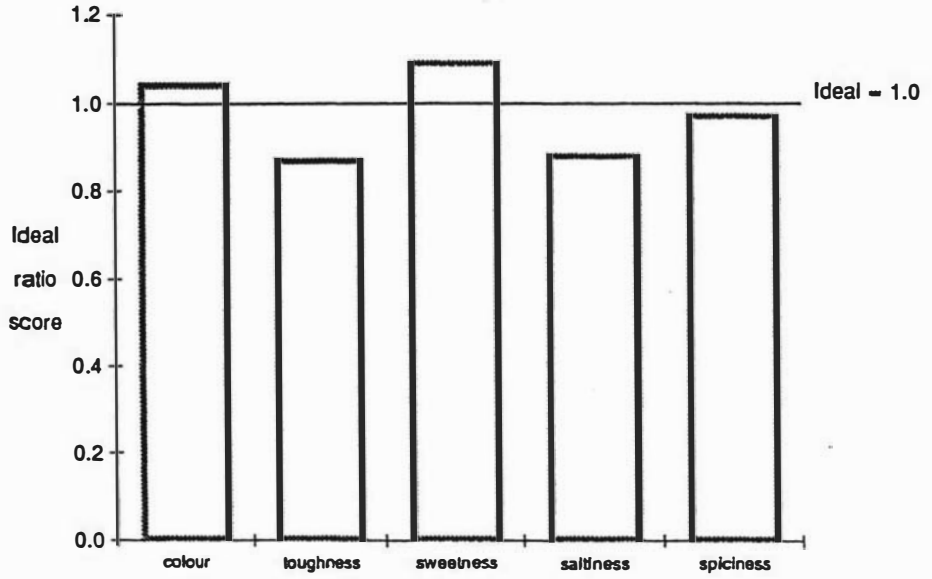


Figure 3.3 Sensory ideal ratio scores(sample score: floating ideal score) for experimental spiced and dried meat(100% mutton)

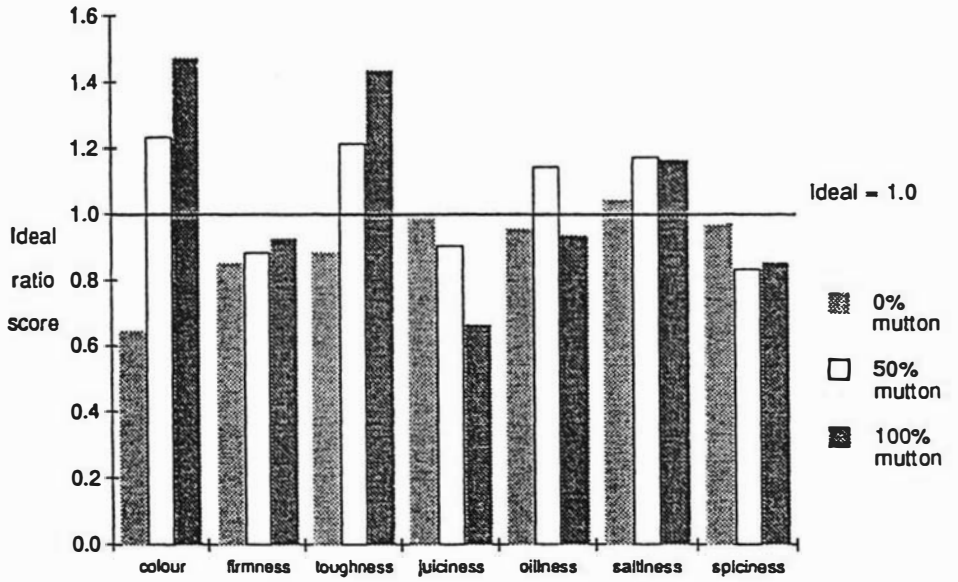


Figure 3.4 Sensory ideal ratio scores(sample score: floating ideal score) for experimental pressed-ham made with varying amounts of mutton

For cocktail sausage, it seemed that the ideal ratio scores were not near the ideals, i.e. the ideal ratio scores of 1.0, especially for firmness and smoothness. For vienna sausage, the scores of the product which was made using solely mutton, seemed to be nearer the ideals than those of the products with lower mutton content. For meatballs, the scores were rather near the ideals, however, most of the sensory scores of the product made by using solely mutton were not as near the ideals as those of the product made without mutton. For spiced and dried mutton, the scores were near the ideals. For pressed-ham, most of the sensory scores were not near the ideals especially the one made by using solely mutton. This product was very dark in colour and very tough. In general, it was apparent that mutton could not be used alone in manufacturing meat products acceptable to the Thais.

Considering the results from the market survey and the preliminary experiments performed, it was decided to drop pressed-ham because its sales quantity was not comparable to the sales quantities of the other three products. In addition, it was expected this product could only with difficulty be made from mutton so as to be acceptable to the Thai consumers. Therefore only three groups of products - meatballs, sausages, and dried meat - were retained.

3.3 SELECTION OF THE FINAL PRODUCT IN NEW ZEALAND

3.3.1 Introduction

The three groups of products selected from a preliminary study in Thailand were studied further at the Department of Food Technology, Massey University, New Zealand. Thai consumer input, through brainstorming, was used to generate variations of the three groups of meat products particularly with added ingredients which could impart flavour. These ideas were reduced in a screening process after further market, technical, and especially consumer information were considered. Processing experiments on the three products (meatball, spiced and dried meat, sausage) studied the effects of mutton fat and beef fat on the sensory attributes of each product. The market potential for each screened product was also determined. Using all the information, a final product was selected.

3.3.2 A Desk Study on Flavours for the Three Groups of Products Using Brainstorming and Screening Techniques

3.3.2.1 Literature Review on Product Idea Generation and Screening

In systematic product development, the process starts with a procedure to generate a large number of product ideas which are thereafter screened to remove the products that are not compatible with the prespecified goals. The methods for generating product ideas are classified as analytical and non-analytical. Analytical methods include morphological

analysis, attribute listing, Heuristic Ideation technique, technological forecasting and gap analysis. Non-analytical methods include those that stimulate thinking along unconventional paths e.g. brainstorming, synectics, lateral thinking, extended creativity group, deliberate dreaming, focus groups and nominal group technique. Techniques accompanying these two methods are many and varied, and a large number can be found in the literature (Sinthavalai, 1986). In this research project, only brainstorming was used for generation of variations of ideas.

Hisrich and Peters (1984) stated that the brainstorming technique evolves from the belief that people can be stimulated to greater creativity by meeting with others and participating in organised group experiences. The technique is probably the most well known and widely used creative problem-solving technique. It is an unstructured process for generating all possible ideas - through spontaneous contributions of participants - about a problem within a limited timeframe. Holt (1983) similarly defined brainstorming as a method for creative thinking based on free association and deferred judgement. The purpose of brainstorming is to generate within a short time a large number of ideas, among which there will be some fitted for further use. These authors suggested that the rules in brainstorming be: no criticism (any form of evaluation and criticism is excluded), freewheeling is encouraged (the wilder the ideas, the better the results), quantity is wanted (the more ideas, the better), and cross fertilisation (combination and improvement on the ideas of others are sought).

Generally, methods for screening and/or evaluation can be classified as "qualitative" and "quantitative", each is appropriate for application in different screening and/or evaluation stages. The most important aim of screening is to coarsely sieve for suitable product ideas which can be developed efficiently and successfully. There are a large number of screening methods, which have been extensively reviewed and summarised by Sinthavalai (1986). In this research project, the steps used for screening followed mainly those suggested by Earle (1971). The author divided the product idea evaluation into two main steps by firstly deciding the important factors related to the project and then rating these factors for each product and comparing the scores among the products. Three techniques are used in a stepwise manner - sequential, checklist and probability screening. Only two techniques, namely sequential and checklist screening, were used in this study because of their ease of use and effectiveness. In addition, market and technical information collected in Thailand and especially information from consumer panel discussion in New Zealand were also used to help in screening.

3.3.2.2 Consumer Input for Idea Generation

The brainstorming was conducted for 30 minutes among a group of six Thai postgraduate students and the author, as a moderator, at the Department of Food Technology, Massey

University. A brief introduction to brainstorming was given to the participants and the rules were explained to them which included: criticism prohibited, no restriction of ideas given, and quantity unlimited. The participants were given the subject "What ideas for processed meat products, made from mutton with added ingredients which can impart flavour, for Thai consumers, can you think of?" The session was allowed to develop as spontaneously as possible with minimal interruption from the moderator. Each participant was encouraged to give the ideas through eye contact and direct questioning whenever necessary. To avoid domination of the session by some participants, interruptions were made by presenting a new question to the group.

A number of ideas were obtained from brainstorming. These were summarised into three groups pertaining to the potential products selected from the work in Thailand and are shown in Appendix 3.6. The suggestion from the consumers was that the processed meat products made from mutton should have added ingredients which could impart flavour. These mainly included spices, smoke and other ingredients from plant origins.

3.3.2.3 Preliminary Screening of Variations of the Ideas

Two techniques were used in the preliminary screening - namely sequential screening and checklist screening.

Sequential screening is primarily qualitative. Basically, the information needed in sequential screening should not be expensive to develop but it must be effective in rejecting concepts or ideas that are not feasible investment proposals. This technique consisted of a major pass (P)/fail (F) system, in which ideas with major shortcomings were rapidly discarded. The ideas were rated against the following limiting factors:

* processing and technical feasibility - processing should maximise the use of existing machinery and equipment. No highly advanced technology and expensive machinery should be required.
* storage life - the product should have a storage life long enough so that, if produced in New Zealand, it could be delivered to Thailand and distributed through the market channels and consumed by the Thais. A minimum period of approximately 4 months should be expected.
* sensory attributes and acceptability - the product should have good sensory attributes especially with no strong odour and flavour of mutton or at least to an extent that it is still accepted by the Thai consumers.
* market potential - other than being accepted by the Thais, the product should have a good market potential comparable to any existing competitive product.

Any idea required a pass value for all the factors listed above before it was retained for further screening. The sequential screening is shown in Appendix 3.7 and variations of ideas remaining after sequential screening are listed in Table 3.2.

Table 3.2 Variations of ideas remaining after sequential screening

Group	Variations of Ideas
Meatball	garlic mutton meatball
	pepper mutton meatball
	satay flavoured mutton meatball
	smoked mutton meatball
	liquid smoked mutton meatball
Dried Mutton	satay flavoured and dried mutton
	spiced and dried mutton
	mutton stick
Sausage	spiced mutton sausage
	texturised vegetable protein and mutton sausage (smoked)
	liver and mutton sausage (spiced and smoked)
	smoked mutton sausage
	liquid smoked mutton sausage

Most ideas failed due to poor performance in sensory attributes, acceptability and market potential.

Checklist screening, a numerical rating method, was applied for screening the ideas remaining from the sequential screening. The procedure of Earle (1971) was followed. This method involves the identification of factors relevant to the success of the product. The factors, whether similar to or different from those of sequential screening, were generated. From the three basic groups of factors, ten sub-factors were chosen according to their importance as follows:

* Product factors
    - suitable sensory properties for Thai consumers
    - acceptable storage life (including time for transportation from New Zealand and distribution in Thai supermarkets, if production is in New Zealand)
    - ease of use and preparation prior to consumption (convenience)
* Processing factors
    - ease of processing and packaging
    - use of existing equipment in the producing country
    - availability of raw materials within the producing country
    - requirement of labour

* Marketing factors
    - export market potential to Thailand
    - retail price in Thai supermarkets
    - fit into eating habits of Thai consumers and popularity.

These sub-factors were rated out of 100 points to reflect their relative importance. The highest rating was 100 and all sub-factors were rated against this base level score. Three sub-factors, availability of raw materials within the producing country, use of existing equipment in the producing country, and requirement of labour, were discarded because of their relative unimportance.

Each idea was scored for each factor and the scores for all the factors were added to give a total score for that idea. A range of total scores from 60-74 out of the maximum of 100 was obtained. A cut-off point of 67 was arbitrarily chosen, and the ideas scoring less than that were rejected. Appendix 3.8 lists the rating of the ideas and Table 3.3 shows the ideas remaining after checklist screening.

Table 3.3 Variations of ideas remaining after checklist screening

Group	Variations of Ideas	Score
Meatball		
	smoked mutton meatball	70
	liquid smoked mutton meatball	70
Dried Mutton		
	spiced and dried mutton	74
	satay flavoured and dried mutton	72
	mutton stick	69
Sausage		
	spiced mutton sausage	69
	smoked mutton sausage	69
	liquid smoked mutton sausage	69
	liver and mutton sausage (spiced and smoked)	67

The scores of the ideas remaining were very close. It was important to point out here that the ideas remaining for meatballs did not include any spiced meatballs at all. The rating was based on the ideas being considered whether they were rational or not. Therefore, the meatballs with only one type of spice added, i.e. garlic or pepper, received lower scores in suitable sensory attributes. This was because, as expected, the use of only one type of spice was not enough to conceal the strong odour and flavour of mutton.

3.3.3 Consumer Information on the Three Groups of Products

Consumer information was obtained from a consumer discussion panel comprised of six postgraduate Thai students (3 males and 3 females) at Massey University. They were asked various questions involving the three groups of processed meat product ideas. Input from the Thai consumers was considered important at this stage since it helped ascertain local tastes and preferences for the ideas. A summary of the results from the consumer panel discussion is as follows:

* Meatballs were more often consumed than the other products. All the consumers ate meatballs on average four days a week and at least once a day in these four days. Sausages were consumed at any meal of the day but mostly with breakfast and dinner. The average amount of meatballs eaten by each individual was 1.44 kg/month as compared with sausages at 1.23 kg/month, and dried meat at 0.4 kg/month.
* All the consumers normally ate meatballs cooked with noodles as their lunch and almost all of them ate roasted meatballs (on bamboo skewers), with sweet and sour chilli sauce, as snacks. Sausages were normally fried prior to being consumed. However, the consumers also made special dishes such as chilli and sour salad from sausages. Sliced and dried salty beef was also normally consumed as a fried dish. However, it should be noted that sliced and dried spicy beef, shredded and sweetened beef and such dried pork products as sliced and dried roasted pork, and pork floss could be directly consumed. These kinds of dried meat products could be considered as convenience foods.
* The consumers were concerned about the qualities of products being sold in Thailand. They mentioned about drawbacks in the product characteristics concerning chemical, physical and microbiological properties. They also wanted the products to be nutritionally labelled. It was, therefore, important that the aspects involving the product qualities should be studied during development of such a product.
* Most of the consumers accepted the eating of lamb (some liked lamb), hogget and mutton. However, they mentioned the strong odour and flavour of mutton. Also the consumers mentioned that mutton texture was tough. All of the consumers did not like the processed meat products made from lamb, hogget and mutton, mainly sausages, which they had consumed in New Zealand.
* The consumers suggested use of spices and herbs in order to conceal odour and flavour of lamb, hogget and mutton if the processed meat product was developed from these meats for Thai consumers. The spices and herbs suggested were pepper, cinnamon, ginger, garlic, onion, garlingale.
* The consumers mentioned that a processed meat product may be developed using mutton if it was comparable to those products existing in Thai markets in terms of product qualities and with a reasonable price.

* Of all variations of the ideas, the consumers preferred to eat most often the dried meat products, especially sliced and dried spicy meat was put in the first rank. The consumers said they ate meatballs more often than sausages but they ranked sausages (in view of preference to try the developed product) before meatballs. Meat stick and sausages with liver were ranked in the last two positions respectively (see Table 3.4).

Table 3.4 Consumer ranking for preference of the ideas

Idea	Rank	Mean Rank Score(a)
Spiced dried meat	1	2.50
Smoked (or liquid smoked) sausage	2	2.83
Spiced sausage	3	4.17
Smoked (or liquid smoked) meatball	4	4.33
Satay flavoured dried meat	5	4.83
Meat Stick	6	6.17
Sausage with liver (spiced and smoked)	7	7.00

(a) 1 - like most, 7 - like least.

Therefore, spiced or smoked flavours were considered the most suitable added ingredients to be added to hide the mutton flavour. From the consumer panel, it seemed likely that mixed spices rather than smoking should be used in production of any processed meat product to be acceptable to Thai consumers. Spices were expected to play more important roles in concealing the strong odour and flavour of mutton. This was supported by the reasons that the Thai consumers are more familiar with spicy products and suggestion from the Thai consumers as discussed previously also showed that spices and herbs should be used if the processed meat products would be developed from sheepmeats. In addition, smoking of the processed meat products, except for some types of sausages, was not a common practice in Thailand.

At this stage, the selection of the final product to be developed was not made. It was decided to firstly investigate the effects of using mutton in the three types of products and to consider their market potential before the final decision was reached.

3.3.4 Preliminary Investigation on the Effects of Using Mutton in the Three Products

Meat patties were firstly used as the experimental product to investigate the effect of using various proportions of mutton in the meat product. The proportions of meats used in the experiment included 100% beef (as a standard), 100% mutton, 25% beef and 75% mutton, and 50% beef and 50% mutton. The triangle test was the sensory evaluation method used

to identify whether there were differences among the samples. Each panelist was asked to identify the odd sample from the other two identical samples. Eight postgraduate Thai students at Massey University participated in the sensory evaluation. The patties were prepared according to the formulations and methods described in Appendix 3.9. The samples were cooked by pan-frying in soy bean oil at 200 ± 5 °C for 2 min, coded with three digit random numbers and randomly presented to the panelists. The results of the triangle test are shown in Table 3.5.

Table 3.5 Triangle test to investigate the effect of various proportions of mutton in meat patties

	Correct Judgement/Total Judgement (1) By Smelling	By Tasting
100% beef vs. 100% mutton	14/16 (***)	14/16 (***)
100% beef vs. (25% beef + 75% mutton)	13/16 (***)	13/16 (***)
100% beef vs. (50% beef + 50% mutton)	9/16 (ns)	9/16 (ns)

(1) According to Larmond (1982) for level of significance,
*** means significant at 99.9%
and ns means not significant at 95%.

It was found that the higher the mutton content in the meat mixtures, the more easily the panelists could detect the difference between the samples. Therefore, in further development of any product for the Thai consumers, it was likely that mutton could probably be used only to a certain proportion in such a product.

Another experiment was conducted to investigate whether spices could help conceal the strong odour and flavour of mutton. Types of spices were arbitrarily chosen and these included garlic, allspice, coriander, fennel and ginger. Salt, sugar and soy sauce were also added to the samples (see Appendix 3.10 for formulations). The samples were tested by the same eight panelists who participated in the previous triangle test. The fried samples were coded with three digit random numbers and randomly presented to the panelists. The results are given in Table 3.6.

Table 3.6 Triangle test to investigate the effect of spices in meat patties incorporated with mutton

	Correct Judgement/Total Judgement (1) By Smelling	By Tasting
(50% beef + 50% mutton) vs. (25% beef + 75% mutton)	7/16 (ns)	7/16 (ns)

(1) According to Larmond (1982) for level of significance, ns means not significant at 95%.

It was found that there was no detectable difference between the samples whether they were formulated with 50% mutton or 75% mutton. This was due mainly to the effect of the spices which helped to conceal the strong odour and flavour of mutton. It was interesting to point out that spices could possibly be valuable ingredients in further development of any product made from mutton to be acceptable to the Thai consumers.

The last experiment in this series was conducted to investigate the effects of mutton and beef fats on sensory attributes and acceptability of the three products namely meatballs, spiced and dried meat and sausages. All products were produced using the same beef and mutton lean with the ratio of 3:1 respectively, but each product has different ingredients which are traditionally used in the commercial product in Thailand (see ingredients used in Appendix 3.11). The proportions of beef fat and mutton fat were varied according to a 2^2 factorial (with the additional centre point) experimental design as shown in Table 3.7.

Table 3.7 Factorial design to study the effects of mutton fat and beef fat content on sensory attributes and acceptability of meatballs, dried meat and sausages

Factorial Design	Mutton Fat (%)	Beef Fat (%)
1	2.7	2.3
a	4.3	2.3
b	2.7	8.2
ab	4.3	8.2
centre point	3.5	5.3

The three products were tested by a group of eight Thai taste panelists using the ideal profile testing. The samples were coded with three digit random numbers and randomly presented to the panelists who were asked to rate each sensory attribute of the product comparing it with the fixed ideal absolute score obtained from the experiments performed in Thailand (refer to Section 3.2.2). The ideal absolute scores for the meatballs and sausages were the scores for the commercial products but those for spiced and dried meat were the scores for the experimental product. The ideal ratio scores are shown in Figures 3.5, 3.6 and 3.7 respectively.

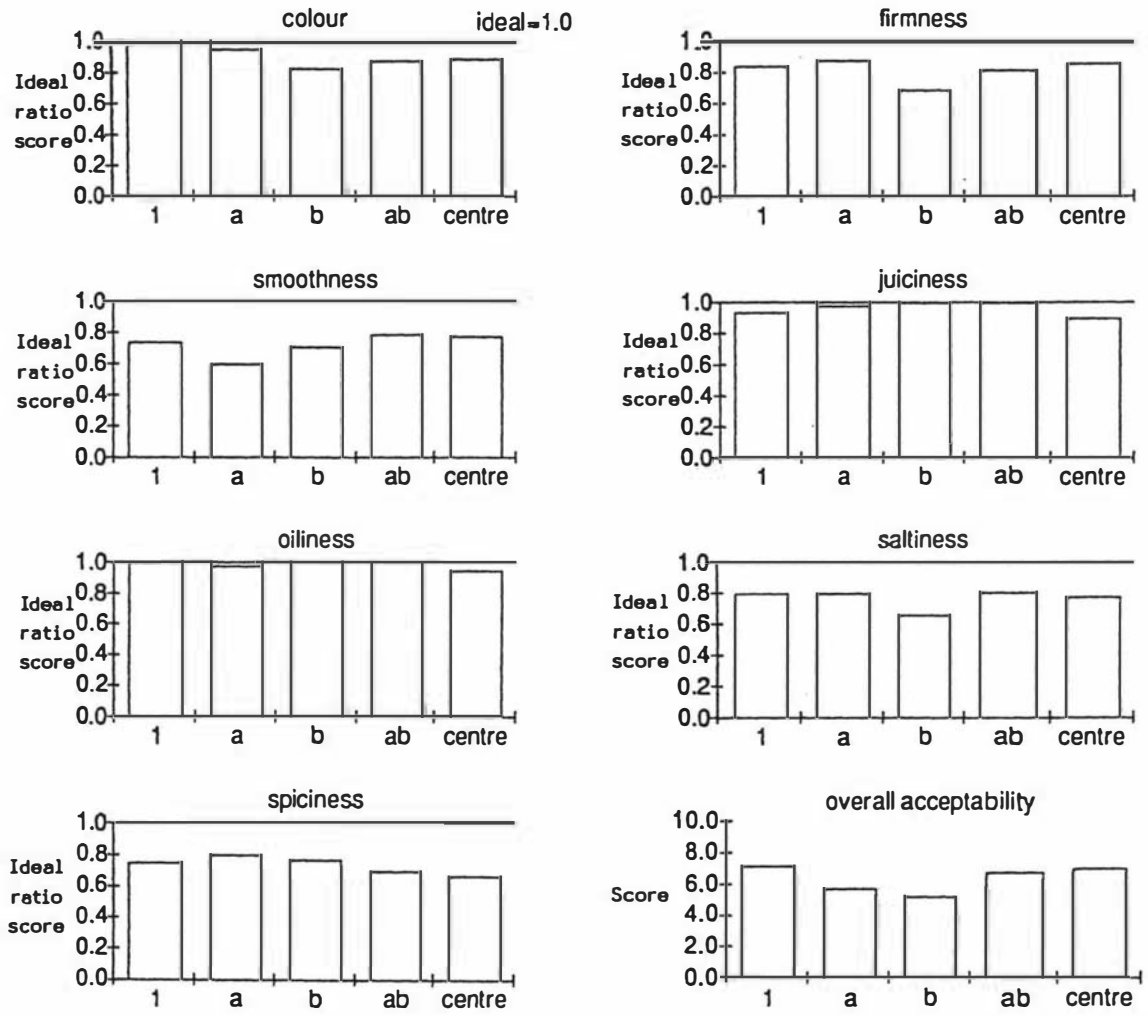


Figure 3.5 Sensory ideal ratio scores(sample score: fixed ideal score) and overall acceptability for meatballs at different beef fat and mutton fat levels

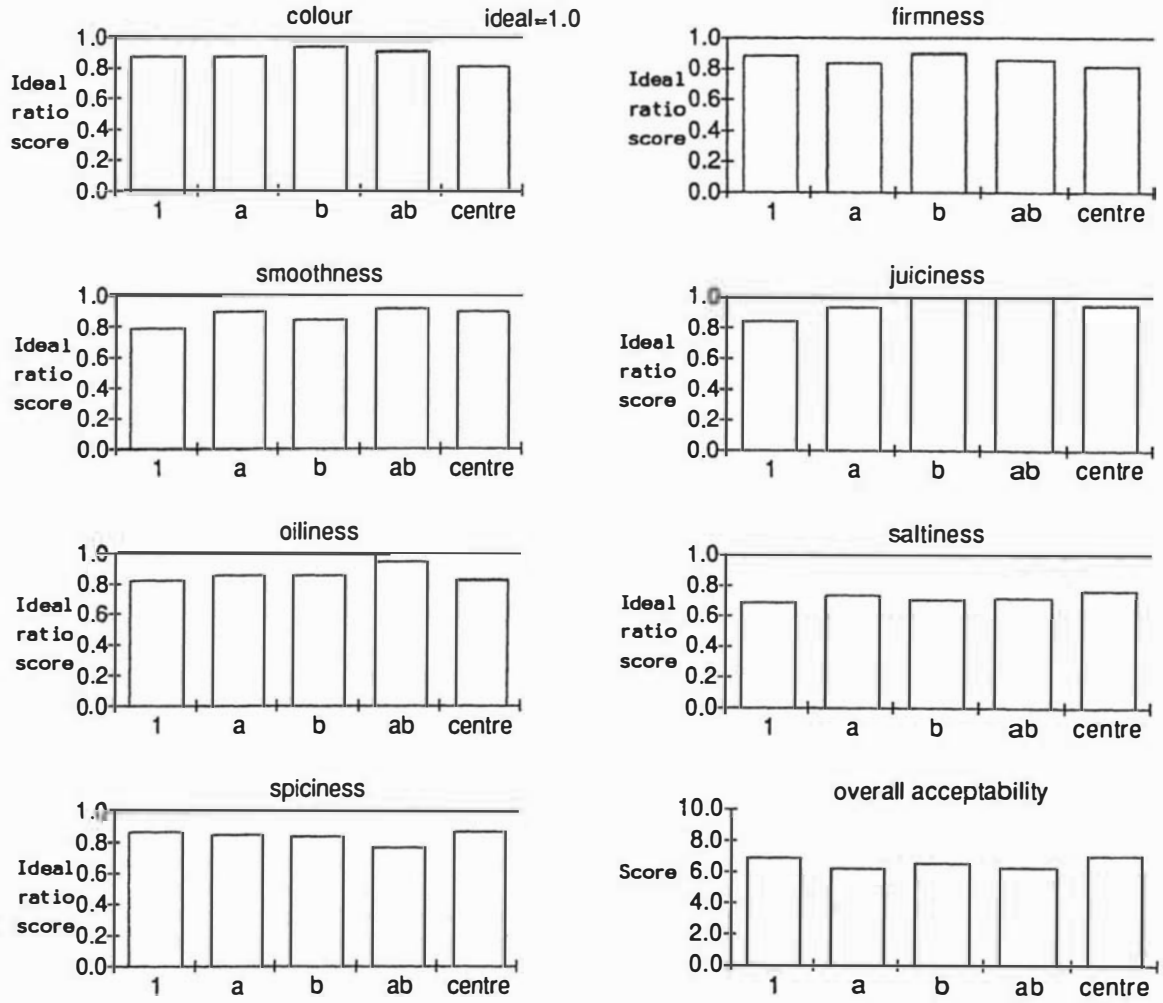


Figure 3.6 Sensory ideal ratio scores(sample score: fixed ideal score) and overall acceptability for sausages at different beef fat and mutton fat levels

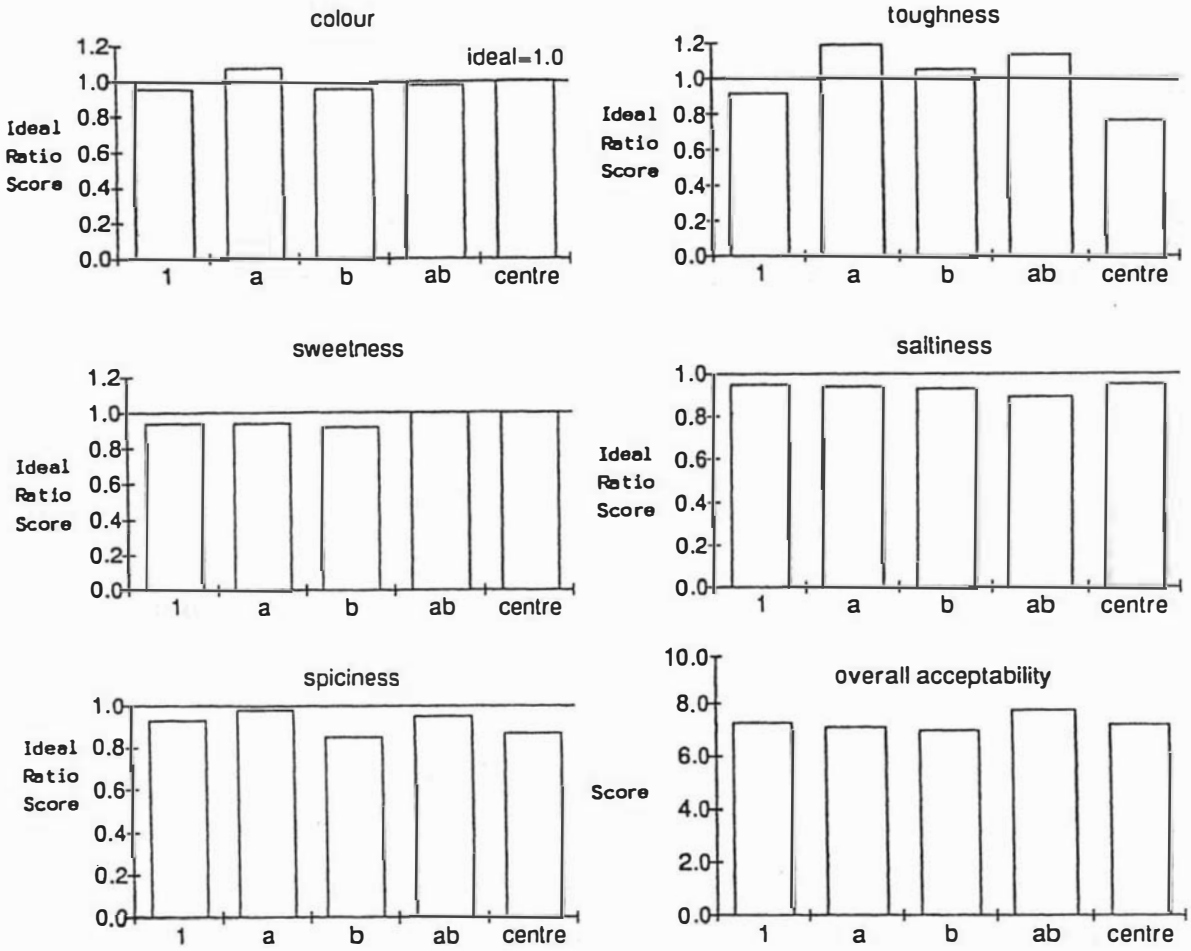


Figure 3.7 Sensory ideal ratio scores(sample score: fixed ideal score) and overall acceptability for spiced and dried meat at different beef fat and mutton fat levels

From these experiments, mutton did not create a significantly objectionable effect on acceptance by the Thai panelists of the experimental meat products. In general, it was evident that the Thai taste panelists fairly accepted the variations of the three products since they gave good scores for sensory characteristics, i.e. not too low or not too high means of ideal ratio scores. In terms of overall acceptability, conclusions could hardly be drawn when considering the mutton fat and the beef fat contents. However, there was a tendency that the products formulated with the low or medium mutton or beef fat content had the higher overall acceptability scores except for the spiced and dried meat formulated with the highest mutton and beef fat contents. In general, spiced and dried meat had higher overall acceptability scores than the other two products.

Therefore, it might be suggested that mutton could possibly be used in developing meat products acceptable to the Thais. However, it should be recommended that mutton be used

at low to medium fat content in the final product since there was a tendency that the products with low or medium fat contents had higher overall acceptability mean scores than those with high fat content. It was therefore preferable to choose the final product so that further study could be conducted to develop the suitable product from mutton for the Thai consumers.

3.3.5 Selection of the Final Thai Meat Product to Be Developed Using Mutton

In the previous sections, information from the literature and from the experimental work identified some reasons which would help in choosing the final product suitable for further development. Since more quantitative details, especially those for the market potentials of the screened products, were necessary for this stage of evaluation, this section is presented to aid the final decision on what product to develop using mutton.

3.3.5.1 Prediction of Market Potential for the Three Screened Products

The market potentials for the three products were estimated from secondary data, consumer discussion results and market survey results. The market potentials for the three screened products were then compared to find the product with greatest market potential. Only the "supermarket" market was considered for the mutton-based products in the first instance.

From the consumer discussion information, the annual per capita consumption of each product was estimated. The number of target consumers was estimated using the official statistics on the middle and high income classes, who were expected to be capable of buying the products in supermarkets in the Bangkok area. Therefore, from these figures, the annual potential sales quantity for each product was estimated, firstly in the total market. Then, the annual sales quantity in the supermarkets was estimated as a proportion of the figure for the total market. From the estimated annual sales quantity of each local product in the supermarkets in the Bangkok area, the optimistic potential sales quantity of each product, made from mutton, was determined taking into consideration that meatballs, spiced and dried meat and sausages have descending order of market shares respectively. The wholesale price of each mutton-based product was estimated using imported mutton and local beef prices. These figures were used to determine the sales potential income for each mutton-based product through the project life cycle of eight years (see Appendix 3.12).

The capital investment cost (including research and development cost, fixed capital cost and working capital cost) and the total product cost were estimated for each mutton-based product. This finally led to the estimation of revenue through the product life cycle. The technique of discounted cash flow was used to estimate the net present value of the products and thus determine the financial return for each screened product. The basic

principle behind the technique is that as time diminishes the value of money, future returns should be calculated at a discounted rate to reduce the future money to present day value. The discounted cash flow over eight years of the product life cycle was estimated (see Appendices 3.13 and 3.14).

It was shown that meatballs had the highest approximate net present value of 9 million baht, with 3 million baht for spiced and dried meat, and 2 million baht for sausages. Therefore, it might be likely in view of market potential that meatballs would be the most appropriate product for further development.

3.3.5.2 Selection of Meatball as the Final Product

From the preliminary experimental results, spiced and dried meat received the highest overall acceptability scores whereas meatballs and sausages received lower but comparable acceptability scores. In view of acceptance of the products to the Thai consumers alone, spiced and dried meat might be suitable for further development. However, this might not be sufficient and reliable justification to finally choose the most appropriate product. Apart from acceptability, another important criterion, market potential showed that meatballs had the best market potential with the highest net present value at three times higher than that of spiced and dried meat and even at almost five times higher than that of sausages. Considering this crucial estimation of market potential together with acceptability of these three products, meatball was chosen as the final product for further study and development because of the following reasons:

* There is good market and sales potential for this product.
* It is very popular among the Thai people.
* From the experimental results, it was likely that meatballs with mutton were relatively acceptable to the Thai consumers. The product might be further developed using mainly mutton and incorporated with other kinds of meats. From the desk study on variations of ideas related to flavours to be used in development of the product, it was suggested, and especially supported by input from a group of Thai consumers, that a number of spices and herbs should be used in any processed meat product if it would be developed from sheepmeats for Thai consumers. Spices and ingredients which could impart flavour were expected to help conceal strong odour and flavour of mutton, thus helping to develop the meatballs to be acceptable to the Thais.

3.4 DESCRIPTION OF THE MEATBALLS

Meatball, being called "lukchin" in Thai, is any finely minced meat product in the shape of a round ball (ca 3.0-3.5 cm in diameter), an oval ball or even an elongated roll which is sliced before serving. Normally, meatball is made from beef or pork but shrimp, fish and chicken

are also used as raw materials, or a combination of these kinds of raw materials are also used. The most common lukchin (meatball) are lukchin nua (beef meatball), lukchin moo (pork meatball), lukchin pla (fish meatball) and lukchin kung (shrimp meatball).

Some proximate compositions of commercial meatballs in Thailand were determined and are shown in Table 3.8.

Table 3.8 Composition of commercial meatballs in Thailand

	Percentage
Protein	15.3 - 17.7
Fat	2.8 - 3.6
Moisture	73.3 - 74.9

Commercial meatballs have a low fat, high moisture and relatively high protein when compared to some other local processed meat products (refer to Appendix 3.15). It was interesting to point out that fat content of the commercial meatballs was relatively low. This was due to the fact that commercial meatballs in Thailand are normally made by using very lean meat, particularly if beef or pork is used as raw material.

As a result of the experiments performed in Thailand, the ideal absolute score for each important sensory characteristic of the commercial meatballs was obtained and is shown in Table 3.9.

Table 3.9 Ideal absolute scores for important sensory attributes of commercial meatballs (1)

Firm-ness	Rubberi-ness	Juici-ness	Oili-ness	Smooth-ness	Salti-ness	Spici-ness	Colour
8.0	6.3	6.1	4.3	8.2	5.6	3.9	7.8

(1) The values were the means calculated from the ideal absolute scores given by twelve panelists in Thailand (see Section 3.2.2).

The ideal meatball should have relatively high firmness, smoothness, and intense colour. The product should be relatively rubbery and juicy but mildly salty and oily and it should not have too much spicy flavour. The above ideal scores were later used as "fixed" ideals for further development of the meatballs.

3.5 USE OF MUTTON IN THE MEATBALL PRODUCT FOR THE THAI CONSUMERS

Meatball was finally chosen as the most suitable product for development by using mutton. It is generally agreed that low consumer acceptance of mutton is due to its characteristic flavour and aroma on cooking (Batcher et al., 1969; Hudson and Loxley, 1983) and its toughness (Prasad et al., 1987). Mutton odour and flavour is not familiar to the Thai people who may even consider it disagreeable or obnoxious. However, it was expected, taking into consideration the preliminary experimental results, that mutton could be used in production of the meatballs to be acceptable to the Thai consumers. However, the amount and quality of mutton needs to be carefully controlled. Mutton might be used in incorporation with other kinds of meats such as beef or pork but up to a specific level. It was expected that the higher the fat content of the mutton used as raw material, the lower the amount that could be used. In addition, the connective tissue of mutton also needed to be taken into account if the meatballs would be developed successfully. The product requires firm and smooth texture; therefore mutton with high connective tissue should be avoided as raw material. Due to these two major inferior properties of mutton, it was advisable that mutton be extensively trimmed to remove fat and connective tissue before being used as raw material for the production of the meatballs. This would concurrently help to make meatballs with both desirable texture and flavour for the Thai consumers. In addition, the problem of strong odour and flavour of mutton could be further alleviated by concealing it with spices and ingredients which could impart flavour.

At this stage of the research project, a final decision was made to choose the product to be developed using mutton. Two major problems of mutton were identified including its strong odour and flavour from the fat tissue and its toughness because of the connective tissue. The following chapter discusses materials, processing methods, testing methods, data analyses, and experimental designs which were used in the development of the meatballs.

CHAPTER 4
MATERIALS AND METHODS

This chapter describes raw materials and ingredients which were used in the meatballs. The processing methods discuss the steps, the equipment and the parameters which were used in manufacturing. The chapter then elaborates on the testing method, objective tests and subjective tests, which were used during the product development process. Analyses of the data are also described and finally the experimental designs used in the research project are presented.

4.1 RAW MATERIALS AND PROCESSING METHODS

4.1.1 Raw Materials

In this project, the quality of raw materials was subjectively controlled by using raw materials of the same type and specification and, where possible, from the same lot from the same suppliers. Unless otherwise specified in the following chapters, the raw materials used in this research project were as follows:

Mutton. The mutton used in the project was mainly 90% chemically lean (CL) boneless mutton or mutton leg purchased from Waitaki International Ltd. either at Feilding or Wanganui, New Zealand. Due to its seasonal availability and the restriction caused by transportation from New Zealand to Thailand, the mutton was stored in freezers at ca -18 °C either at Food Technology Department, Massey University, Palmerston North, New Zealand or at Food Technology Department, Chulalongkorn University, Bangkok, Thailand. The storage time, before its use in any experiments in this project, varied but did not exceed four months.

Pork and Pork Backfat. The pork used in all experiments in New Zealand was 90% visually lean (VL) boneless pork from carcasses aged overnight (ca 18 hr) after slaughtering. This pork and the pork backfat were purchased from Kiwi Bacon Co. Ltd. at Longburn, New Zealand. The pork was used immediately after purchasing without any frozen storage.

For the experiments performed in Thailand, boneless leg of pork was used instead of 90% VL pork because such a classification system in selling pork does not exist in Thailand. Boneless leg of pork was used because it was expected to be relatively lean and comparable to 90% VL pork. The pork and pork backfat were purchased from the supermarket or the open market in Bangkok.

Beef. The beef used at the beginning of the formulation stage was 95% CL boneless beef from carcasses aged overnight (ca 18 hr). It was purchased from Waitaki International Ltd. at Feilding, New Zealand.

Mutton Fat Trimmings. The mutton fat trimmings used at the beginning of the formulation stage was purchased from Waitaki International Ltd. at Feilding, New Zealand.

Ice. The ice used in all experiments was flaked ice. The experiments in New Zealand utilised the flaked ice obtained from the Scotsman (model AF-30) automatic ice-making machine supplied by Hansen Products Ltd., Wanganui, New Zealand. The experiments in Thailand utilised the flaked ice obtained from the automatic ice-making machine manufactured by a private Thai company whose name was not available.

Sodium Tripolyphosphate (STPP) and Tetrasodium Pyrophosphate (TSPP). STPP was used in most experiments from the formulation stage until the final product was made for consumer testing in Thailand. TSPP was used only to compare its effect on characteristics of the meatballs, especially texture, with that of STPP and, during the formulation stage performed in New Zealand, was dropped due to its very high price. These two chemicals were food grade polyphosphates supplied by Robert Bryce and Co., Ltd., Lower Hutt, New Zealand.

Borax (Disodium Tetraborate Decahydrate). During the formulation stage, the effect of borax on the meatball's characteristics, especially the texture, was investigated. Due to its inferior properties and possible health hazard, this chemical was discarded. The borax used was a product of Koch-Light Laboratories Ltd., Colnbrook, Buckinghamshire, England.

Salt. For all experiments, the salt used was iodised commercial salt, in New Zealand supplied by Cerebos-Skellerup Ltd., Auckland and in Thailand supplied by R. and J. Trading Ltd., Bangkok.

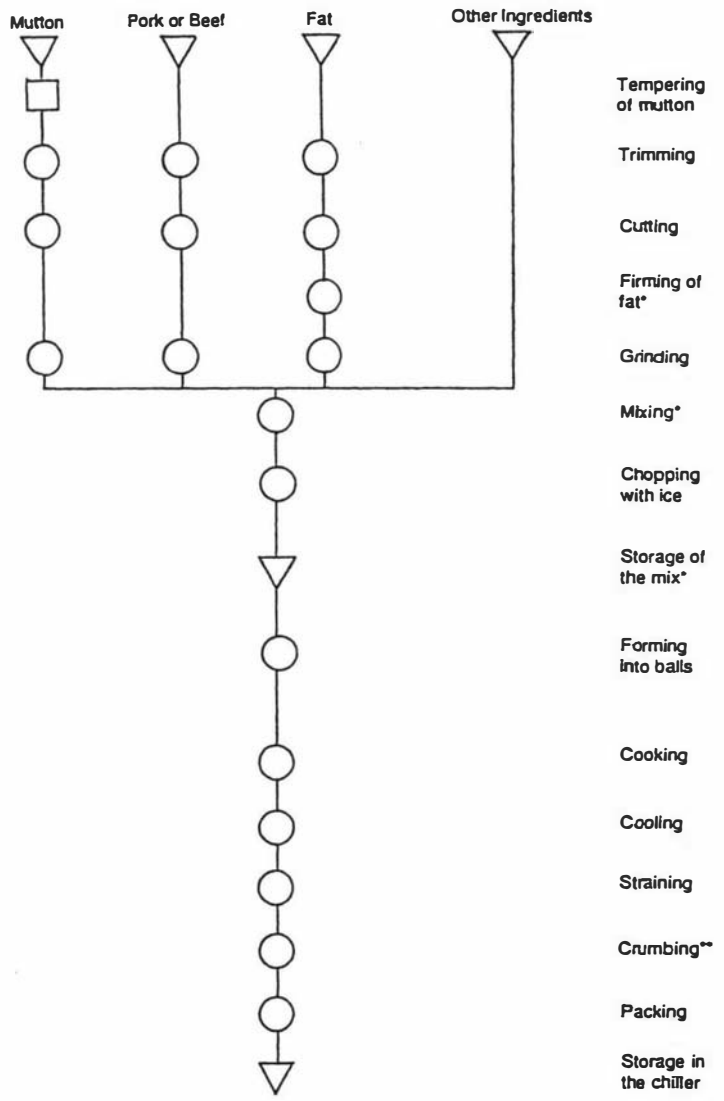
Tapioca Starch. The tapioca starch used in New Zealand was the unmodified commercial product supplied by N.Z. Starch Products Ltd., Auckland; and in Thailand it was the unmodified product supplied by Thai Starch Ltd., Bangkok.

Spices and Flavourings. Spices and flavourings were used during the formulation stage in New Zealand and in the formulation improvement and production trial in Thailand. White pepper powder, garlic powder, coriander powder and fennel powder were the commercial products supplied by Henry Berry Ltd., Palmerston North. Dehydrated onion flakes were supplied by Unilever (N.Z.), Ltd., Hastings. Toasted sesame oil was a product

manufactured by Kairoa Natural Co. Ltd., Auckland. Dried ground ginger was supplied by Calico Pie Ltd., Palmerston North. White pepper powder used in the production trial in Thailand was purchased from the market in Bangkok since its price was very much cheaper than that in New Zealand.

4.1.2 Processing Methods

In general, the processing methods used in production of the meatball product, whether for laboratory scale experiments or for the production trial, were as in Figure 4.1.



* only for laboratory experiments (both in New Zealand and in Thailand)

** only for laboratory experiments (either at the final stage of the development in New Zealand or during the optimisation process in Thailand) and a production trial in Thailand

Figure 4.1 Process flow chart for production of the meatballs

Frozen boneless mutton was tempered before use at ambient temperature (ca 15 °C) overnight for 15 hr in New Zealand or at 4 °C for 48 hr in Bangkok. The tempered mutton,

boneless pork (or beef used at the beginning of formulation), and pork backfat (or mutton fat trimmings used at the beginning of formulation) were trimmed, to remove as much as possible, visible fat and/or connective tissue. The trimmed tissues were then cut into cubes of ca 2.5 cm. The fat tissue was then stored in a freezer to firm it before use. Flores et al. (1986) stated that grinding and blending of hot fat decreased binding in restructured beef roasts. These authors hypothesised that fat-smearing over the lean surface occurred, thus reducing myosin extraction which in turn resulted in decreased binding. All cut tissues were then separately ground through a grinder. The ground mutton muscle tissue, pork (or beef) muscle tissue and pork (or mutton) fat were mixed together with appropriate ingredients. However, this mixing step was omitted during the production trial in Thailand since there was no mixer available at the Department of Livestock Development, Ministry of Agriculture and Cooperatives.

The mix was then chopped with ice until a paste-like material was obtained and it was stored in a chiller or a refrigerator at 2-4 °C overnight (ca 15 hr). On the following day, the mix was manually pressed through a sausage stuffer to form into cylinders which were then segmented and manually formed into balls of ca 3 cm. However, it was not possible to store the mix after chopping during the production trial in Thailand; and to form the mix into cylinders before making the balls. The balls were manually formed by the expert officers at the Department.

The meatballs were then cooked, firstly in hot water at 65-70 °C until they floated (ca 9 min), and then at 85-90 °C until they refloated (ca 1 min). The internal temperature of the meatballs after cooking was 68 °C. The meatballs were finally cooled in cold water at 20 °C for 2 min. The prepared meatballs were then strained, packed in polyethylene bags and stored in the chill room or the refrigerator at 2-4 °C until used in subsequent tests. In addition, for the final laboratory experiments during the final stage of the development process in New Zealand and during the optimisation process and the production trial in Thailand, the meatballs were crumbed by manually dipping them in blended whole egg and crumbing with bread crumbs before packing.

Due to availability and accessibility for use, the following equipment and processing parameters were used in production of the meatballs.

Processing Step	Stage of Development	Equipment and Processing Parameters
Grinding	Formulation in New Zealand	Kenwood Chef (model A703C) through a 10 mm perforated plate at speed one.

	Laboratory experiments in Thailand Production trial in Thailand	Kenwood (model A9070) through a 8 mm perforated plate at speed one. Strommen grinder through a 2mm perforated plate.
Mixing	Formulation in New Zealand	Kenwood Chef (model A703C) assembled with the K-shape blade, mixed until the components were evenly mixed, 1.5 min.
	Laboratory experiments in Thailand	Kenwood (model A9070) assembled with the K-shape blade, mixed until the components were evenly mixed, 1.5 min.
Chopping	Formulation in New Zealand	Scharfen bowl chopper (model 60302) assembled with 4 sickle knives (20 cm apart diagonally between the tips) rotating at 16.3 rpm until the paste-like material obtained. Total chopping time - 6 min (stopped after 3 min to scrape down the mix from the sides of the bowl). Final temperature after chopping 12 °C.
	Laboratory experiments in Thailand	National Food Processor (model MK-5070N) until the paste-like material obtained. Total chopping time - generally 3 min (stopped twice at the end of each minute to scrape down the mix from the sides of the bowl). Final temperature after chopping 16 °C.
	Production trial in Thailand	Muller Food Processor assembled with 6 sickle knives (36cm apart diagonally between the tips) until the paste-like material obtained. Final temperature after chopping 16 °C.
Forming into cylinders	Formulation in New Zealand	Sausage stuffer.
	Laboratory experiments in Thailand	Kenwood (model A9070).
Ball forming	All stages	No equipment used. Manually formed.

4.2 TESTING METHODS

4.2.1 Introduction

The quality evaluation in this research project was conducted differently in various stages of the product development process depending on the aim of each particular experiment.

Methods and procedures for quality evaluation in this project were divided into two groups, namely objective tests and subjective tests.

4.2.2 Objective Tests

In all objective tests, replications were made.

4.2.2.1 Weight

The weights of any objects were measured by electric balances and expressed in metric units, i.e. g or kg.

4.2.2.2 Percentage Cook Yield

The percentage cook yield of the meatballs was determined by weighing the raw meatballs and the meatballs after cooking, cooling and then straining for 10 minutes at ambient temperature, and was expressed as follows:

$$\% \text{ Cook Yield} = \frac{\text{weight of the meatballs after cooking, cooling and straining}}{\text{weight of the mix before cooking}} \times 100$$

Percentage cook yields of the meatball samples were determined for each batch, from the two treatment replications.

4.2.2.3 pH Value

Twenty grammes of finely chopped sample were blended with 100 ml of deionised water in a Kenwood blender (model A703C) at speed one until well blended, i.e. 1 min. The pH of the suspension was then measured by using a pH-meter (Triac, model DPH-1). The pH values of the meatball samples were measured for the two treatment replications.

4.2.2.4 The Instron Compression and Shear Force

Normally, the consumer evaluated the textural characteristics of the meatballs by compressing and chewing during mastication. To relate this condition to the objective tests, compression and shear were the modes considered to be appropriate. The forces needed for compressing or shearing the product were measured by using the Instron Universal Texture Meter. The test description and parameters used are shown below.

Type: Instron Universal Texture Meter (model 1140, Instron Ltd., Buckinghamshire, England)

Sample: Meatball (ca 3 cm in diameter, with a weight of ca 20 g)

Fixture: Compressing - A flat support plate (9.9 cm in each side) to hold the meatball in place and a flat square plunger plate (6.7 cm in each side) to compress the sample.

Shearing - An anvil with a groove to hold the meatball and allow for passing of the shear blade, and the Warner-Bratzler (W-B) shear blade to shear through the sample.

Crosshead speed: 50 mm/min

Chart speed: appropriately varied but in the range of 50-200 mm/min

Force range: appropriately varied but normally 50 Newton

The parameters measured from the force deformation curves were:

* the compression force which was expressed as the maximum force, in Newton, to vertically compress the sample until the reduction by 33.33% in its diameter was reached.
* the compression slope which was expressed as Newton/mm by measuring the slope of the compression curve.
* the initial yield force which was expressed as the force, in Newton, at which the sample first began to yield after being compressed, i.e. the first major inflexion on the compression curve.
* the W-B shear force which was expressed as the maximum force, in Newton, required to vertically shear through the sample until it was fractured.
* the W-B shear slope which was expressed as Newton/mm by measuring the slope of the shearing curve.

The stored meatballs were taken from the chiller and tempered to approximately 15 °C before being used for the Instron testing. The above parameters were measured for 12 meatball samples for each treatment, six from the first replicate and six from the second replicate.

4.2.2.5 Chemical Analyses

The chemical compositions of the samples were determined according to the official methods of AOAC (1984) as follows:

Moisture	method 24.002
Fat	method 18.044
Protein	method 7.015
Ash	methods 24.009 and 31.012
Crude fibre	method 7.066
Carbohydrates	by difference.

4.2.3 Subjective Tests

The major sensory testing methods used and organising the sensory tests are discussed below.

4.2.3.1 Ideal Profile Testing

To develop a new product or improve an old one, it is particularly important to evaluate the sensory characteristics of that product to ensure that the features which are inherently important in the consumers' perception of the product are being attained. One of the techniques used for evaluating the product characteristics is the ideal profile testing. In this study, the ideal profile ratio method followed the one developed by the Food Technology Research Centre, Massey University (FTRC,1984; Beausire and Earle 1986).

In the questionnaire, a horizontal line scale (10 cm) was used and it was an interval scale which was partitioned at every 1 cm. However, only the numbers 0, 5, and 10 were put at the left end, the middle and the right end of the scale respectively. The scale was also labelled at each end with appropriate words or expressions. One line scale was used for each sensory attribute and the panelist indicated, by marking a vertical line across the horizontal line scale, the intensity of the sensory attribute of a product compared to its individual "ideal" score. The ideal could be either a "fixed" point on the line scale or a "floating" point which the panelist freely placed at the position wherever he or she wished. Floating ideals were used as a preliminary step to "fixed" ideals and in one-off studies where no fixed ideal had been previously determined.

To analyse the results, the sample score and the ideal score for each sensory attribute were measured and recorded. The ideal ratio score was obtained by dividing the sample score by the ideal score. For example, if the distance of the sample score for saltiness was measured at 2.0 cm and that of the ideal score was at 4.5 cm, then the ideal ratio score was calculated as

$$\text{Ideal ratio score} = \frac{2.0}{4.5} = 0.44$$

By calculating the ideal ratio score in this manner, the data were standardised for each attribute between panelists who might use different parts of the scale. The ideal ratio scores given by all panelists were then averaged for the mean ideal ratio score for each attribute. The mean ideal ratio score indicated whether and in what way the product being developed should be altered for each attribute that was profiled.

Where the:
Mean ideal ratio score = 1.0, the product did not require changing for this particular attribute.
Mean ideal ratio score > 1.0, a decrease in strength or intensity of the attribute is needed.
Mean ideal ratio score < 1.0, an increase in strength or intensity of the attribute is needed.

4.2.3.2 Ranking

Ranking as described by Larmond (1982) was used as a technique during screening of the product ideas. It was performed when holding a consumer panel discussion among six graduate Thai students at Massey University. Each panelist was asked to rank for preferences of the product ideas from 1 - like most to 7 - like least.

4.2.3.3 Triangle Test

The triangle test as described by Larmond (1982) was the sensory method used to determine a difference between samples. The panelist received three coded samples. The panelist was told that two of the samples were the same and one was different and was asked to identify the odd sample. All samples were randomly distributed and identified only by three digit random numbers.

Analysis of the results of triangle tests is based on the probability that if there is no detectable difference, the odd sample will be selected by chance one-third of the time. The results of a triangle test indicate whether or not there is a detectable difference between two samples. Higher levels of significance do not indicate that the difference is greater but that there is less probability of saying there is a difference when in fact there is none. The levels of significance were established according to Larmond (1982).

4.2.3.4 Category Scaling Tests

Category scaling methods have long been used as one of the major methods in sensory evaluation of food acceptability in the form of the 9-point hedonic scale (Peryam and Pilgrim, 1957; Pearce, 1980; Pearce et al., 1986 and Recio et al., 1987).

Two techniques of category scaling were used in this study. They included hedonic scaling and descriptive category scaling.

Hedonic Scaling. Larmond (1982) stated that the term "hedonic" is defined as "having to do with pleasure" therefore it should only be used in connection with scales in which the panelist expresses a degree of liking or disliking. The most commonly used scale for preference testing is the 9-point hedonic scale. However, a 7-point hedonic scaling was used in this research.

Descriptive Category Scaling. The descriptive category scaling technique used in this study followed the method used by Shand et al. (1985). A descriptive category scale was designed for each sensory characteristic of the product being developed. Each panelist rated each attribute in the samples using eight point descriptive category scale. For example, each panelist rated with a score of 8 for extremely firm and with a score of 1 for extremely soft in accordance with firmness of the product being tested.

4.2.3.5 Sensory Testing Organisation

In this research project, sensory evaluation was performed by four types of sensory panels, namely, laboratory panel, household consumer panel, focus group panel and consumer test panel. These four types of panel are discussed below and further information is given in the following chapters associated with each type of sensory panel evaluation.

Laboratory Panel. For a laboratory panel sensory testing, the panel members were those who were interested in participating in the sensory project and were available for sensory testing when needed. Also, these panelists were capable of detecting the sensory factors under test. The laboratory panel in Thailand, when performing preliminary experiments concerning some potential products, consisted of 12 staff members and graduate students at the Food Technology Department, Chulalongkorn University. The laboratory panel in New Zealand comprised of 8 Thai graduate students at Massey University.

Before the test, the panelists were given an orientation on the sensory testing method. Each panelist was asked to read the instructions in the questionnaire before performing the test. The meaning of each sensory attribute term in the questionnaire was explained to each panelist so that any error in panel interpretation could be avoided. If any panelist did not fully understand any sensory attribute term, it was explained until that term was clearly perceived. However, explanation of sensory terms in the questionnaire was done only at the beginning of the sensory testing in the first few sessions. When the panelists were accustomed to all the sensory attribute terms used, it was not necessary to repeat doing this.

In general, any kind of laboratory sensory tests was performed in a separate room from the preparation area, partitioned into separate booths, with adequate ventilation. Lighting for the booth area was uniform and provided by overhead daylight fluorescent lamps.

Preparation of the samples was different depending on each specific test. In general, the samples were prepared for the panelists either by boiling or by deep fat frying. For boiling, the meatball samples, which had been stored in the chill room at 2 °C, were cooked in boiling water (100 °C) for 2 min before serving. For deep fat frying, the meatball samples

were fried in vegetable cooking oil at 200° ± 5 °C for 2 min until the outer surface was golden brown before serving.

Presentation of the samples was done by serving them in odourless, white porcelain bowls situated on a white plate along with stainless steel knife and fork. Each panelist was provided with a glass of warm water (40 °C) to rinse his or her mouth and a serviette. A specific type of questionnaire, related to each sensory method under test, was also given to each panelist. In general, there were 4-5 samples, as a maximum, given to each panelist during any sensory testing. One meatball, representing each sample, was approximately 20 grammes. The samples were always coded with three digit random numbers and were served to the panelists in random order. Any sensory testing was usually performed between 10.00-12.00 a.m. or between 2.00-4.00 p.m., the times which suited most panelists.

Household Consumer Panel. This type of sensory evaluation panel was used after the formulation of the product in New Zealand. It was used to test whether the product was acceptable to the Thai consumers. The formulated product was distributed to 17 Thais, living in separate houses in Palmerston North, who had facilities to cook the meatball product and could test them in a household situation. Most of the Thais were graduate students at Massey University and the rest were working persons.

No orientation or training of the panel was done since it was decided to investigate the responses from the group of these Thai consumers whether they liked or accepted the formulated product or not. Since the conditions of preparing and presenting the samples were not expected to resemble those used in the laboratory sensory panels, an instruction sheet also accompanied the questionnaire, only to give adequate information on how the consumers had to prepare and test the samples. The consumers were asked to prepare the samples by frying. Hedonic scaling was used as the sensory testing method.

Focus Group Panel. This type of sensory panel was used to optimise the formulation and improve sensory characteristics of the product before the final formulation could be obtained for a production trial and a consumer test in Thailand. The first group of focus group panelists was 6 staff members from the Department of Home Economics, Kasetsart University, Bangkok. When the product with desirable sensory characteristics was obtained, it was retested with a new focus group panel. This new group consisted of 6 graduate students at Food Technology Department, Chulalongkorn University. The meatball samples were prepared for serving by deep frying. The ideal profile testing was the sensory method used. After any ideal profile testing session had finished, another session was organised to have a discussion among the panelists to obtain their ideas as to

how to improve the sensory characteristics of the product. All panelists were encouraged to give their ideas by conversation with the researcher and among themselves. The conversation during any discussion session was recorded on a tape recorder.

Orientation on the ideal profile testing method and explanation of sensory attributes were also done similarly to those used for the laboratory panel.

Consumer Test Panel. The consumer test panel was the important and the final sensory evaluation panel performed in this study. It was used to investigate the preference or acceptability of the developed product among the target Thai consumers in the Bangkok area. Hedonic scaling questionnaires accompanied with instructions for preparing (by frying) and testing the product were distributed to 200 households. In addition, a separate questionnaire was also given to each household specifically for the housewife to answer. This type of questionnaire was designed to investigate some necessary information concerning the developed product.

Once again, no orientation or training of the panel was done because this consumer test was designed for the real use or consumption of the developed product. Therefore, orientation or training was deemed unnecessary.

4.3 ANALYSES OF DATA

For subjective and objective tests, the scores or measured values for various characteristics of the samples, were subjected to analysis by the MINITAB (Ryan et al., 1976) to calculate the mean and standard deviation of each characteristic of the sample and compare the means by analysis of variance. This programme was also used in correlation and regression analyses. The levels of significance were determined according to Parker (1979) for correlation analysis and Steel and Torrie (1980) for regression analysis.

4.4 EXPERIMENTAL DESIGNS USED IN THE RESEARCH

The experimental designs used in the research project are as follows.

4.4.1 Mixture Design

The mixture design was used in the experiments for choosing types and levels of meats and fats to be incorporated with mutton in the meatballs (Chapter 5). In the general mixture experiments, the proportion of each component in the mixture had to be between 0 and 1 and the sum of the proportions of all the components had to equal 1.0 (Hare, 1979; Cornell, 1981; Snee, 1971).

$$\sum_{i=1}^{q} X_i = 1.0 \qquad 0 \le X_i \le 1.0$$

In the experiments performed, it was not possible to explore the total range of 0-1.0 on all components. Therefore, there were upper and lower limits specified for the different components.

$$0 \le a_i \le X_i \le b_i \le 1.0 \qquad i=1,2,3.....$$

Thus, the proportions of each component were constrained within the specific boundaries and the design was available by choosing those points located on the intersections of the constraint boundaries. The design was done by also adding the overall centroid (an average of all intersection points).

4.4.2 Factorial Design

The factorial design was used in the experiments for the texture development (Chapter 6). A class of designs that are of great practical importance is two-level factorial designs (Box et al., 1978). To perform the factorial design, the author selected a fixed number of 'levels' (or 'versions') for each of a number of variables (or factors); that is, the number of levels was two and the number of variables was three. Therefore, there were 2^3=8 experimental runs used in the whole experiment.

4.4.3 Plackett and Burman Design and Fractional Factorial Design

The Plackett and Burman design and the fractional factorial design were used for the flavour and aroma development (Chapter 7). Screening of ingredients often requires consideration of a large number of possible variables. An efficient method for screening ingredients to select the more important ones is frequently desired. One such method, as cited by Stowe and Mayer (1966), was a Plackett and Burman design which is reputed to be the most efficient for screening large numbers of variables. Stowe and Mayer (1966) listed the first row of the designs for 7, 11, 15, 19, 23 and 31 variables by using 8, 12, 16, 20, 24 and 32 runs respectively. In the experiment, a 7-variable design was used. The first row for the eight runs to evaluate seven factors by a Plackett and Burman design is:

+ + + - + - -

where + signifies the high level of a variable and - the low level.

For any particular value of N - the number of the experimental runs - the appropriate row is selected and written down as the first row. The remainder of the matrix is generated by shifting this row cyclically one place N-2 times and then adding a final row of minus signs. The result will be a matrix containing N rows and N-1 columns.

Normally at least two factors are used as 'dummy' factors to determine the significance of the effects. In the experiment performed, only one factor was used as a dummy because six variables had to be tested. The next design to include more dummies would have had twelve runs. The objective of the experiment was only to roughly screen for suitable spices. Therefore, an eight run design was used.

Another experimental design which has been frequently used for studying the effects of a high number of variables is a fractional factorial design. Winer (1971) stated that the number of treatment combinations in a complete factorial set became quite large as the number of factors increased. The numbers of experiments required by a full 2^k design, when k was the number of factors, increased geometrically as k was increased. When k was not small, information on the main effects of the factors or the variables but only a limited number of the interactions could be obtained by performing a fraction of the full factorial design (Box et al., 1978). A one-half or one-quarter of the full factorial design have often been used. In the study, only sixteen runs, which were a quarter of a full 2^6 factorial were performed. The sixteen treatments assigned for combination of the factors followed the fractional design as proposed by Cochran and Cox (1957). The design was chosen in such a manner that the alias of any main effect was interaction among at least three factors and some of the aliases of two factor interactions were themselves two-factor interactions. By choosing this design, the estimates of all six factors and of some two-factor interactions could be furnished.

4.5 CHAPTERS RELATED TO THE METHOD OF THE PRODUCT DEVELOPMENT PROCESS IN THIS STUDY

The following chapters elaborate on the experiments and their results in the process of development of a mutton-based processed meatball product for the Thai consumers starting from selection of meats and fats to be incorporated with mutton until it ended with the developed product being consumer tested.

Chapter 5 - the study of the types of meats and fats to be used in production of the meatballs. A mixture design experimentation was used to compare different blends of mutton, beef, pork and mutton fat, and pork fat.

Chapter 6 - the development of the texture of the meatballs, using a factorial design.

Chapter 7 - experimental designs including a Plackett and Burman design and a fractional factorial design to obtain the formulation with desirable sensory characteristics, especially flavour and aroma.

Chapter 8 - optimisation of the formulation by using focus groups in Thailand to improve the product's sensory characteristics.

Chapter 9 - the final product testing by a consumer test in the Bangkok area.

Chapter 10 - a discussion and conclusion of the research project.

CHAPTER 5
SELECTION OF MEATS AND FATS FOR INCORPORATION WITH MUTTON TO PRODUCE MEATBALLS

5.1 INTRODUCTION

The preliminary experimental results, showed that meatballs could be made from mutton for the Thai consumers, but that mutton, due to its strong odour and flavour and to its connective tissue, could not solely be used in manufacturing. Therefore, the experiments were designed to investigate what other kinds of meats and fats could be incorporated with mutton to produce the meatballs.

5.2 LITERATURE REVIEW

5.2.1 Use of Mutton in Processed Meat Products

There has been limited research concerning processed meat products made from mutton. Carpenter et al. (1966), using composite meats including beef, pork and mutton in frankfurters, found that flavour preference was given to the formulation containing the smallest percentage of mutton (10%) at the lowest mutton fat level (10% mutton fat in 23% total fat). For overall acceptability, the formulations with all pork at high fat level (27%) or all mutton at high fat levels (23-25%) were ranked lowest; with 100% mutton, there was a typical residual fat taste in the mouth which most people found objectionable. The author concluded that an acceptable frankfurter could be produced from a combination of beef, pork and mutton and that mutton was acceptable in amounts of 10% of the meat. Baliga and Madaiah (1970) prepared Indian sausages from emulsions containing various proportions of mutton and fillers and concluded that, for good texture and stability after cooking, the optimum level of lean mutton prepared from a composite sample obtained by deboning a whole mutton carcass was 43% and prepared from the boned leg of mutton was 46%. Anderson and Gillet (1974a) reported that mechanically deboned mutton had higher emulsifying capacity than manually deboned bull or cow rounds. Anderson and Gillet (1974b), in a further study on the acceptability of mutton in salami, concluded that high levels of mutton (60-85%) could be as successfully utilised as beef or pork, providing pork was the complementary meat source and the level of mutton fat was kept below 10% in the final product. Wenham (1974) concluded that lean mutton was potentially a useful source of raw material for ground meat patties. With up to 10% mutton fat added, the patties increased in acceptability, but declined to an unacceptable level at higher additions (20% and 30%). The lean patties were improved by adding beef fat, reaching a maximum of acceptability at the much higher fat level of 30%. The author suggested that there was a possibility, through both carcass selection for low fat and heavy fat trimming, of upgrading

mutton by blending it with ground beef. Selvarajah et al. (1974), in an experiment on canned mutton sausages containing 40, 45, 50 and 55% of lean mutton, with respectively 13.3, 15.0, 16.7 and 18.3% of added mutton fat, found that there was no splitting and/or disintegration of the sausages containing 55% lean stored at ambient temperature. There was fat separation to a varying extent and this was least at 45% lean. The water absorption was also highest at 45% lean. The authors concluded that sausages containing 50% lean mutton with 16.7% added mutton fat were the most suitable for canning. Marshall et al. (1977) concluded that use of 10, 25 or 40% of mechanically deboned (MDB) goat or mutton had little effect on processing characteristics and palatability attributes of frankfurters in spite of their strong flavour and odour. For instance, addition of 10, 25 or 40% of MDB mutton increased juiciness in comparison to control frankfurters comprised of manually deboned beef and pork and the sausages containing 10 or 25% MDB mutton were more desirable in texture than the controls. The results of Chattoraj et al. (1979) showed that sheep muscle proteins have a higher emulsion capacity than muscle proteins from pork. Akatsuka (1984) found that partially hydrolysed egg white was effective in improving the flavour of mutton/pork sausages. Turgut (1984) compared the emulsifying capacity and stability of goat, waterbuffalo, sheep and cattle muscle proteins and concluded that goat, waterbuffalo, and sheep muscle were as good as cattle muscle for sausage manufacturing, and sheep muscle had a higher extractable protein content. Bartholomew and Osuala (1986) used mutton meat as the main ingredient in different processed meat items to obtain prototype products lacking objectionable mutton off-flavours and found that the objectionable mutton flavour was apparently reduced by reducing mutton fat to a level of 10% or less. Prasad et al. (1987) evaluated the influence of monosodium glutamate (MSG) and lamb on characteristics of restructured mutton roasts. The characteristics of restructured mutton and lamb roasts made with MSG were not distinguishable from control roasts (without MSG), with 100% lamb roasts and roasts with increased proportions of lamb having better "bind" than 100% mutton roasts. Bushway et al. (1987) concluded that combinations of mutton and fowl (older layers) might be successfully used in formulating fresh breakfast sausages that would be acceptable to the consumers. No significant differences were found by judges in juiciness, flavour or texture between the samples formulated with 50% mutton:50%fowl or 67% mutton:33% fowl and the control formulated with pork; all the three formulations had comparable fat contents of approximately 30%.

According to the past research, it is apparent that mutton can be used in manufacturing of acceptable processed meat products because it contributes desirable functionalities. However, a number of researchers suggested that mutton not solely be used but rather be incorporated, at varying proportions, with other kinds of meats to result in products with good characteristics. For desirable textural characteristics, mutton as high as 67% (Baliga and Madaiah, 1970; Selvarajah et al., 1974; Bushway et al., 1987) or 25% mechanically

deboned mutton (Marshall et al., 1977) could be used. For desirable flavour, the researchers suggested the content of mutton fat in the finished products be kept within the maximum level of 10% (Carpenter, et al., 1966; Bartholomew and Osuala, 1986). Other researchers also suggested that reduction of mutton flavour was achieved by reducing mutton fat to a level of 10% or less in processed products (Anderson and Gillet, 1974b; Wenham, 1974; Brennand and Mendenhall, 1981). Mutton imparted a strong odour and flavour to the finished products since its fats contained both species-related flavour components and high levels of saturated fatty acids (Cramer, 1983) which resulted in a residual fat taste in the mouth which most people found objectionable. Researchers agreed that the meaty aroma comes from the lean portion of meat while species-specific flavours originate in or are deposited in the fat portion (Pearson et al., 1973; Wasserman and Spinelli, 1972). For overall acceptability, it was likely that as high as 60-85% mutton could be used (Anderson and Gillet, 1974b). In addition, mutton also contributed desirable functional properties such as higher extractable proteins, emulsifying capacity, increased juiciness and increased yield in the processed products.

Therefore, there was an indication that mutton could possibly be used at relatively high proportions in production of acceptable processed meat products but the mutton fat content should be maintained at a relatively low level.

5.2.2 Meatball Products

A limited amount of research on meatball products was available. Researchers studied effects of added proteins, binders, or flavourings on various characteristics of the products. Chang (1985) reviewed the process improvement for manufacturing the Chinese meatball called Hsinchu which was probably similar to the commercial meatballs in Thailand. The meatballs were made from pork using salt (2%), sugar (3%), monosodium glutamate (0.3%) and sodium polyphosphate (0.3%); the amounts were based on the total weight of the meat mixture. They were cooked in boiling water. The author suggested the use of pre-rigor mortis meat as raw material since it has superior water holding capacity which is closely related to emulsifying ability and these two properties are associated with each rigor state, or with the rate of post mortem change (Forrest et al., 1975). In addition, the author also recommended that pale, soft and exudative (PSE) meat should not be used for making the meatballs. It was indicated by the author that the temperature during the extraction of myofibrillar proteins and emulsification was very critical in meatball processing. A lower temperature of 2-4 °C was required during protein extraction, and a higher temperature of 13-15 °C for the following emulsification. If a temperature rise occurred uncontrollably during processing, the protein might be denatured, causing breakdown of the emulsion. Generally, the temperature during cutting could be controlled by adding ice or using frozen meat. It was also suggested that the ratio of lean to fat was three to one. If the fat added

was more than the level which could be emulsified by the meat proteins, there would be a significantly higher cooking loss, and the product would not have good binding. Regarding the process improvement, the author stated that the blending method was suitable for small-scale production whilst the silent cutter method was suitable for mass production; the conventional pounding method would probably be gradually abandoned because of its low productivity, noisiness and danger during processing.

Some other research involved meatball products made with variations of ingredients. Hermansson (1975) added various vegetable and dairy proteins to Swedish meatballs containing 50% meat (pork and beef) and other ingredients (potatoes and golden bread crumbs, dried milk, onions and spices, water). The author found that although only 4% protein was added, significant changes were measured both by instrumental and sensory evaluation. Junnila et al. (1981), in an attempt to make use of by-products of brewing and alcohol production, used brewer's grains, brewer's yeast and distiller stillage in Finnish meatballs containing approximately 54% meat (pork and beef) and other ingredients (dry bread crumbs, salt, pepper and water). These authors found that meatballs in which minced meat was partly replaced by brewer's grain differed substantially in organoleptic scores from the control (without added test material); the difference being greater the higher the replacement level (maximum at 30%). The replacement of minced meat in meatballs by brewer's grain lowered the overall organoleptic quality. For brewer's yeast, the difference in organoleptic scores between the samples added with test material and the control, also increased with an increasing replacement level. In addition, a distinct off-flavour was observed at 10%. Meatballs in which minced meat was partly substituted by distiller's stillage differed only slightly from the control at 1% and 5% replacement levels.

According to the research discussed previously, a number of meatball products were made by using conventional types of meat, mainly beef and pork, and with variation of added ingredients. The proportion of meats used in these products was approximately one half of the total weight of the mixtures; other ingredients being carbohydrates, binders, protein substitutes, and flavourings.

5.2.3 Scaling for Sensory Evaluation

Generally, three major types of scales have been used in sensory evaluation: category, linear and ratio scales.

O'Mahony (1979) stated that category scaling was a simple technique in that judges were asked to place the intensity response on a monotonically increasing scale. However, care had to be taken not to use too few categories or else the scale would not differentiate well enough. Too many categories had to be avoided also because the categories would not

really be different. Miller (1956) suggested that the optimum number of categories that a human could simultaneously manipulate was of the order of 7 ± 2. Cooper (1981) noted that category scales have been widely used because of their diversity and ease of use and because they are conceptually simple for both the experimenter and the panelist. However, descriptive category scaling, generally employed for the descriptive sensory assessment of meat, might have shortcomings in that panelists might be reluctant to use extremes of the scale and this 'category end effect' might bias the ratings (O'Mahony, 1979). Moskowitz (1983) stated that avoidance of using extremes on the fixed point scale occurred because taste panelists showed conservative behaviour. They often declined to use the end points of the scale unless they encountered a stimulus which seemed so good or so poor that they felt they had to use those end points.

Line scales have also been used under widespread circumstances in sensory evaluation (Lai, 1987). The semi-structured line scale consists of a line scale of a specific length, with markers half an inch from each end, and a verbal anchor at each end. These scales have become popular in the sensory evaluation of non-food products (Lawless and Malone, 1986). From observation, it is apparent that line scales are extensively used in the food industry.

The ideal profile technique was developed and adopted for use in product development by FTRC (1984). Basically, this technique used the line scales together with the basic principles of the 'profile' method to evaluate the sensory attributes of the samples comparing them with the 'ideal' characteristics. In the 1940's, flavour studies at Arthur D. Little, Inc., motivated the development of the flavour profile which was founded on the natural process of evaluating and comparing flavours by describing their impressions - either as a whole or by individual characteristics. The flavour profile method was formalised and officially introduced to the food field in 1949 (Cairncross and Sjostrom, 1950). The profile aimed at complete flavour information - not only information about differences but also definition of differences, similarities, and likenesses, and it could be defined as a semiquantitative descriptive analysis of flavour (Caul, 1957). The profile method was later applied to texture following the general principles of the flavour profile scheme (Civille and Szczesniak, 1973). A review of sensory methods of texture assessment, including profiling, was given by Abbott (1972).

Cooper et al. (1988) stated that researchers and marketers engaged in new product development have for some years perceived a need to identify the target consumers' "ideal" product. When scaling techniques were used, consumers were asked to indicate the "ideal" product on prespecified attributes (Szczesniak et al., 1975; Moskowitz et al., 1977). Although these ideal profile techniques have been evident for a number of years, it is

apparent that they have not significantly been used in product development. In the late 1970's Earle (unpublished data) investigated the relationship between product sample scores and the ideal product profile. Initially, the ratios of the sample scores to the ideal scores were used to decide the size and direction of changes required to reach the ideal product. Further development by Beausire and Earle (1986) described the technique called 'optimum location profile' which could be used, in factorial experimental designs, to guide the formulation for the ideal product. Use of the ideal ratio scores has continuously been used at Massey University for product development projects in both New Zealand and in South East Asia. The ideal product profile has been used with both large and small consumer panels throughout the product development process from the first product concept to the final consumer test (Sinthavalai, 1986; Lai, 1987).

Sinthavalai (1986) noted that three types of ideal scores could be used in assessing the product's characteristics. This author defined the first type, 'ideal absolute score' as the length in centimetres from the zero end of a linear scale to the point assigned for the strength or intensity of the ideal characteristic in the product. The 'ideal interval score' was defined as the score obtained by subtracting the ideal score of each attribute from its sample score. The 'ideal ratio score' was calculated by dividing the sample score by the ideal score for each attribute.

The ideals could be either 'floating' ideals or 'fixed' ideals. In floating ideals, the consumer was free to place the ideal position wherever he or she wished on a line scale. Floating ideals were used as a preliminary step to fixed ideals at the very beginning of the project when ideals were being determined by the consumers. In any long term product development project, consumers often had difficulty remembering the positions of the ideals in previous testing. In these circumstances, Lai (1987) showed that panelists responded enthusiastically to the suggestion of fixing the ideals for the remainder of the project.

Cooper et al. (1988) stated that the use of ideals either in hedonic scales or in a scale when 'absence' was the ideal, presented problems. A score of zero for the ideal caused particular problems in calculating the ideal ratio score since the ratio of the product to the ideal score was infinity. This could be overcome by assigning '0' to the 'extreme' end of the scale and '10' to the 'absent' end of the scale at the analysis stage. Alternatively, in studies where an ideal had been fixed at '0', an approximation of 0.1 was used in the calculation (Lai, 1987).

Magnitude estimation, a technique whose scale is believed to have ratio properties, refers to a class of psychophysical scaling procedures which were developed by S.S.Stevens at Harvard University in the 1950's (Moskowitz, 1977). It has been popularly used in food research and product development (McDaniel and Sawyer, 1981). However, its use appears to have decreased in the United States of America in recent years.

Lai (1987) summarised advantages and disadvantages of the previously mentioned scaling techniques for sensory evaluation. There have been several studies comparing reliability, sensitivity and ease of use of category scales, line scales and magnitude estimation. Giovanni and Pangborn (1983) compared graphic scales which were line scales with magnitude estimation for the measurement of taste intensity and degree of liking of beverages. These authors concluded that both graphic scaling and magnitude estimation were reliable, useful procedures which should be selected and used carefully depending on the objective of a particular experiment. Shand et al. (1985), in their comparative studies examining the use of category scaling, line scaling and magnitude estimation for the descriptive assessment of beef, found that category scaling was the most sensitive and line scaling, the least sensitive in detecting differences in steak quality attributes. Magnitude estimation was as sensitive as category scaling to most treatment differences. This was in contrast with the past findings by the other workers (Cooper, 1981; McDaniel and Sawyer, 1981; Giovanni and Pangborn, 1983).

McDaniel and Sawyer (1981) compared magnitude estimation with category scaling and concluded that there was little difference in the judges' ability to use either method. However, there were large differences in other criteria. The use of magnitude estimation resulted in far more panelist-sample interaction, whereas use of category scaling resulted in more panelist and replication variability. Cooper (1981), in a study of New Zealand commercial whole milk powders, compared category scales with magnitude estimation scales and also interval scales using a number of criteria. The author found that the magnitude estimation scale was the least effective. The category scale was easy to use and appeared sensitive to changes in the samples. To test reliability, some authors compared the different scales by comparing the values from one scale against another. Cooper (1981) found significant linear relationship between category and linear scales for physical attributes of milk powder, but the scales correlated less closely with magnitude estimation.

From the viewpoint of unfamiliarity of the panelists to the scales, ease of use is an essential criterion. If a panelist was not comfortable with the task of scaling, sensory performance might be affected (Shand et al. 1985). Some authors (Cooper, 1981; Lawless and Malone, 1986) reported that the line scale was the easiest for the panelists to understand and use, closely followed by category scales, while magnitude estimation was the most difficult. However, Shand et al. (1985) indicated that the panelists preferred category scaling over both line scaling and magnitude estimation, with line scaling being ranked intermediate in preference.

Different scaling techniques have been used in sensory evaluation of foods by numerous researchers. Each scaling technique has both advantages and disadvantages. Some

workers found one specific scaling more superior than the others whereas the other workers found the opposite. Choosing of each scaling for sensory evaluation of foods seemed to depend mainly on sensitivity, reliability and ease of use.

5.3 THE EXPERIMENTATION

No reported research was found on the use of mutton in meatballs and therefore it was desirable at this stage of the study to verify the types and proportions of other kinds of meats and fats which should be incorporated with mutton to produce the meatballs. It was decided firstly to study the effects of meats and fats on the texture of the meatballs in order to find whether mutton could be incorporated with beef or pork to give the texture desired by the Thai consumers.

Mutton lean was incorporated with beef or pork lean and mutton or pork fat in the study. Since the proportions of mutton lean, beef or pork lean and mutton or pork fat added up to 100% of the total weight of the meat and fat mixture, a mixture design was used to investigate the effects of these meat and fat components on the texture characteristics of the meatballs. Other ingredients, which are normally used in commercial meatballs in Thailand, such as salt, tapioca starch, spices and condiments, were not used in the formulation. Ice, the only other ingredient, was used to control the temperature of the mixture during chopping to prevent breakdown of the emulsion.

5.3.1 Effect of Mutton Lean, Beef or Pork Lean and Mutton Fat on Characteristics of the Meatballs

5.3.1.1 Experimental Methods

For the purpose of this research, as much mutton as possible should be used in the finished product since it is a major meat. Mutton lean, beef or pork lean and mutton fat were the three components used in this study. Their respective ranges were chosen from recommendations in the literature and from the minimum amount of mutton that would give its economic use. Therefore, the ranges used were:

mutton lean	20-80%
beef or pork lean	20-80%
mutton fat	5-15%

Figure 5.1 shows the complete space available for the mixture design.

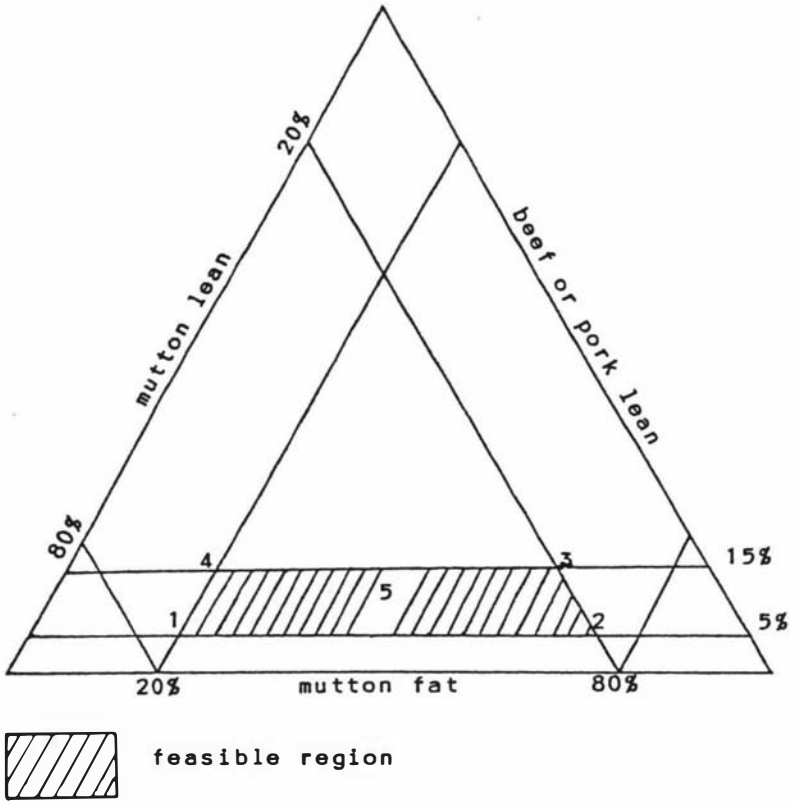


Figure 5.1 Complete mixture space showing feasible area for experimentation

The limits in the three components restrained the experimentation to the shaded feasible region with the following vertices.

Treatment	Mutton Lean (%)	Beef or Pork Lean (%)	Mutton Fat (%)
1	20	75	5
2	75	20	5
3	65	20	15
4	20	65	15
5	45	45	10

The meatballs were made, according to the above formulations, using the materials and methods described in Chapter 4 (sections 4.1.1 and 4.1.2). However, only flaked ice (20%, based on the total weight of meats and fat) was added during chopping; no other ingredients were added.

The prepared meatballs were tested by a group of eight Thai panelists who were graduate students at Massey University. These panelists were the ones who participated in the previous preliminary experiments. Therefore, they had adequate experience and were familiar with the sensory terms used in the evaluation. In this experiment, two types of scaling techniques were used in sensory evaluation of the meatball's characteristics - the ideal profile testing, IPT, (see Section 4.2.3.1) using only the ideal ratio scores, and descriptive category scaling, DCS (see Section 4.2.3.4). These two sensory evaluation

methods were performed according to the methods described in Section 4.2.3.5 (Sensory Testing Organisation). The meatballs were prepared for serving by cooking in boiling water (100 °C) for 2 minutes. Appendix 5.1 shows details of the questionnaires used for sensory evaluation.

In the objective tests, the percentage cook yield (Section 4.2.2.2) and the Instron texture properties (Section 4.2.2.4) were determined.

Analyses of the data were performed according to the methods in Chapter 4 (Section 4.3).

5.3.1.2 Subjective Evaluation Results

The sensory scores for all characteristics of the samples formulated with various proportions of mutton lean, beef or pork lean and mutton fat are shown in Table 5.1. The mean scores for the DCS and also the mean ideal ratio scores (the sample score:the fixed ideal score) as determined by the IPT are given.

For meatballs incorporating beef, although there were no significant ($p \leq 0.05$) differences in the means of each sensory attribute as determined by both the DCS and the IPT, the meatballs with lower levels of mutton fat (treatments 1 and 2) had higher scores for firmness and rubberiness than those with higher mutton fat contents (treatments 3 and 4). The meatballs with higher mutton fat content had higher smoothness, juiciness and oiliness scores.

For meatballs incorporating pork, at least one treatment mean for firmness, rubberiness and juiciness was significantly different ($p \leq 0.05$) from the others as determined by the DCS. Only mean scores for firmness were significantly different between the treatments as determined by the IPT. However, it was also evident that the meatballs with lower level of mutton fat had higher textural scores such as firmness and rubberiness than those with higher mutton fat content but the meatballs with higher mutton fat had higher smoothness, juiciness and oiliness scores.

In general, when the mutton lean content was high (75%) and the added mutton fat content was low (5%) the textural scores for firmness and rubberiness were high. When comparing between species of meats incorporated with mutton, there was a tendency that meatballs incorporating pork were superior to meatballs with beef in terms of sensory scores as determined by both the DCS and the IPT, for example higher firmness, smoothness and rubberiness scores. Pork has extremely fine texture, thus creating higher smoothness scores for the meatballs incorporating it. Anderson and Gillet (1974b) stated that pork trim was preferred over beef trim in combination with mutton to make salami products as indicated by higher panel scores on moisture, texture and calculated overall acceptability.

Table 5.1 Sensory attribute scores for meatballs formulated with various proportions of mutton lean, beef or pork lean and mutton fat (1)

Type of Meat Incorporated With Mutton	Sensory Method	Attribute	Treatment (2) 1	2	3	4	5
Beef	DCS	firmness	3.81 ± 0.07	4.31 ± 0.32	3.56 ± 0.19	2.94 ± 0.19	3.81 ± 0.82
		smoothness	4.38 ± 0.25	3.81 ± 0.44	4.63 ± 0.13	5.06 ± 0.32	4.19 ± 0.06
		rubberiness	2.75 ± 0.50	2.94 ± 0.06	2.50 ± 0.10	2.44 ± 0.19	3.13 ± 0.13
		juiciness	4.69 ± 0.31	4.63 ± 0.13	5.25 ± 0.50	5.31 ± 0.69	5.19 ± 0.81
		oiliness	4.13 ± 0.25	4.25 ± 0.13	4.25 ± 0.50	4.56 ± 0.57	4.56 ± 0.13
	IPT	firmness	0.60 ± 0.04	0.63 ± 0.05	0.53 ± 0.03	0.50 ± 0.02	0.56 ± 0.08
		smoothness	0.61 ± 0.01	0.61 ± 0.04	0.61 ± 0.02	0.65 ± 0.02	0.60 ± 0.02
		rubberiness	0.50 ± 0.07	0.55 ± 0.04	0.42 ± 0.03	0.47 ± 0.07	0.50 ± 0.03
		juiciness	0.80 ± 0.14	0.81 ± 0.05	0.91 ± 0.11	0.88 ± 0.18	0.89 ± 0.17
		oiliness	0.93 ± 0.11	0.95 ± 0.00	0.90 ± 0.13	0.98 ± 0.10	1.03 ± 0.00
Pork	DCS	firmness	4.44 ± 0.06^{b}	4.44 ± 0.31^{b}	3.06 ± 0.19^{a}	2.88 ± 0.00^{a}	3.63 ± 0.13^{ab}
		smoothness	4.06 ± 0.07	4.94 ± 0.06	4.69 ± 0.31	5.13 ± 0.13	4.31 ± 0.32
		rubberiness	4.56 ± 0.19^{c}	4.44 ± 0.06^{bc}	3.50 ± 0.25^{abc}	3.31 ± 0.32^{a}	3.44 ± 0.19^{ab}
		juiciness	3.81 ± 0.19^{a}	4.94 ± 0.06^{ab}	5.94 ± 0.19^{b}	5.75 ± 0.13^{b}	5.44 ± 0.44^{b}
		oiliness	4.19 ± 0.19	4.44 ± 0.06	5.06 ± 0.32	5.19 ± 0.31	4.81 ± 0.07
	IPT	firmness	0.65 ± 0.02^{cd}	0.66 ± 0.03^{d}	0.50 ± 0.02^{ab}	0.43 ± 0.02^{a}	0.54 ± 0.03^{bc}
		smoothness	0.62 ± 0.01	0.70 ± 0.03	0.64 ± 0.04	0.70 ± 0.02	0.60 ± 0.05
		rubberiness	0.66 ± 0.05	0.66 ± 0.02	0.51 ± 0.06	0.49 ± 0.07	0.51 ± 0.05
		juiciness	0.76 ± 0.02	0.90 ± 0.05	0.91 ± 0.01	0.92 ± 0.01	0.87 ± 0.05
		oiliness	0.97 ± 0.02	0.92 ± 0.05	1.07 ± 0.01	1.08 ± 0.13	0.91 ± 0.03

(1) The scores were given by eight Thai panelists. Values are means ± standard errors of the means between two replications. Any two means within the same row bearing one of the same letters in the superscripts are not significantly different at $p \leq 0.05$.

(2) Refer to Figure 5.1 for formulations.

5.3.1.3 Correlations of Subjective Evaluation Results

When the sensory scores were subjected to correlation analysis, some significant correlation coefficients were found and are shown in Table 5.2.

Table 5.2 Correlation coefficients between sensory characteristics of the meatballs

Type of Meat Incorporated with Mutton	Sensory Method	Attribute	Correlation Coefficient (1)
Beef	DCS	firmness - juiciness	-0.74 ***
		juiciness - oiliness	0.69 **
	IPT	firmness - juiciness	-0.75 ***
		juiciness - oiliness	0.69 **
Pork	DCS	firmness - rubberiness	0.89 *****
		firmness - juiciness	-0.81 ****
		firmness - oiliness	-0.75 ***
		smoothness - juiciness	0.63 *
		rubberiness - juiciness	-0.85 ****
		rubberiness - oiliness	-0.58 *
		juiciness - oiliness	0.70 **
	IPT	firmness - rubberiness	0.82 ****
		firmness - oiliness	-0.67 **
		smoothness - juiciness	0.65 **

(1) * = significant at $0.1 \geq p > 0.05$

** = significant at $0.05 \geq p > 0.02$

*** = significant at $0.02 \geq p > 0.01$

**** = significant at $0.005 \geq p > 0.001$

***** = significant at $p \leq 0.001$

It was evident that there were correlations among some sensory attributes of the meatballs especially those incorporated with pork. Firmness or rubberiness correlated negatively with juiciness or oiliness. Carpenter et al. (1966) found with frankfurters the positive correlation ($p < 0.01$) between juiciness and tenderness, an attribute opposite to firmness or rubberiness. As expected, firmness correlated highly and positively with rubberiness as shown by the r values of 0.89 (DCS) and 0.82 (IPT) for meatballs incorporating pork.

The correlations between the DCS and the IPT results were also determined and are shown in Table 5.3.

Table 5.3 Correlation between the descriptive category scaling and the ideal profile testing

Type of Meat Incorporated with Mutton	Attribute	Correlation Coefficient (1)
Beef	firmness	0.94 ****
	smoothness	0.78 **
	rubberiness	0.80 **
	juiciness	0.92 ****
	oiliness	0.92 ****
Pork	firmness	0.98 ****
	smoothness	0.91 ****
	rubberiness	0.97 ****
	juiciness	0.85 ***
	oiliness	0.60 *

(1) * = significant at $0.1 \geq p > 0.05$

** = significant at $0.01 \geq p > 0.005$

*** = significant at $0.005 \geq p > 0.001$

**** = significant at $p \leq 0.001$

The DCS and the IPT were related to each other as shown by highly significant coefficients, i.e. mostly at $p < 0.01$. Cooper (1981), in a study with milk powder also found significant relationships between category and linear scales for physical attributes.

5.3.1.4 Relationships between Sensory Attributes and Meatball Components

All the sensory attribute scores of the meatballs incorporated with either beef or pork lean were regressed against the three meat and fat components and their interactions. Only the regression equations showing the relationships between the sensory attributes, firmness and rubberiness, and mutton lean, pork lean and their interactions were significant. There was no significant relationship between sensory attributes and beef lean and mutton fat. Regression equations with significant coefficients are given in Table 5.4.

Table 5.4 Regression equations showing the relationships between sensory attributes and mutton lean and pork lean

Sensory Method	Attribute	Regression Equation(1)	R^2x100(%)	t-Ratio(2)
DCS	firmness	= -11.2 + 0.165(ML) + 0.167(PL)	93.6	-3.46 ****
				5.28 *****
				4.57 *****
	rubberiness	= -8.81 + 0.149(ML) + 0.155(PL) -0.000837(MLxPL)	85.9	-2.17 **
				3.80 ****
				3.37 ***
				-2.15 **
IPT	firmness	= -1.71 + 0.0248(ML) + 0.0251(PL)	94.1	-4.09 *****
				6.16 *****
				5.35 *****
	rubberiness	= -1.08 + 0.0199(ML) + 0.0201(PL)	68.1	-1.10 ns
				2.09 **
				1.81 *

(1) ML = mutton lean PL = pork lean

(2) t-Ratio is a ratio of each regression coefficient to its standard deviation. The first t-Ratio value in the list relates to the first regression coefficient and so on.

ns = not significant at $p > 0.20$

* = significant at $0.20 \geq p > 0.10$

** = significant at $0.10 \geq p > 0.05$

*** = significant at $0.05 \geq p > 0.02$

**** = significant at $0.02 \geq p > 0.01$

***** = significant at $0.01 \geq p > 0.001$

It was interesting to note, for meatballs incorporating pork, that firmness and rubberiness scores increased as mutton lean and pork lean content increased.

5.3.1.5 Objective Evaluation Results

The objective test results for the meatball samples formulated with different proportions of mutton lean, beef or pork lean and mutton fat are given in Table 5.5.

It was evident that there were some significant differences in objective test values of the meatballs. In general, the meatballs, incorporated with either beef or pork lean, which had lower mutton fat content (treatments 1 and 2), had higher Instron values as determined by both the compression method and the W-B shear method. On the other hand, the cook yields were higher for the meatballs with higher mutton fat contents.

Table 5.5 Objective test values for meatballs formulated with various proportions of mutton lean, beef or pork lean and mutton fat(1)

Type of Meat Incorporated With Mutton	Objective Test Value	Treatment (2) 1	2	3	4	5
Beef	compression force (Newton)	13.14 ± 0.09^{b}	12.33 ± 0.75^{b}	8.98 ± 0.57^{a}	9.10 ± 0.29^{a}	13.34 ± 0.85^{b}
	compression slope (Newton/mm)	1.76 ± 0.03	1.73 ± 0.06	1.19 ± 0.09	1.16 ± 0.13	1.64 ± 0.26
	W-B shear force (Newton)	6.82 ± 0.13	7.20 ± 1.00	6.49 ± 0.24	5.99 ± 0.15	7.04 ± 0.31
	W-B shear slope (Newton/mm)	1.04 ± 0.07^{b}	0.94 ± 0.10^{ab}	0.66 ± 0.10^{a}	0.62 ± 0.00^{a}	0.76 ± 0.03^{ab}
	cook yield (%)	75.20 ± 0.78^{ab}	72.90 ± 0.25^{a}	77.50 ± 0.34^{bc}	82.50 ± 0.85^{d}	78.40 ± 0.47^{c}
Pork	compression force (Newton)	12.18 ± 0.15^{b}	11.52 ± 0.29^{b}	6.67 ± 0.74^{a}	7.83 ± 0.43^{a}	11.39 ± 0.14^{b}
	compression slope (Newton/mm)	1.71 ± 0.07^{b}	1.54 ± 0.10^{b}	0.89 ± 0.10^{a}	1.04 ± 0.02^{a}	1.45 ± 0.06^{b}
	W-B shear force (Newton)	8.03 ± 0.50^{ab}	7.73 ± 0.38^{ab}	6.81 ± 0.08^{ab}	5.53 ± 0.90^{a}	8.88 ± 0.88^{b}
	W-B shear slope (Newton/mm)	0.99 ± 0.01^{b}	0.84 ± 0.04^{ab}	0.77 ± 0.05^{ab}	0.60 ± 0.12^{a}	1.05 ± 0.04^{b}
	cook yield (%)	67.80 ± 0.70^{a}	73.20 ± 0.50^{b}	75.30 ± 0.12^{b}	75.70 ± 1.46^{b}	73.60 ± 0.32^{b}

(1) Values are means ± standard errors of the means between two replications. Any two means within the same row bearing one of the same letters in the superscripts are not significantly different at $p \leq 0.05$.

(2) Refer to Figure 5.1 for formulations.

5.3.1.6 Correlations of Instron Values

The Instron values were subjected to correlation analysis, and the significant correlation coefficients are shown in Table 5.6.

Table 5.6 Correlation coefficients between the Instron values

Type of Meat Incorporated with Mutton	Instron Value			Correlation Coefficient (1)
Beef	compression force	-	compression slope	0.90 ***
	compression force	-	W-B shear force	0.58 *
	compression force	-	W-B shear slope	0.68 **
	compression slope	-	W-B shear force	0.38 ns
	compression slope	-	W-B shear slope	0.65 **
	W-B shear force	-	W-B shear slope	0.62 *
Pork	compression force	-	compression slope	0.98 ***
	compression force	-	W-B shear force	0.66 **
	compression force	-	W-B shear slope	0.70 **
	compression slope	-	W-B shear force	0.62 *
	compression slope	-	W-B shear slope	0.69 **
	W-B shear force	-	W-B shear slope	0.92 ***

(1) ns = not significant at $p > 0.1$
* = significant at $0.01 \geq p > 0.05$
** = significant at $0.05 \geq p > 0.02$
*** = significant at $p \leq 0.001$

The compression force and the compression slope were highly correlated with each other for the meatballs with either beef or pork lean; but the W-B shear force and the W-B shear slope were highly correlated only for the meatballs incorporated with pork but not with beef.

5.3.1.7 Relationships between Objective Test Values and Meatball Components

Some regression equations showing the relationships between the objective test values and mutton lean, beef or pork lean, mutton fat contents and their interactions were found significant and are shown in Table 5.7. It was shown that as mutton lean and beef or pork lean content increased, the Instron values increased.

Table 5.7 Regression equations showing the relationships between objective test values and mutton, beef, pork lean and mutton fat

Type of Meat Incorporated With Mutton	Objective Test Value	Regression Equation(1)	R^2x100(%)	t-Ratio(2)
beef	compression force(Newton)	= -25.7 + 0.33(ML) + 0.35(BL) + 0.0039(MLxBL)	91.8	-2.36 ** 3.14 *** 2.85 *** 3.75 ****
	W-B shear slope(Newton/mm)	= -3.48 + 0.0463(ML) + 0.0469(BL)	84.1	-2.65 *** 3.66 **** 3.35 ***
	cook yield(%)	= 160 - 0.927(ML) - 0.919(BL) + 0.00234(MLxBL) - 0.00686(MLxMF)	96.9	14.58 ******* -8.76 ******* -7.42 ******* 2.23 ** -2.88 ***
pork	compression force(Newton)	= -25.2 + 0.343(ML) + 0.349(PL) + 0.00298(MLxPL)	96.7	-3.27 *** 4.63 ***** 4.02 **** 4.05 ****
	compression slope(Newton/mm)	= -4.47 + 0.0586(ML) + 0.0617(PL) + 0.000254(MLxPL)	94.6	-3.24 *** 4.41 ***** 3.97 **** 1.93 *
	W-B shear force(Newton)	= -20.9 + 0.238(ML) + 0.261(PL) + 0.00289(MLxPL)	76.9	-1.78 * 2.10 ** 1.97 * 2.58 ***
	W-B shear slope(Newton/mm)	= -3.70 + 0.0377(ML) + 0.0437(PL) + 0.000391(MLxPL) + 0.000651(MLxMF)	86.6	-3.14 *** 3.32 *** 3.29 *** 3.47 **** 2.55 **
	cook yield(%)	= 161 - 0.874(ML) - 1.03(PL) - 0.0106(MLxMF)	93.2	11.19 ******* -6.29 ***** -6.31 ***** -3.39 ****

(1) ML = mutton lean, BL = beef lean, PL = pork lean, MF = mutton fat

(2) t-Ratio is a ratio of each regression coefficient to its standard deviation. The first t-Ratio value relates to the first regression coefficient and so on.

* = significant at $0.20 \geq p > 0.10$
** = significant at $0.10 \geq p > 0.05$
*** = significant at $0.05 \geq p > 0.02$
**** = significant at $0.02 \geq p > 0.01$
***** = significant at $0.01 \geq p > 0.001$
****** = significant at $p \leq 0.001$

5.3.1.8 Correlations between Subjective Evaluation Results and Instron Values

The correlation coefficients between the sensory scores for firmness and rubberiness and the Instron values, i.e. the compression force and slope and the W-B shear force and slope were determined. Only the significant correlation coefficients are given in Table 5.8.

Table 5.8 Correlation coefficients between the sensory attribute scores and the Instron objective test values of the meatballs (1)

Sensory Method	Attribute	Instron value	Correlation Coefficient (1)
DCS	firmness	compression force	0.77 ****
	firmness	compression slope	0.85 *****
	firmness	W-B shear force	0.66 **
	firmness	W-B shear slope	0.65 **
	rubberiness	W-B shear force	0.57 *
IPT	firmness	compression force	0.75 ***
	firmness	compression slope	0.83 *****
	firmness	W-B shear force	0.63 *
	firmness	W-B shear slope	0.67 **
	rubberiness	W-B shear force	0.56 *

(1) The data were analysed by combining the values of meatballs incorporating pork with those of meatballs incorporating beef.

* = significant at $0.1 \geq p > 0.05$

** = significant at $0.05 \geq p > 0.02$

*** = significant at $0.02 \geq p > 0.01$

**** = significant at $0.01 \geq p > 0.005$

***** = significant at $0.005 \geq p > 0.001$

Firmness was more highly correlated with compression force or compression slope than with W-B shear force or W-B shear slope. Rubberiness was only correlated with W-B shear force but the correlation coefficients were not high. Evaluation by the Instron texture meter was comparable to subjective evaluation of texture of the meatballs.

5.3.1.9 Discussion and Conclusion

From the subjective test evaluation results, meatballs with low level (5%) of added mutton fat generally had higher firmness and rubberiness scores but lower smoothness, juiciness

and oiliness scores than those with higher levels (10% or 15%) of added mutton fat. The oiliness scores of the meatballs, as determined by the ideal ratio score, were close to 1 and with some samples were even higher than 1. Therefore, it was expected that no more fat could be added to the meatballs and probably the maximum level could not exceed 15%. A number of researchers suggested, for desirable characteristics of the processed meat products made from mutton, that the content of mutton fat be kept within 10% (Carpenter et al., 1966; Anderson and Gillet, 1974b; Wenham, 1974; Brennand and Mendenhall, 1981; Bartholomew and Osuala, 1986).

The developed meatballs should have as little mutton fat as possible since it could give undesirable odour and flavour. Extensive trimming of mutton fat and replacing it with another kind of fat, such as pork fat which is usually familiar to the Thai consumers, was expected to help develop meatballs with very much better odour and flavour.

There was a tendency that meatballs containing pork were superior to meatballs containing beef in terms of sensory attribute scores. This was shown by the higher sensory attribute scores for firmness, rubberiness and particularly smoothness. Therefore, pork was chosen for incorporation with mutton to produce the meatballs. In addition, pork would be more appropriate than beef due to its significantly lower price in Thai markets. Therefore, this was an additional advantage to support the choosing of pork if the meatballs were to be produced in Thailand.

Descriptive category scaling and ideal profile testing were similar for assessing sensory characteristics of meatballs. Nevertheless, there were some reasons to support the choosing of ideal profile testing for further formulation. Firstly, the ideal profile testing has the advantage of showing easily whether the sensory characteristics of the product are close to the ideals and concurrently showing in what direction the product should be altered for each attribute that is profiled. Secondly, and the most important reason, there were comments given by some panelists that the ideal profile testing was easier to understand and more convenient to use.

From the objective evaluation results, meatballs made with beef or pork and with low added mutton fat (5%) generally had higher measured Instron values as determined by both the compression method and the W-B shear method than those with high added mutton fat (10% or 15%).

The correlation analysis indicated that firmness was highly and positively correlated with rubberiness but firmness and rubberiness were negatively correlated with juiciness or oiliness. Also there were significant correlations between the Instron values as determined

by the compression and the W-B shear methods and between these objective test values and such subjective attributes as firmness and rubberiness.

The regression analysis showed that as the mutton lean and the pork lean content increased, sensory attribute scores for firmness and rubberiness increased and that the increasing mutton lean and the beef or pork lean content resulted in an increase in both the compression and the W-B shear values.

5.3.2 Effect of Mutton Lean, Pork Lean and Pork Fat on Characteristics of the Meatballs

This part of the study was a continuation of the previous experiment. A further mixture design was planned according to the results obtained from the past experiment. Therefore, mutton lean content was increased but mutton fat content was kept constant at 5-15%. In addition, pork fat replaced mutton fat in this study to examine and compare, with mutton fat, its effect on characteristics of the meatballs.

5.3.2.1 Experimental Methods

There were two parts to this experiment:

* an extension of the past experimental design to the bottom right corner of the tri-component mixture design area using mutton lean, pork lean and mutton fat;
* a tri-component mixture design covering all feasible vertices (both used in the past experimental design and in the present extension of the design) but using pork fat in place of mutton fat.

Figure 5.2 shows the complete space available for the mixture design. The new area of investigation is shown relative to the initial area of experimentation.

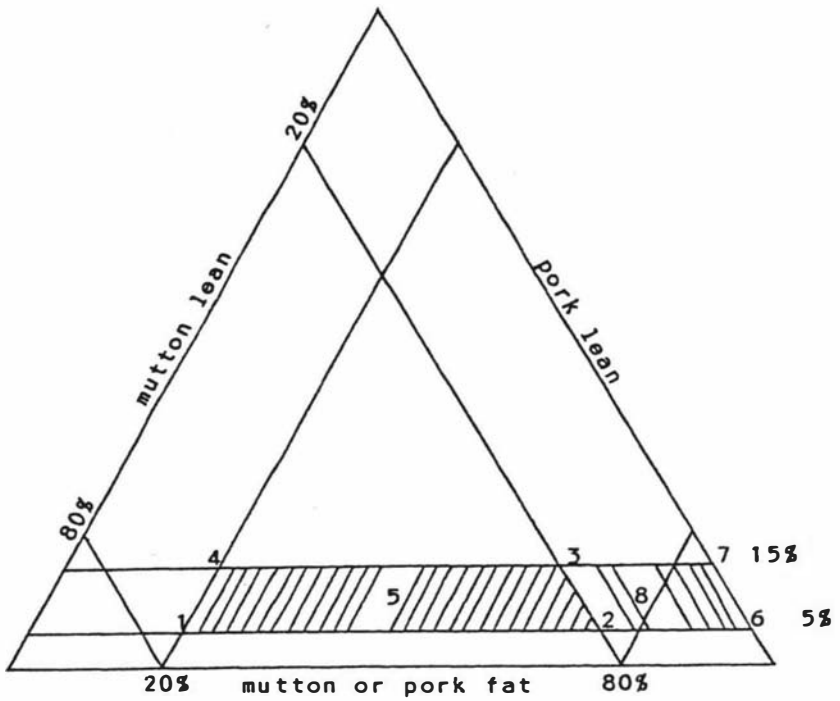


Figure 5.2 Complete mixture space showing feasible area for experimentation (with an extension)

Vertices used in the experimentation were as follows:

Use of mutton fat (an extension of the initial area)

Treatment	Mutton Lean(%)	Pork Lean(%)	Mutton Fat(%)
6	95	0	5
7	85	0	15
8	80	10	10

Use of pork fat (both the initial area and the extension)

Treatment	Mutton Lean(%)	Pork Lean(%)	Pork Fat(%)
1	20	75	5
2	75	20	5
3	65	20	15
4	20	65	15
5	45	45	10
6	95	0	5
7	85	0	15
8	80	10	10

The meatballs were made using the same materials and methods as described in the previous experiment. The prepared meatballs were tested by the same eight panelists. Only the ideal profile testing was used in sensory evaluation of the samples. The percentage cook yields of the prepared meatballs were also determined.

Analysis of variance was performed according to the method in Chapter 4 (Section 4.3).

5.3.2.2 Subjective Evaluation Results

The ideal ratio scores for all characteristics of the samples formulated with various proportions of mutton lean, pork lean and pork fat are shown in Table 5.9. The ideal ratio scores from the previous experiment are also given.

In general, there were significant differences between means of the ideal ratio scores of the meatballs formulated with either mutton fat or pork fat. There was a tendency that the meatballs with low (5%) level of added mutton fat or pork fat (treatments 1, 2 and 6) had higher firmness and rubberiness scores than those with high (15%) added mutton or pork fat content (treatments 3, 4 and 7) but the meatballs with high mutton or pork fat content had higher smoothness, juiciness and oiliness scores for most formulations; the scores for oiliness being over the ideal ratio score of 1. When comparing species of meat fat, it seemed probable that the meatballs with added pork fat had higher and nearer ideal firmness, smoothness and rubberiness scores than those with added mutton fat.

To obtain the overall effect of mutton lean, pork lean and mutton or pork fat, the deviation of the ideal ratio scores from the value of 1 was determined for each sensory attribute of each formulation. Then the deviations for all attributes were averaged taking into consideration that each sensory attribute was equally important. This was done to compare all formulations and to choose the appropriate formulation for further development. The results are given in Table 5.10.

Table 5.9 Ideal ratio scores for meatballs made from various proportions of mutton lean, pork lean, and mutton or pork fat (1)

Type of Fat	Attribute	Treatment (2) 1	2	3	4	5	6	7	8
Mutton (3)	firmness	0.65^{bc}	0.66^{c}	0.50^{ab}	0.43^{a}	0.54^{ab}	0.79^{c}	0.61^{b}	0.69^{c}
		(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.06)	(0.04)	(0.06)
	smoothness	0.62	0.70	0.64	0.70	0.60	0.69	0.73	0.72
		(0.01)	(0.03)	(0.04)	(0.02)	(0.05)	(0.06)	(0.00)	(0.02)
	rubberiness	0.66	0.66	0.51	0.49	0.51	0.70	0.57	0.68
		(0.05)	(0.02)	(0.06)	(0.07)	(0.05)	(0.07)	(0.04)	(0.04)
	juiciness	0.76^{a}	0.90^{ab}	0.91^{b}	0.92^{b}	0.87^{ab}	0.89^{ab}	1.08^{c}	0.99^{bc}
		(0.02)	(0.05)	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.04)
	oiliness	0.97^{a}	0.92^{a}	1.07^{ab}	1.08^{ab}	0.91^{a}	1.25^{b}	1.34^{b}	1.28^{b}
		(0.02)	(0.05)	(0.01)	(0.13)	(0.03)	(0.02)	(0.03)	(0.03)
Pork	firmness	0.82^{b}	0.81^{b}	0.59^{a}	0.69^{ab}	0.78^{b}	0.81^{b}	0.73^{ab}	0.78^{b}
		(0.05)	(0.02)	(0.03)	(0.02)	(0.01)	(0.03)	(0.03)	(0.05)
	smoothness	0.89^{d}	0.71^{abcd}	0.70^{abc}	0.88^{cd}	0.81^{bcd}	0.67^{ab}	0.60^{a}	0.67^{ab}
		(0.05)	(0.05)	(0.01)	(0.01)	(0.03)	(0.02)	(0.08)	(0.01)
	rubberiness	0.74^{b}	0.75^{b}	0.52^{a}	0.62^{ab}	0.73^{b}	0.70^{ab}	0.63^{ab}	0.65^{ab}
		(0.00)	(0.06)	(0.02)	(0.04)	(0.02)	(0.07)	(0.05)	(0.05)
	juiciness	1.02^{bcd}	0.85^{a}	1.17^{d}	1.15^{d}	1.01^{abcd}	0.89^{ab}	1.07^{cd}	0.93^{abc}
		(0.05)	(0.05)	(0.03)	(0.06)	(0.02)	(0.04)	(0.03)	(0.01)
	oiliness	1.22^{ab}	1.03^{a}	1.33^{b}	1.27^{b}	1.29^{b}	1.17^{ab}	1.23^{b}	1.16^{ab}
		(0.08)	(0.07)	(0.06)	(0.02)	(0.03)	(0.01)	(0.05)	(0.01)

(1) The scores were given by eight Thai panelists. Values are means and standard errors of the means between the two replications (in parentheses). Any two means within the same row possessing one of the same letters in the superscripts are not significantly different at $p \leq 0.05$.

(2) Refer to Figure 5.2 for formulations.

(3) For mutton fat, the scores for treatments 1,2,3,4 and 5 were those obtained from the previous experiment.

Table 5.10 Mean deviations from ideal for meatballs with added pork or mutton fat

Type of Fat	Treatment							
	1	2	3	4	5	6	7	8
Mutton	0.27	0.23	0.30	0.31	0.31	0.24	0.30	0.24
Pork	0.16	0.18	0.34	0.25	0.20	0.22	0.27	0.23

The meatballs with low (5%) level of either added mutton or added pork fat (treatments 1, 2 and 6) had smaller deviations from the ideal than those with high (15%) levels of added fats (treatments 3, 4 and 7). Thus, acceptable meatballs could not be formulated with too high a level of fat. Increasing levels of fat lowered the overall characteristic scores of the meatballs.

When comparing the types of fat, pork fat gave the products with better overall characteristic scores. Treatment 1 had the lowest deviation from ideal of 0.16 but treatment 2, although having the second lowest deviation from ideal of 0.18, was likely the most suitable formulation for further development. This was due to the fact that the meatballs made by using this formulation possessed sensory attributes with relatively good ideal ratio scores and that it was also made with a relatively high amount of mutton lean, i.e. 75%. It was also interesting to note that some panelists mentioned that the odour and flavour of the meatballs were better than the odour and flavour of the meatballs in the past experiment. This also indicated the benefit of using pork fat for making meatballs.

5.3.2.3 Percentage Cook Yield

The percentage cook yield values of the meatball samples are given in Table 5.11.

Generally, pork fat gave products with higher percentage cook yields than mutton fat. For the products containing either mutton fat or pork fat, the formulations with high fat contents (treatments 3, 4 and 7) had higher percentages cook yield than those with low fat contents (treatments 1,2 and 6). Mittal and Blaisdell (1983) indicated, in the experiment with frankfurters, that as the fat-to-protein ratio of the products decreased, the moisture loss, i.e. the reverse implication for percentage cook yield, increased. The results in this experiment also supported the findings of these authors.

Table 5.11 Percentage cook yield of the meatballs made from various proportions of mutton lean, pork lean, and mutton or pork fat (1)

Type of fat	Treatment							
	1	2	3	4	5	6	7	8
Mutton (2)	67.8 ± 0.70^{a}	73.2 ± 0.50^{b}	75.3 ± 0.12^{bcd}	75.7 ± 1.46^{bcde}	73.6 ± 0.32^{bc}	77.9 ± 0.85^{def}	80.7 ± 0.14^{f}	79.2 ± 1.14^{ef}
Pork	74.9 ± 1.55^{a}	75.6 ± 2.08^{a}	84.0 ± 0.00^{b}	92.1 ± 1.07^{c}	89.3 ± 0.33^{c}	73.4 ± 0.00^{a}	87.8 ± 0.21^{bc}	83.6 ± 0.52^{b}

(1) Values are means ± standard errors of the means between two replications. Any two means within the same row possessing one of the same letters in the superscripts are not significantly different at $p \leq 0.05$.

(2) For mutton fat, the values for treatments 1,2,3,4 and 5 were those obtained from the previous experiment.

5.3.2.4 Discussion and Conclusion

Pork fat resulted in products with better firmness, smoothness, and rubberiness scores than mutton fat. When comparing the overall effect of pork fat or mutton fat by the mean deviations from ideal, it was also evident that pork fat was superior. The meatballs made with pork fat also generally had higher percentage cook yield than those with mutton fat. This was another advantage of using pork fat. In addition, pork fat was expected not to adversely affect the odour and flavour of the meatballs.

From the overall results, it was shown that either pork lean or mutton lean at high level (75%) with pork fat at 5% yielded meatballs with better overall characteristic scores than the other formulations. The formulation with 75% mutton lean was chosen for further development due to its relatively high usage of mutton.

5.3.3 Overall Discussion and Conclusion

This part of the research showed that an increasing content of mutton lean and a decreasing content of mutton fat resulted in meatballs with higher firmness and rubberiness but lower smoothness, juiciness and oiliness. Considering that firmness and rubberiness of the meatballs are very important to the Thai consumers, it was decided that mutton lean could be used at the high level of 75%. Pork was shown to be more appropriate than beef to be incorporated with mutton, the optimum level being 20%.

Pork fat was superior to mutton fat in that it produced meatballs with better sensory attributes such as firmness, rubberiness and smoothness and with higher cook yields. Therefore, fat trimming of mutton raw materials was necessary for these meatballs. Trimming of mutton fat would also significantly remove the distinctive and strong odour and flavour and, in turn, result in meatballs with improved odour and flavour. Wenham (1974) also recommended trimming of mutton fat to upgrade mutton. An addition of pork fat, which is very familiar to the Thai consumers, to replace mutton fat, would even further improve the meatballs' odour and flavour. The low level of added pork fat was chosen, i.e. 5%. This added fat level was chosen since a higher addition of fat, even at 10%, resulted in meatballs with too high oiliness; the ideal ratio scores for oiliness being higher than 1. Therefore, the formulation used in further experiments was 75% mutton lean, 20% pork lean and 5% added pork fat.

At this stage of development, some sensory scores, including firmness, rubberiness and smoothness, were distant from the ideals. It was concluded that the meats and fat themselves were not sufficient to develop meatballs with required textural acceptability. Thus, the other ingredients normally used in production of commercial meatballs - tapioca

starch, salt and phosphates - were tested in further development of the meatballs. The next chapter discusses the formulation study using these ingredients which helped to improve the texture of the meatballs.

CHAPTER 6
DEVELOPMENT OF TEXTURE OF MEATBALLS

6.1 INTRODUCTION

It was decided at this stage of the research to improve the texture of the meatballs, especially firmness and rubberiness, by using salt, tapioca starch and phosphate, food additives which are generally used in Thai processed meat products. This chapter describes an investigation on the effects of these ingredients on the textural characteristics of the meatballs. Borax was also compared with the phosphates; at the present time it is used in meatballs in Thailand, but its use should be stopped because of its toxicity.

6.2 LITERATURE REVIEW ON USE OF SALT, PHOSPHATE AND OTHER ADDED INGREDIENTS IN PROCESSED MEAT PRODUCTS

There are several factors which can affect the characteristics of processed meat products; these may be classified into the 'indigenous' and 'exogenous' factors. The indigenous factors are the properties of the meats used as raw materials: the proximate composition, pH, stage of rigor (pre rigor or post rigor mortis), the musculature, colour and appearance, odour and flavour, the microbiological properties. The exogenous factors are those which are 'given' or added to the products. These may be such factors as processing conditions and properties of added ingredients. Several ingredients have been used in processed meat products to improve the products' physical, chemical, microbiological and sensory characteristics. Among the important ingredients, salt and phosphates have been used by numerous researchers to investigate their effects on the characteristics of meat products.

A comminuted meat product, like meatball, requires the extraction of proteins to bind its comminuted meat particles, fat and water together. The salt soluble proteins are best suited for this specific function (Macfarlane et al., 1977; Siegel and Schmidt, 1979). Although salt will improve flavour (Mandigo et al., 1972), the principal reason for its addition is to extract protein.

An addition of salt and phosphates affected the physical characteristics of meat products. Increasing salt levels increased the binding characteristics and the water retention, which in turn reduced cooking loss, but increasing salt level sometimes resulted in increased fat oxidation (Neer and Mandigo, 1977). Increasing levels of phosphates helped to improve the characteristics of the products by aiding in water binding and acting as emulsifiers. Phosphates also had a synergistic effect with salt by positively promoting the effects of salt on the product's qualities; reduction in oxidative rancidity could be achieved by the addition of phosphate (Farr and May, 1970).

For products made mainly using beef, buffalo, goat and poultry meat, a number of researchers found, in general, that increasing salt and phosphate content resulted in an increase in binding strength (Moore et al., 1976; Sofos, 1985; Lam key et al., 1986), water holding capacity (Kondaiah et al., 1985), and cook yield (Moore et al., 1976; Mawson and Schmidt, 1983; Kondaiah et al., 1985; Lam key et al., 1986). An addition of salt helped increase the extraction of myosin heavy chain and actin which was necessary for binding (Choi et al., 1987). An addition of phosphates resulted in increased pH (Kondaiah et al., 1985; Sofos, 1985) and reduced amount of oxidation (Lam key et al., 1986).

Numerous researchers studied the effects of salt and phosphates on the characteristics of products made from pork. Sherman (1961) concluded that the addition of salt, tetrasodium pyrophosphate, or alkaline polyphosphate improved the water binding capacity of fresh lean pork. Schwartz and Mandigo (1976) studied the effect of salt and sodium tripolyphosphate (STP) on restructured pork and showed that the use of salt and STP had several positive effects concerning the production of an acceptable product. Added salt improved cooked colour, aroma, flavour and eating texture and decreased cooking loss. Increase in STP decreased cooking loss. Neer and Mandigo (1977) found that as salt (0 to 3%) and/or STP (0 to 0.5%) concentrations increased, smokehouse and cooking yields of a flaked, cured pork product increased; products became darker; the sensory properties (colour, appearance, juiciness, flavour) and the general acceptability improved. Salt was found to enhance rancidity whereas STP retarded its development. Combinations of 2.25%/0.25%, 3.0%/0.25%, 3.0%/0.125%, and 3.0%/0.375% of salt and STP, respectively, were found to yield superior products to all other combinations. Theno et al.(1978), in their study on the microstructure of binding junctions in sectioned and formed hams using 0 to 3% salt and 0 and 0.5% phosphate, found that junctions in low salt rolls (< 2%) were filled with fat cellular fragments but those with adequate salt (> 2%) and phosphate (0.5%) exhibited good binding characteristics. Hand et al. (1987) prepared frankfurters from preblended or non-preblended pork to contain traditional and reduced levels of salt (1.5, 2.0 or 2.5%) and/or fat (17% = low, 25% = high). The findings were that salt had a positive effect on emulsion stability and low fat products with 1.5% salt had a softer texture than those with 2.0 or 2.5% salt. Preblending did not affect textural properties.

van Eerd (1971), in a study on mutton emulsion stability, stated that the salt concentration influenced the solubility of the meat proteins. Field et al. (1984a) investigated the influence of salt (0.5 or 1%) and other factors on restructured lamb roasts containing 0.3% sodium tripolyphosphate and found that roasts with 1% salt were juicier than roasts with 0.5% salt but they were harder and required more chews before swallowing. Also, the addition of 1% salt significantly resulted in less total cook loss, but rancidity scores for roasts containing 1% were higher, but not significantly, than roasts with 0.5% salt. Field et al. (1984b), using an

objective measurement to evaluate binding in restructured lamb roasts, found that as the level of salt increased from 1% to 1.5%, values for bind characteristics (breaking strength and elongation) increased. Brewer et al. (1984) studied the effects of salt level and other factors on qualities of chunked and formed lamb roasts. Roasts with 0.5% salt had significantly lower juiciness and flavour scores than roasts with 1 to 2% salt and separation of muscle chunks was more extensive and Instron breaking strength values were lower at the 0.5% salt level. Brewer et al. (1986) evaluated the influence of salt level and freezing on actin and myosin content of exudate from chunked and formed lamb roasts and showed that roasts prepared from frozen lean had lower shear values and Instron peak loads than did roasts prepared from fresh lean. Freezing of lean prior to processing lowered percentage actin in exudate but significant salt level x freezing interactions existed for percentage actin and mysosin. Increasing salt levels from 0.5 to 2.0% decreased cook loss in all roasts made from fresh and frozen meat and increased Instron measures of bind in roasts made from fresh but not frozen meat. These authors concluded that effects of freezing and salt level on extractability and functionality of the myofibrillar proteins into the exudate at meat chunk surfaces was probably responsible.

The use of polyphosphates in different meat products has been studied for many years (Bendall, 1954; Swift and Ellis, 1957; Sherman, 1961; Pepper and Schmidt, 1975). Although phosphates could very effectively replace salt in meat products, their effectiveness depended on the type of phosphate (Shults et al., 1972) and the conditions under which they were used (Puolanne and Terrell, 1983). Shults et al. (1972) found that tetrasodium pyrophosphate (TSPP) was more effective in increasing water holding capacity than sodium tripolyphosphate (STPP), sodium metaphosphate, sodium hexametaphosphate (SHMP) and the blends of commercial phosphates. Cassidy (1977) stated that tripolyphosphates were used extensively in meat products to improve moisture retention, emulsification, colour retention and binding. Trout and Schmidt (1984) showed that the effectiveness of the phosphates on binding in restructured beef rolls was: TSPP > STPP > sodium tetrapolyphosphate > SHMP. The effects of phosphate type and other factors on the characteristics of Chinese sausage were determined by Kuo et al. (1987). These workers found that sausage containing a blended phosphate (sodium tripolyphosphate + sodium hexametaphosphate + tetrasodium pyrophosphate) had the highest water holding capacity. The product with TSPP had the highest pH, followed by the product with STPP, blended phosphate and SHMP.

A number of researchers used soy proteins, milk proteins, legume proteins and starches as the fillers or the binders in meat products to reduce costs. Comer (1979) studied the effects of soy proteins, milk proteins, wheat flour and potato starch on characteristics of a comminuted canned meat product and concluded that, in general, the fillers had beneficial

effects on emulsion stability and yield but negative effects on product firmness. However, Comer et al. (1986), in a study on functional effects of soy protein, milk protein, wheat proteins and modified corn starch, found that all fillers improved stability and textural firmness of weiner sausages; the starch filler produced the firmest texture. Verma et al. (1984) found that incorporation of chickpea flour in English type sausages led to increased cooking losses, softer texture, discolouration of the raw sausages which was more distinct during storage at 0 °C.

Some effects of added starch on gelation of a fish protein -starch system have been studied by Wu et al. (1985a) who reported that the gelatinisation of starch during thermal processing caused an increase in the rigidity of an actomyosin-starch system. Wu et al. (1985b), in a study on starch-fish protein systems added with potato starch, waxy maize starch, modified waxy starches, and a pregelatinised tapioca starch, reported that the effects of starches on the textural characteristics of cooked gels were dependent on their gelatinisation characteristics, such as gelatinisation temperature, degree of swelling and water uptake of the granules. Skrede (1986) used potato, wheat, corn, tapioca or modified potato starch at 4% in wiener sausages and concluded that no differences in taste attributed to the different types of starch were observed, but the physical properties varied according to the cooking and storage temperatures. Skrede et al. (1987), in a study on cooked and vacuum packed beef sausages, reported starch degradation in the products containing 4% starch from potato flour.

From the literature search, the levels of salt and tapioca starch and types and levels of phosphates used in meatballs made from mutton were not found. However, salt and phosphate were used at the maxima of 3% and 0.5% respectively in other comminuted meat products by a number of researchers. Tapioca starch was, in general, used at 4%.

6.3 THE EXPERIMENTATION

The overall experiment studied the effects of types and levels of phosphates and of levels of salt and tapioca starch on the textural characteristics of the meatballs, as determined by both subjective and objective evaluations. Due to its common usage in various processed meat products, sodium tripolyphosphate (STPP) was firstly used together with salt and tapioca starch in the formulations.

It was decided, from the results obtained in the first part of the experiments, to choose the most appropriate formulation and further compare the effects of STPP, tetrasodium pyrophosphate and borax on the textural characteristics of the meatballs.

6.3.1 Effects of Tapioca Starch, Salt and STPP on Characteristics of Meatballs

6.3.1.1 Experimental Methods

A 2^3 factorial experimental design was used for the experimentation. The three input variables were tapioca starch, salt and STPP; each of which was used at their respective low and high levels. Therefore, there were 2^3 or 8 treatment combinations as shown in Table 6.1.

From the literature, the levels of salt and phosphates generally used were at the maxima of 3% and 0.5% respectively. Therefore, in this experiment, the maximum level of salt was used at 3%. However, according to the limitation in the Thai food regulations, the maximum level of phosphate was used at 0.3%. The minimum levels of salt and phosphate were arbitrarily chosen at one-third of the maximum levels. The commercial meatballs in Thailand normally contain 1-2% tapioca starch. Therefore, the minimum level of tapioca starch was used at 2% and the maximum level was arbitrarily chosen at two times of the minimum level, i.e. 4%. This value was identical to the one generally used by researchers as given in the literature.

Table 6.1 Factorial design to study the effects of tapioca starch, salt and STPP on the characteristics of the meatballs

Run No. (or Treatment)	General Treatment Code	Tapioca Starch (%) A	Salt (%) B	STPP (%) C
1	1	2(-)	1(-)	0.1(-)
2	a	4(+)	1(-)	0.1(-)
3	b	2(-)	3(+)	0.1(-)
4	ab	4(+)	3(+)	0.1(-)
5	c	2(-)	1(-)	0.3(+)
6	ac	4(+)	1(-)	0.3(+)
7	bc	2(-)	3(+)	0.3(+)
8	abc	4(+)	3(+)	0.3(+)

The meatballs were made by using mutton lean (75%), pork lean (20%) and pork fat (5%), (refer to Chapter 5) and the above proportions of ingredients were added. The percentage of each additive was based on the total weight of the meats and fat mixture. Materials and processing methods for the meatballs are given in Chapter 4 (Sections 4.1.1 and 4.1.2). Flaked ice, another ingredient, was also added at 20% (based on the weight of meats and fat) to control the temperature of the mixture during chopping.

The prepared meatballs were subjectively evaluated by the same eight Thai panelists. Only the ideal profile testing was used in sensory evaluation of the samples (refer to Section

4.2.3.1). The evaluation was performed according to the methods described in Section 4.2.3.5. The meatballs were prepared for serving by cooking in boiling water (100 °C) for 2 minutes. The questionnaires used in sensory evaluation were similar to those used in the previous experiments except that oiliness was omitted since all the formulations had the same fat contents; 'muttoniness' and saltiness were additional characteristics which the panelists were asked to evaluate. Fixed ideal absolute scores were given for firmness, smoothness, rubberiness, juiciness, and saltiness. Each panelist located his or her own 'floating' ideal for muttoniness. The complete questionnaire is shown in Appendix 6.1. The ratio scores for muttoniness were calculated from transformed data since some panelists gave the floating ideal at 0. Therefore, the ratio of product's score to the ideal score (zero in this case) could not be calculated. Due to this reason, the ideal score was changed to a value of 1 and the product's score was simultaneously increased by 1, thus allowing possible calculation of the ratio score.

In the objective evaluation, the percentage cook yield (refer to Section 4.2.2.2), the pH's before and after cooking of the meatballs (refer to Section 4.2.2.3) and the Instron texture properties, with the additional initial yield force (refer to Section 4.2.2.4) were determined.

Analyses of the data were performed according to the methods in Chapter 4 (Section 4.3).

6.3.1.2 Subjective Evaluation Results

The mean ideal ratio scores of the samples formulated with different proportions of tapioca starch, salt, and STPP are shown in Figure 6.1. The figure illustrates the distinct effects of salt together with STPP; tapioca starch had only a slight effect as shown by the closeness of the tapioca lines at each salt level (refer to Appendix 6.2 for the detailed numerical results).

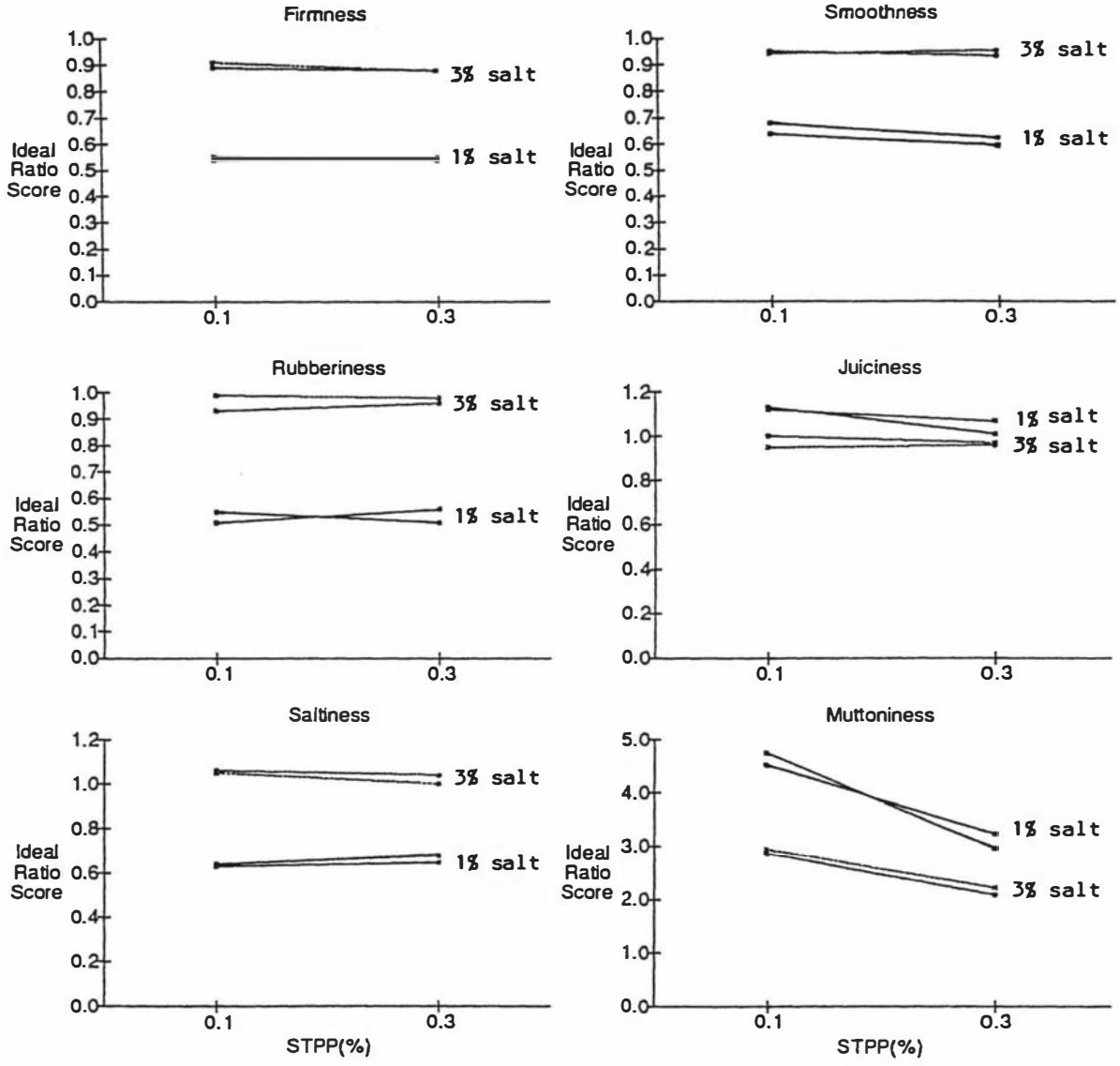


Figure 6.1 Ideal ratio scores for sensory attributes of the meatballs as affected by tapioca starch, salt and sodium tripolyphosphate (STPP) contents

The high salt content (3%) significantly improved such sensory attributes as firmness, smoothness, rubberiness and saltiness when compared to the low salt content (1%). Salt decreased juiciness, but the ideal ratio score for juiciness was still near 1.0 at 3% salt. STPP tended, although not significantly, to improve the sensory characteristics of the meatballs especially for those blended with 4% tapioca starch. Tapioca starch also tended, although not significantly, to improve the meatballs' sensory properties especially firmness, smoothness and rubberiness. Muttoniness was still detected by the taste panelists as shown by the high ideal ratio scores. However, it was interesting to note that the meatballs with high salt or high STPP had lower muttoniness.

Deviation of the ideal ratio score from the ideal value of 1 was determined for each sensory attribute of each formulation using the results in Appendix 6.2. The deviations of the ideal ratio scores were summed and the mean deviation was determined by dividing the total sum by six, assuming that each sensory attribute contributed equally to the overall acceptability of the meatballs. This was done to compare all the formulations and to choose the appropriate formulation. The results are presented in Table 6.2.

Table 6.2 Mean deviations from ideal for meatballs with different tapioca starch, salt and STPP contents

Treatment (1)							
1	2	3	4	5	6	7	8
0.92	0.88	0.36	0.37	0.62	0.65	0.23	0.24

(1) Refer to Table 6.1 for each treatment formulation.

Treatments 7 and 8, i.e. 'bc' and 'abc', with high levels of salt and STPP and in treatment 8 also with high tapioca starch had the lowest mean deviations from ideal indicating that the meatballs made by these two formulations had the closest overall sensory characteristic scores to the ideal. Therefore, these formulations, with 3% salt, 0.3% STPP and either 2% or 4% tapioca starch, were more acceptable to the panel than other formulations used in this experiment.

6.3.1.3 Correlations of Subjective Evaluation Results

The sensory scores were subjected to correlation analysis and some significant correlation coefficients were obtained and are given in Table 6.3.

Table 6.3 Correlation coefficients between sensory characteristics of the meatballs with salt, phosphate and tapioca starch

Attribute	Correlation Coefficient(1)
firmness - smoothness	0.92 ***
firmness - rubberiness	0.96 ***
firmness - juiciness	-0.73 **
firmness - saltiness	0.97 ***
smoothness - rubberiness	0.96 ***
smoothness - juiciness	-0.60 *
smoothness - saltiness	0.95 ***
rubberiness - juiciness	-0.73 **
rubberiness - saltiness	0.98 ***
juiciness - saltiness	-0.73 **
muttoniness - saltiness	-0.74 ***

(1) * = significant at $0.01 \geq p > 0.005$

** = significant at $0.005 \geq p > 0.001$

*** = significant at $p \leq 0.001$

It was evident that there were high correlations among the sensory characteristics of the meatballs. As expected, firmness was very highly ($p \leq 0.001$) and positively correlated with rubberiness ($r = 0.96$). In addition, firmness and rubberiness were highly correlated with smoothness ($r = 0.92$ and 0.96 respectively) and all these three attributes were, in turn, significantly correlated with saltiness. These results may be explained by the reason that a comminuted meat product, like meatball, inevitably needs the extraction of proteins to bind its chopped meat particles. Salt can solubilize the proteins which, in tum, will fulfill this specific function (Macfarlane et al., 1977; Siegel and Schmidt, 1979). The high salt content at 3% would certainly have extracted more of the soluble proteins required in good binding, thus resulting in meatballs with higher firmness, rubberiness and smoothness scores. However, firmness and rubberiness were negatively correlated, ($p < 0.005$) with juiciness. This finding was in agreement with the previous experimental results and also with Carpenter et al. (1966) who found a positive correlation ($p < 0.01$) between juiciness and tenderness, an attribute opposite to firmness or rubberiness. Muttoniness was negatively correlated with saltiness.

6.3.1.4 Relationships between Sensory Attributes and Meatball Components

All the sensory attribute scores of the meatballs were regressed against tapioca starch, salt and STPP contents and interactions among these input variables. The significant equations which had at least one significant coefficient ($p < 0.05$) are shown in Table 6.4.

Table 6.4 Regression equations showing the relationships between sensory attributes of the meatballs and tapioca starch, salt, STPP contents and their interactions

Sensory Attribute	Regression Equation(1)	R^2x100(%)	t-ratio(2)
smoothness	= 0.404 + 0.196(S)	96.3	2.32 *** 2.53 ***
rubberiness	= 0.555 - 0.0787(TS) + 0.0925(S) - 1.12(STPP) + 0.04(TSxS) + 0.375(TSxSTPP) + 0.5(SxSTPP) - 0.162(TSxSxSTPP)	98.6	3.91 **** -1.76 * 1.46 * -1.77 * 1.99 ** 1.87 ** 1.76 * -1.81 *
saltiness	= 0.385 + 0.227(S) + 0.55(STPP)	99.5	5.07 ***** 6.70 ***** 1.62 *
muttoniness	= 7.56 - 0.373(TS) - 1.44(S) -14.9(STPP) + 1.82(TSxSTPP) + 3.56(SxSTPP)	95.6	9.67 ***** -1.51 * -4.13 **** -4.28 **** 1.65 * 2.28 **

(1) TS = tapioca starch S = salt STPP = sodium tripolyphosphate

(2) t-ratio is a ratio of each regression coefficient to its standard deviation. The first t-ratio value relates to the first regression coefficient and so on.

* = significant at $0.20 \geq p > 0.10$

** = significant at $0.10 \geq p > 0.05$

*** = significant at $0.05 \geq p > 0.02$

**** = significant at $0.01 \geq p > 0.001$

***** = significant at $p \leq 0.001$

There were some significant regression equations. As the salt content increased, the sensory ideal ratio scores for such attributes as smoothness, rubberiness and saltiness increased. Moreover, when levels of the three ingredients, especially STPP, increased, muttoniness score decreased.

6.3.1.5 Objective Evaluation Results

The results for the objective evaluation are presented in Figure 6.2 (see the detailed numerical results in Appendix 6.3).

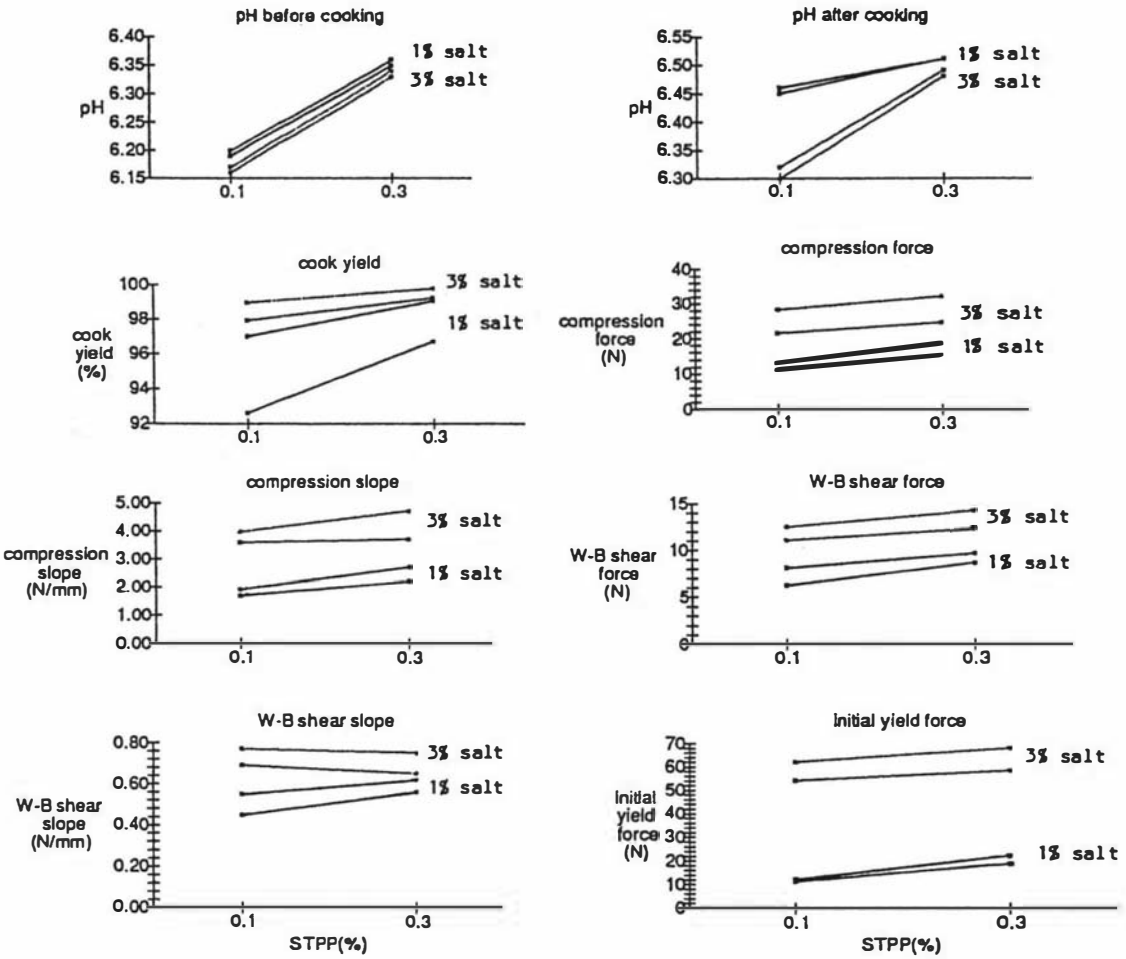


Figure 6.2 Objective test values for the meatballs as affected by tapioca starch, salt and sodium tripolyphosphate (STPP) contents

It was obvious that STPP significantly ($p \leq 0.05$) increased the pH of the meatballs both before and after cooking. STPP is an alkaline chemical and, when used at higher level (0.3% vs. 0.1%) should raise the pH of the meatballs. Cooking also raised the pH of the meatballs. Trout and Schmidt (1984) found that pH of the restructured beef rolls also increased when cooked in hot water. Goodno and Swenson (1975) predicted such an increase with cooking, hypothesizing that during thermal processing the myosin molecule unravels and exposes unprotonated histidine residues. These residues will, in turn, attract protons from the environmental solvent, thus resulting in an increase in pH.

An increase in STPP concentration also raised cook yield. This result was in agreement with Trout and Schmidt (1984). An increasing level of STPP also generally caused an increasing compression force, compression slope, W-B shear force, W-B shear slope or initial yield force. These results might be explained by the reason given by Hamm (1970) who stated that the addition of phosphate helped to cleave bonds between myofilaments in meat muscle, thereby further increasing the surface areas for protein extraction. This phenomenon will lead to a good binding of comminuted meat particles. Disassociation of the actomyosin by phosphate might also occur (Yasui et al., 1964; Siegel et al., 1978; Shimp, 1983), creating greater binding ability due to an increase in myosin concentrations (Hegarty et al., 1963).

Tapioca starch also helped increase all objective test values. However, its effect on pH was relatively marginal especially for the cooked meatballs. Starch, possessing free hydroxyl groups in its structure, can attract water molecules through hydrogen bonding and, in combination with thermal treatment, will swell and even absorb more water molecules. This could be the reason why an increasing amount of tapioca starch gave an increased cook yield. However, the effectiveness of tapioca starch at low (1%) salt was more pronounced than at high (3%) salt, both at low (0.1%) and high level (0.3%) of STPP. The effectiveness of salt, at its high level, on cook yield was slightly greater than that of tapioca starch. Tapioca starch also helped to increase compression force and slope, W-B shear force and slope, and initial yield force. The effect of tapioca starch on these characteristics was also less prominent than that of salt.

In general, an increase in salt level resulted in increasing physical characteristics but not in an increase of pH. The addition of salt to meat samples containing phosphates including STPP was found by Shults et al. (1972) to depress pH. It was apparent that increasing salt content helped to improve cook yield and this was in agreement with Trout and Schmidt (1986). An increase in salt level from 1% to 3% markedly raised all the objective test values measured by the Instron texture meter. Similar findings were reported by Siegel and Schmidt (1979) and Brewer et al. (1984).

The results showed that treatment 8 (with 4% tapioca starch, 3% salt and 0.3% STPP) had the highest cook yield and Instron values.

6.3.1.6 Correlations of Instron Values

The Instron objective test values were subjected to correlation analysis and significant correlation coefficients are given in Table 6.5.

Table 6.5 Correlation coefficients between the Instron objective test values of the meatballs

Instron Value	Correlation Coefficient(1)
compression force - compression slope	0.99
compression force - W-B shear force	0.98
compression force - W-B shear slope	0.93
compression force - initial yield force	0.95
compression slope - W-B shear force	0.98
compression slope - W-B shear slope	0.92
compression slope - initial yield force	0.98
W-B shear force - W-B shear slope	0.93
W-B shear force - initial yield force	0.95
W-B shear slope - initial yield force	0.90

(1) All the values are significant at $p \leq 0.001$.

There were very highly significant ($p \leq 0.001$) correlations among the Instron objective test values indicating that the compression force and slope, the W-B shear force and slope, and the initial yield force were comparable in determining the objective textural properties of the meatballs.

6.3.1.7 Relationships between Objective Evaluation Values and Meatball Components

The objective test results were regressed against tapioca starch, salt and STPP contents and interactions among these input variables. Some significant equations were found and are shown in Table 6.6.

Table 6.6 Regression equations showing the relationships between objective test values of the meatballs and tapioca starch, salt, STPP contents and their interactions

Objective Test	Regression Equation(1)	$R^2 \times 100$ (%)	t-ratio(2)
pH before cooking (3)	= 6.11 + 0.005(TS) - 0.0125(S) + 0.825(STPP)	99.9	1994.66 •••••• 6.93 •••••• -17.32 •••••• 114.31 ••••••
pH after cooking (3)	= 6.39 - 0.0425(S) + 0.587(STPP)	81.5	172.70 •••••• -4.87 •••••• 6.73 ••••••
% cook yield	= 79.8 + 3.74(TS) + 5.38(S) + 41.2(STPP) - 1.03(TSxS) - 7.13(TSxSTPP) - 10.8(SxSTPP) + 1.94(TSxSxSTPP)	98.7	57.72 •••••• 8.55 •••••• 8.69 •••••• 6.66 •••••• -5.28 •••••• -3.65 ••••• -3.89 ••••• 2.22 ••
compression force(N)	= 4.78 + 2.97(S) + 13.8(STPP) + 1.29(TSxS) + 4.81(TSxSTPP)	99.8	2.44 ••• 3.38 ••••• 1.58 • 4.65 ••••• 1.73 •
compression slope(N/mm)	= 1.05(S) + 3.06(STPP) - 1.89(SxSTPP) + 0.437(TSxSxSTPP)	99.7	7.59 •••••• 2.21 •• -3.05 •••• 2.23 ••
W-B shear force(N)	= 1.48(TS) + 3.34(S) + 23.2(STPP) - 0.298(TSxS) - 3.92(TSxSTPP) - 6.37(SxSTPP) + 1.69(TSxSTPP)	99.7	6.24 •••••• 9.93 •••••• 6.90 •••••• -2.80 ••• -3.69 ••••• -4.24 ••••• 3.56 •••••
W-B shear slope(N/mm)	= 0.0725(TS) + 0.181(S) + 1.34(STPP) - 0.188(TSxSTPP) - 0.537(SxSTPP) + 0.075(TSxSxSTPP)	98.9	3.76 ••••• 6.65 •••••• 4.91 ••••• -2.18 •• -4.41 ••••• 1.95 ••
initial yield force(N)	= -11.4 - 1.75(TS) + 18.8(S) + 36.3(STPP) + 1.76(TSxS) + 5.84(TSxSTPP) - 7.41(SxSTPP)	100.0	-6.54 •••••• -3.16 •••• 24.01 •••••• 4.64 ••••• 7.13 •••••• 2.37 ••• -2.12 ••

(1) TS = tapioca starch S = salt STPP = sodium tripolyphosphate

(2) t-ratio is a ratio of each regression coefficient to its standard deviation. The first t-ratio relates to the first regression coefficient and so on.

(3) These two regression equations were obtained without considering interactions between the three additives.

* = significant at $0.20 \geq p > 0.10$

** = significant at $0.01 \geq p > 0.05$

*** = significant at $0.05 \geq p > 0.02$

**** = significant at $0.02 \geq p > 0.01$

***** = significant at $0.01 \geq p > 0.001$

****** = significant at $p \leq 0.001$

It was apparent from the regression equations that increased levels of tapioca starch and STPP raised pH of the meatballs, whether before or after cooking; but, salt depressed the pH values. All three ingredients helped increase cook yield. An increase in tapioca starch, salt, and STPP contents generally resulted in an increase in compression force and slope, W-B shear force and slope, and initial yield force.

6.3.1.8 Correlations between Subjective Evaluation Results and Instron Values

The correlation coefficients between the sensory attribute ideal ratio scores and the Instron values were significant and are shown in Table 6.7.

Table 6.7 Correlation coefficients between the sensory ideal ratio scores and the Instron values

Sensory Attribute	Objective Test	Correlation Coefficient(1)
firmness	compression force	0.84
firmness	compression slope	0.89
firmness	W-B shear force	0.84
firmness	W-B shear slope	0.81
firmness	initial yield force	0.95
smoothness	compression force	0.83
smoothness	compression slope	0.87
smoothness	W-B shear force	0.84
smoothness	W-B shear slope	0.81
smoothness	initial yield force	0.93
rubberiness	compression force	0.89
rubberiness	compression slope	0.92
rubberiness	W-B shear force	0.88
rubberiness	W-B shear slope	0.84
rubberiness	initial yield force	0.98
juiciness	compression force	-0.81
juiciness	compression slope	-0.81
juiciness	W-B shear force	-0.80
juiciness	W-B shear slope	-0.77
juiciness	initial yield force	-0.79
saltiness	compression force	0.85
saltiness	compression slope	0.89
saltiness	W-B shear force	0.85
saltiness	W-B shear slope	0.82
saltiness	initial yield force	0.96

(1) All the values are significant at $p \leq 0.001$.

It was shown that sensory attributes were significantly ($p \leq 0.001$) correlated with the Instron measurements. There were positive correlations between firmness, smoothness, rubberiness, but negative correlation between juiciness, and the Instron parameters.

It was interesting to note that the initial yield force was more highly correlated with such textural characteristics as firmness, smoothness and rubberiness; the correlation coefficients being 0.95, 0.93 and 0.98 respectively, than was the compression force or slope and the W-B shear force or slope. This was confirmed by the higher correlation coefficient (0.96) between the initial yield force and saltiness. Therefore, the initial yield force was more suitable than the other Instron parameters for objectively assessing texture of meatballs.

6.3.1.9 Use of Empirical Equations to Estimate the Optimum Contents of the Three Ingredients

The empirical equations obtained by both the subjective tests and the objective tests were considered together in order to estimate the optimum contents of the three ingredients to be used in meatballs.

The empirical equations for the subjective test results were firstly considered and, whenever valid, the variables with 'low level of significance' coefficients - i.e. normally lower than 90% - were omitted. The equations were

$$\text{smoothness} = 0.404 + 0.196\,(\text{salt}) \quad (1)$$

$$\text{saltiness} = 0.385 + 0.227\,(\text{salt}) \quad (2)$$

$$\text{muttoniness} = 7.56 - 1.44\,(\text{salt}) - 14.9\,(\text{STPP}) \quad (3)$$

$$\text{rubberiness} = 0.555 + 0.04\,(\text{tapioca starch} \times \text{salt}) + 0.375\,(\text{tapioca starch} \times \text{STPP}) \quad (4)$$

Setting the ideal ratio score to 1 and solving the above equations, the optimum contents of the ingredients could be estimated as:

From equation (1), the optimum salt content for ideal smoothness was 3%.
From equation (2), the optimum salt content for ideal saltiness was 2.7%.
From equation (3) and substituting salt at 3% and 2.7%, the optimum contents of STPP for ideal muttoniness were 0.15% and 0.18% respectively.
From equation (4) and substituting salt and STPP at respectively 2.7% and 0.15%, 2.7% and 0.18%, 3% and 0.15%, and 3% and 0.18%; the optimum tapioca starch contents for ideal rubberiness were 2.71%, 2.54%, 2.52% and 2.37% respectively.

For the objective tests, the empirical equation for such an important property as % cook yield was:

$$\%\ \text{cook yield} = 79.8 + 3.74\,(\text{tapioca starch}) + 5.38\,(\text{salt}) + 41.2\,(\text{STPP}) - 1.03\,(\text{tapioca starch} \times \text{salt}) - 7.13\,(\text{tapioca starch} \times \text{STPP}) - 10.8\,(\text{salt} \times \text{STPP}) + 1.94\,(\text{tapioca starch} \times \text{salt} \times \text{STPP}) \quad (5)$$

Setting the ideal cook yield of 100% and substituting the values of all combinations of salt at 2.7% and 3% and tapioca starch at 2.37%, 2.52%, 2.54%,and 2.71%, the optimum contents of STPP for ideal cook yield were 0.44% - 0.45%.

When all characteristics, whether from the subjective or the objective test, were considered together, a suggestion was made as follows:

* The optimum salt contents were between 2.5% - 3% to yield meatballs with ideal saltiness and smoothness. A number of researchers reported that salt concentration at > 2% was necessary to provide the processed meat products with desirable characteristics (Neer and Mandigo, 1977; Theno et al., 1978; Hand et al., 1987). The ideal content for saltiness for the Thai panelists was 2.7%. However, the low level was chosen at 2.5% to broaden the range to be used for further study. The high level at 3% was estimated for ideal smoothness and it was expected that no more salt could be added since ideal ratio scores for saltiness, at this level of salt, was higher than 1.

* The optimum contents of tapioca starch were between 2% - 4%. Although the optimum level to yield ideal rubberiness was between 2.4% - 2.7%, this range was considered not to be broad enough for further study. In addition to rubberiness, physical characteristics such as cook yield, which could be increased by raising starch content, was also important. Although research concerning utilisation of tapioca starch in processed meat products was limited, some researchers used, in general, 4% of tapioca starch in processed meat products. Taking all these reasons into consideration, the optimum contents of tapioca starch were chosen between 2% - 4%.

* The optimum STPP content was at 0.25% - 0.3%. It was found that approximately 0.2% STPP was needed to yield meatballs with ideal muttoniness and that a high level at 0.45% was needed for ideal cook yield. This high level was beyond the maximum level used in the experiment. The empirical equations were valid for the region in the factorial experiment. Therefore, 0.45% STPP might not be appropriate under these circumstances. However, the Thai regulations allow the maximum level of 0.3% phosphates to be used in processed meat products. Therefore, taking all these reasons into consideration, the maximum level was set at 0.3%. The minimum level was chosen at 0.25% in order to try to get as high cook yield as possible but also to relatively broaden the range to be used in further study. Neer and Mandigo (1977) reported that combinations of STPP at 0.25% and salt at 2.25% - 3.0% yielded flaked and cured pork products with superior characteristics.

When the contents of salt, tapioca starch and STPP at 3%, 4% and 0.3% respectively were substituted in the objective test empirical equations, it was found that most of the predicted test values especially % cook yield and pH before cooking were very close to the actual values for treatment 8. The predicted % cook yield was 99.61% (the actual value was 99.7%) and the predicted pH before cooking was pH 6.34, being equal to the actual value.

6.3.1.10 Discussion and Conclusion

From the subjective evaluation results, it was shown that increasing salt content increased firmness, smoothness, rubberiness and saltiness, but decreased muttoniness ideal ratio scores. When compared with salt, STPP only slightly improved the texture of the meatballs but was more effective when 4% tapioca starch was included in the formulation. Tapioca starch improved, but not significantly, such textural attributes as firmness, smoothness and rubberiness. Overall, the effect of salt on the sensory characteristics of the meatballs was more pronounced than those of tapioca starch and STPP. It was interesting that the three ingredients, particularly STPP, helped to depress muttoniness.

The objective evaluation results also indicated that an increasing content of salt gave an increase for all the objective test values measured except for pH. There was a tendency that increasing contents of tapioca starch and STPP increased the objective test values.

The correlation analysis showed that there were significant and positive correlations between firmness, smoothness, rubberiness and saltiness but these sensory attributes were negatively correlated with juiciness and that there were significant and positive correlations between the Instron values as determined by the compression, the W-B and the initial yield measurement.

The regression analysis showed that an increasing level of salt resulted in increased smoothness, rubberiness and saltiness scores. Moreover, raising levels of salt, tapioca starch and STPP resulted in a decrease in muttoniness score - more close to the ideal ratio score of 1. As salt, tapioca starch and STPP contents increased, an increase in cook yield and the Instron values were obtained.

The correlation between the subjective evaluation and the objective evaluation showed significant and positive correlations between such sensory attributes as firmness, smoothness, rubberiness, saltiness and the Instron values. However, juiciness was significantly but negatively correlated with the Instron values.

In conclusion, salt, tapioca starch and STPP helped to improve both the subjective and objective characteristics of the meatballs. It was shown that these three ingredients,

especially salt, helped increase the ideal ratio scores for such sensory attributes as firmness, smoothness and rubberiness and also the objective test values especially cook yield. Therefore, the implication was that salt, tapioca starch and STPP were necessary for development of the meatballs to have desirable characteristics, especially the sensory attributes, for the Thai panelists.

6.3.2 A Comparison between Sodium Tripolyphosphate, Tetrasodium Pyrophosphate and Borax for Their Effects on the Characteristics of Meatballs

This experiment extended the previous experiment. From the results obtained, the formulation yielding the meatballs with most desirable characteristics was 4% tapioca starch, 3% salt and 0.3% STPP. This present investigation was performed to compare the effect of STPP, TSPP and borax (disodium tetraborate decahydrate) on the meatballs' characteristics.

In Thailand, commercial meatballs are generally prepared using phosphates which are allowed to be used to a certain extent in processed meat products. However, some producers use borax, which is illegal and prohibited from use in food products, in the meatballs. This is due to the belief that borax helps to make meatballs with high rubberiness, which is desirable.

6.3.2.1 Experimental Methods

The meatballs were made by using mutton lean (75%), pork lean (20%) and pork fat (5%), with 4% tapioca starch, 3% salt and 0.3% STPP or TSPP or borax (based on the weight of meats and fat). Flaked ice was added at 20%, on the weight of meats and fat, to control the temperature of the mixture during chopping. Refer to Chapter 4 (Section 4.1.1 and 4.1.2) for materials and processing methods used for manufacturing.

The prepared meatballs were assessed for their sensory characteristics in exactly the same manner as those used in the previous experiment (refer to Section 6.3.1.1). Only the samples with STPP or TSPP were used in sensory evaluation. The samples with borax were evaluated by the objective means only since borax is hazardous to health.

In the objective evaluations, the same parameters as given in Section 6.3.1.1 were determined.

Analyses of the data were also performed according to the methods in Chapter 4 (Section 4.3).

6.3.2.2 Subjective Evaluation Results

The ideal ratio scores for sensory attributes of the meatballs added with different phosphates are given in Table 6.8.

Table 6.8 Ideal ratio scores for sensory attributes of the meatballs with sodium tripolyphosphate (STPP) or tetrasodium pyrophosphate (TSPP) (1)

Attribute	STPP(Previous Exp.)	STPP	TSPP
firmness	0.88 ± 0.01	0.92 ± 0.03	0.89 ± 0.01
smoothness	0.95 ± 0.00	0.95 ± 0.01	0.95 ± 0.02
rubberiness	0.98 ± 0.04	0.98 ± 0.03	0.96 ± 0.01
juiciness	0.96 ± 0.01	0.97 ± 0.03	0.99 ± 0.02
saltiness	1.00 ± 0.01	1.04 ± 0.03	1.01 ± 0.02
muttoniness	2.22 ± 0.21	2.41 ± 0.02	2.13 ± 0.12

(1) The scores were given by eight Thai panelists. Values are means ± standard errors of the means between two replications. The two values within the same row are not significantly different ($p \leq 0.05$). This was analysed excluding the values from the previous experiment.

The results indicated that there were not any significant differences between sensory attributes of the meatballs made with either STPP or TSPP. The results were very similar to the previous experiment.

6.3.2.3 Objective Evaluation Results

The results determined by the objective tests are shown in Table 6.9.

Table 6.9 Effect of sodium tripolyphosphate (STPP), tetrasodium pyrophosphate (TSPP) and borax on the objective test values of the meatballs (1)

Objective Test	STPP (Previous Exp.)	STPP	TSPP	Borax
pH before cooking	6.34 ± 0.00	6.13 ± 0.00^{a}	6.25 ± 0.00^{c}	6.23 ± 0.00^{b}
pH after cooking	6.49 ± 0.00	6.31 ± 0.01^{a}	6.41 ± 0.01^{b}	6.40 ± 0.01^{b}
cook yield(%)	99.70 ± 0.05	99.40 ± 0.18^{ab}	99.80 ± 0.01^{b}	98.90 ± 0.07^{a}
compression force(N)	32.30 ± 0.37	33.36 ± 0.08^{b}	33.85 ± 0.00^{b}	31.23 ± 0.24^{a}
compression slope (N/mm)	4.71 ± 0.01	4.73 ± 0.00^{b}	4.76 ± 0.01^{b}	4.48 ± 0.00^{a}
W-B shear force(N)	14.25 ± 0.03	11.62 ± 0.16^{b}	11.93 ± 0.05^{b}	9.84 ± 0.00^{a}
W-B shear slope(N/mm)	0.75 ± 0.01	0.60 ± 0.01^{b}	0.63 ± 0.01^{b}	0.53 ± 0.01^{a}
initial yield force(N)	68.23 ± 0.31	68.86 ± 0.32^{b}	71.15 ± 0.73^{b}	57.82 ± 0.11^{a}

(1) Values are means ± standard errors of the means between two replications. Any two means within the same row possessing one of the same letters in the superscripts are not significantly different at $p \leq 0.05$. This was analysed excluding the values from the last experiment.

It was apparent that meatballs with STPP had significantly lower pH - whether before or after cooking - than those with TSPP or borax. This finding was in agreement with Trout and Schmidt (1984) who found that TSPP was more effective in raising the pH of the restructured beef rolls and with Kuo et al. (1987) who found similar results in Chinese sausages.

The effectiveness of the additives on cook yield was TSPP > STPP > borax. Similar results were also found by Trout and Schmidt (1984) in that both phosphate type and concentration had an effect on cook yield. TSPP was more effective than STPP ($p < 0.05$). Shults et al. (1972) also showed that TSPP was more effective in increasing water holding capacity than STPP.

STPP and TSPP produced meatballs with similar characteristics especially the Instron values, but borax did not appear to be comparable to these two phosphates. However, Trout and Schmidt (1984) found that TSPP addition gave the restructured beef rolls, which required higher tensile strengths to shear, indicating the better effectiveness of TSPP in binding when compared to that of STPP.

It was interesting to note that the objective test measurements, particularly the initial yield force, were reproducible in assessing the texture of the meatballs.

6.3.2.4 Discussion and Conclusion

It was shown that STPP and TSPP were comparable to each other in providing relatively the same textural characteristics, whether determined subjectively or objectively, for the meatballs. Although TSPP might be better in view of the practical advantage of giving the meatballs with higher cook yield, this parameter was relatively marginal.

The price of TSPP is much more expensive than that of STPP. In Thailand, the price of TSPP as quoted in late 1984 was 490 baht/kg whereas the price of STPP was 290 baht/kg (1 NZ$ = 13 baht at that time). It was for these reasons that STPP was chosen as an additive, in addition to salt and tapioca starch, for further development.

In considering the data and results available and by taking into account that borax is harmful to health, it might be concluded that borax was not necessary at all in production of the meatballs with desired texture.

6.3.3 Overall Discussion and Conclusion

From the results obtained in this part of the study, it was concluded that salt, tapioca starch and sodium tripolyphosphate all helped to improve the characteristics of the meatballs, whether assessed by the subjective or the objective evaluation. In the subjective evaluation, the effects of salt were more prominent than those of the other two ingredients. It was interesting to note that the textural characteristics of the meatballs, especially firmness, smoothness and rubberiness were substantially improved by an addition of salt indicating that it was an indispensable ingredient for the meatballs. Salt not only improved the texture but also gave saltiness - a sensory attribute which was also desired in the meatballs. In addition to salt, tapioca starch and sodium tripolyphosphate also helped to improve the characteristics of the meatballs indicating that they were also necessary for formulation.

In the objective evaluation, increasing contents of the three ingredients increased the values measured, except that salt lowered the pH values. Moreover, from a standpoint of practical advantage, the cook yield was raised by increasing the levels of these three additives.

It was shown that sodium tripolyphosphate and tetrasodium pyrophosphate were comparable, resulting in meatballs with similar characteristics. However, sodium tripolyphosphate was chosen for use due to its significantly lower price. Borax was shown to be inferior and not necessary at all for texture improvement.

In conclusion, due to the beneficial effects of salt, tapioca starch and sodium tripolyphosphate, these three ingredients would be used in further development of the meatballs. Their estimated optimum contents were in the range of 2.5-3% for salt, 2-4% for tapioca starch and 0.25-0.3% for sodium tripolyphosphate.

At this stage of the development, the texture of the meatballs was notably improved and acceptable to the Thai panelists. Nevertheless, the improvement of the odour and flavour of the product had not been accomplished. Spices and ingredients, which could impart desirable odour and flavour to food products, were expected to improve the meatball's odour and flavour and also to concurrently disguise the strong odour and flavour of mutton.

The following chapter discusses selection of spices and flavouring ingredients for use in the meatballs. The selected spices would then be used with salt, tapioca starch and sodium tripolyphosphate for formulation work to simultaneously investigate the effects of all the ingredients on the sensory attribute acceptability of the product.

CHAPTER 7
DEVELOPMENT OF THE FLAVOUR AND AROMA

7.1 INTRODUCTION

The low consumer acceptance of sheep meats especially mutton has been attributed to the flavour and aroma of these meats (Batcher et al., 1969; Wong et al., 1975; Sink and Caporaso, 1977; Hudson and Loxley, 1983). Mutton is not only an unfamiliar meat but its flavour and aroma is also objectionable to the Thai people.

Although trimmed mutton, with fat and connective tissue removed, had been used in all previous experiments, it was expected and supported by comments given by the panelists, that 'muttoniness' still persisted in the meatballs. It was expected that some spices and ingredients which could impart flavour would help disguise the strong and objectionable flavour and aroma of mutton and result in meatballs which were acceptable to the Thai panelists.

This chapter discusses the selection of spices which helped in masking the strong flavour and aroma of mutton. The selected spices were then used together with salt, tapioca starch and sodium tripolyphosphate to study the effects of all the ingredients on the acceptability of meatballs made from either untrimmed or trimmed mutton. Then the meatballs were made with the optimum levels of all ingredients and various proportions of mutton and they were tested for acceptability or preference by the laboratory taste panel and a small consumer panel.

7.2 LITERATURE REVIEW

7.2.1 Masking of Mutton Flavour and Aroma

In recent years, attempts have been made by a number of researchers to mask the strong flavour and aroma of mutton (Hudson and Loxley, 1983; Akatsuka, 1984; Bartholomew and Osuala, 1986). Objectionable mutton flavour was apparently reduced by spicing and mutton products containing higher levels of pepper, garlic, fennel, paprika, appeared to be more acceptable (Bartholomew and Osuala, 1986).

Due to their roles as flavour and aroma enhancers, spices have long been used to flavour Thai foods, and therefore Thai food is always characterised by Western people as very spicy (Sinthavalai, 1984). Spices like garlic, onion, pepper, coriander, fennel and sesame are normally used in preparation of Thai foods (Anon., 1970; Sinthavalai, 1984). In Thailand, only pepper and garlic are normally used in commercial meatballs but it was

expected that these two spices would not be effective in concealing the strong flavour and aroma of mutton. Therefore, onion, coriander, fennel and sesame were also selected (see descriptions of these spices in Appendix 7.1). The possible amounts of all six spices were chosen by consulting recipes for Thai foods (Anon., 1970).

Spices not only act as odour and flavour enhancers but also furnish microbiological advantages. Garlic exhibited antibacterial activities (Walton et al., 1936; Al-Delaimy and Ali, 1970; DeWit et al., 1979), and antifungal activities (Tansey and Appleton, 1975; Barone and Tansey, 1977; Moore and Atkins, 1977). Onion also exhibited antibacterial activities (DeWit et al., 1979). Conner and Beuchat (1984) found that essential oils of garlic and onion were inhibitory to thirteen food-spoilage and industrial yeasts. In addition, many spices were shown by a number of researchers to exhibit antioxidant activity. These spices were white pepper, coriander, and fennel (Chipault et al., 1952) and black pepper and ginger (Al-Jalay et al., 1987).

Spices could help to disguise the strong flavour and aroma of mutton. In addition to their flavour and aroma enhancing roles, spices could possibly give antimicrobial and antioxidant activities to the mutton-based meatballs.

7.2.2 Consumer Panel Evaluation of Acceptability of a Product

Amerine et al. (1965) stated that although members of a laboratory panel were consumers, their opinions and preferences might not be representative of the general population. Generally, the laboratory panel was selectively obtained, well trained and hypercritical as compared to the general consumer. The criteria used in a laboratory panel such as test-booth conditions, coded containers and scoring methods were definitely not typical of normal conditions of food consumption. In addition, the opinions of the laboratory panel were not influenced by such factors as packaging, advertising, ease of preparation, price or prestige, as the opinions of the general consumer might be.

Consumers were untrained evaluators who based their judgement mainly on their own feelings and perceptions and, therefore, their impressions and judgement might be different from those of trained laboratory panelists (Pangborn and Russell, 1976; Gatchalian, 1981). The communication bridge between the findings of analytical laboratory panels and the consumer preference panels was very important (Gatchalian, 1981). A number of researchers found that consumers generally agreed with laboratory findings in direction but not in magnitude (Miller et al., 1955; Simone et al., 1956).

Consumer panelling is probably the most frequently used method for obtaining consumer attitudes. In 1981, Anderson noted that consumer panels could be applied throughout the

full course of the product development process. The author suggested a consumer panel size of 10-15 members for the later testing during product formulation before it was used in pilot plants trials. Earle (1981) discussed selection and organisation of consumer panels. The author indicated that the 20-30 member panel was used for initial discussions and testing of product attributes during new product development, product reformulation and quality assurance programmes. Moskowitz (1985) who has worked extensively in the area of sensory evaluation had also started using consumer panels for many different purposes; i.e. screening of ingredients, developing and optimising concepts, optimising products for acceptance, cost and stability, and determining attributes of importance to consumers.

Because of its simplicity and flexibility, the hedonic-rating scale could be recommended for use at the consumer level and the language it employed was easily understood and the test required only brief and simple instructions (Amerine et al., 1965). In addition, subjects could respond meaningfully without previous experience, the data could be handled by the statistics of variables and in contrast to other methods, within broad limits the results were meaningful for signifying general levels of preference (Peryam and Pilgrim, 1957). The hedonic scale method was a rating scale method which could be used to measure the level of liking of foods (ASTM, 1968; Moskowitz, 1983).

Purchase behaviour represents a more complicated variation of hedonic reaction. People may purchase a food product that they do not really like because the product is cheaper than its competitor which they may like much more. Moskowitz (1983) also stated that the researcher could not predict whether or not consumers would purchase the product by simple acceptance scales alone, as the tasters would often evaluate the product in isolation from real world stimulus conditions. Therefore, apart from the fact that consumers accept a food product, their willingness of purchasing is also an important criterion in testing the product.

7.3 SCREENING OF SPICES

7.3.1 Experimental Methods

The experiments for screening spices were divided into two parts. Firstly, an investigation was made to preliminarily determine the responses of the panelists to the flavour and aroma of meatballs, with a number of spices. Based on the results obtained from this investigation, a Plackett and Burman experiment was used to screen for suitable spices.

The basic formulation for the meatballs was 75% mutton (trimmed product from 90% chemically lean meat), 20% pork and 5% pork fat, with 4% tapioca starch, 3% salt, 0.3% sodium tripolyphosphate. This was used for both the preliminary investigation and the Plackett and Burman experiment.

The meatballs were made by using the materials and ingredients described previously (refer also to Section 4.1.1) and the methods given in Chapter 4 (Section 4.1.2). Ice (20%) was added during chopping. The meatball samples were prepared for serving by deep frying in soybean oil at 200 ± 5 C° for two minutes since it was expected that cooking oil would help enhance flavour and aroma of spices in the meatballs.

The eight Thai panelists were asked to evaluate two characteristics of the samples: desirable flavour and aroma and undesirable flavour and aroma (see Figure 7.1).

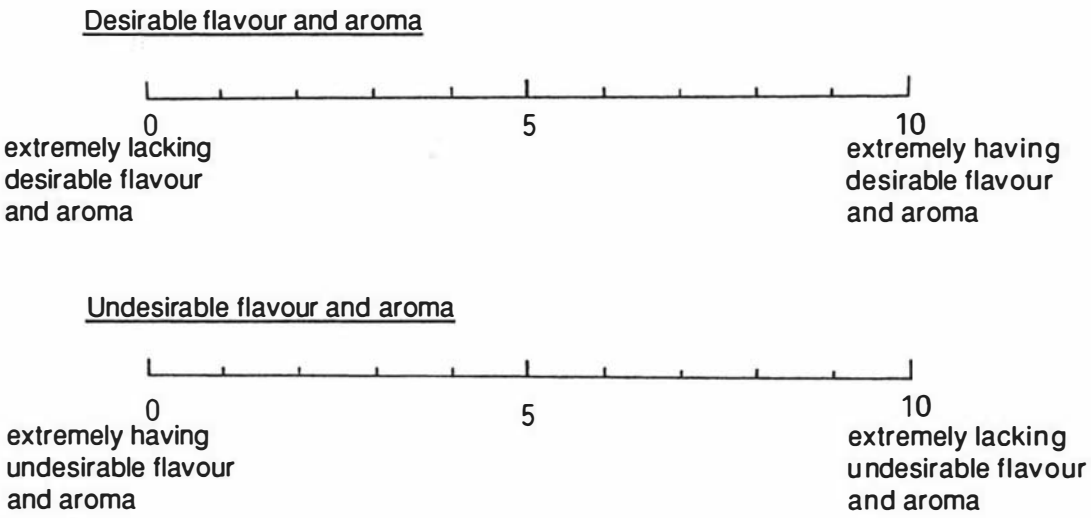


Figure 7.1 Scales used for screening of spices

The questionnaire included only two questions so that it would be convenient for the panelists to express their impressions of the samples, i.e. there were not too many characteristics to assess. 'Muttoniness' was not directly used as a descriptive term to be assessed by the panelists. Instead, 'undesirable flavour and aroma' was used. This was due to the presumption that the panelists would have been prejudiced in assessing odour and flavour if they had been told beforehand about muttoniness.

Cooper et al. (1988) stated that a score of zero for the ideal caused particular problems in calculating the ideal ratio score since the ratio of product's score to the ideal score would be infinity. Due to this reason, the descriptions at both ends of the undesirable flavour and aroma scale were reversed when compared to those of the desirable flavour and aroma scale, that 10 was extremely lacking undesirable flavour and aroma, 0 was extremely having undesirable flavour and aroma.

In the preliminary investigation, the panelists were asked to test the meatball samples and give their ideal absolute scores for each sensory characteristic. The mean ideal absolute scores for the two characteristics were later used in the Plackett and Burman experiment. Concurrently, the panelists also showed their perceptions of the flavour and aroma of the meatballs by giving the product's scores for the two characteristics.

In the Plackett and Burman experiment, the vertical line of the mean ideal absolute score was marked on each line scale (see Appendix 7.2). The panelists were asked to evaluate the meatball samples and give the product's scores comparing them with the fixed ideal absolute scores given.

7.3.2 Preliminary Investigation

Spices in this experiment were white pepper (0.75%), garlic (0.75%), onion (0.5%), coriander (0.375%), fennel (0.375%) and sesame oil (0.3%). The mean ideal absolute scores for desirable flavour and aroma and undesirable flavour and aroma were 8.4 and 8.0 respectively. The mean ideal ratio scores (product score:ideal absolute score) for desirable flavour and aroma (0.87) and undesirable flavour and aroma (0.80) were below the ideal ratio score (1.0).

Therefore, it was expected that increasing the percentages of these spices would improve flavour and aroma. However, since there were comments by some panelists that the meatball samples were too hot, the white pepper was maintained at 0.75%; and because garlic has a very strong odour and flavour, it was maintained at 0.75%. However, the percentages of onion, coriander, fennel and sesame oil were slightly raised to 0.6%, 0.4%, 0.4% and 0.5% respectively. Therefore, the percentages of the six spices were set at their high levels at 0.75%, 0.75%, 0.6%, 0.4%, 0.4% and 0.5% for white pepper, garlic, onion, coriander, fennel and sesame oil respectively. The low levels were set by reducing all the high values by one half. These low and high values of six spices were used in the Plackett and Burman experiment.

7.3.3 Plackett and Burman Experiment

There were eight experimental runs to study the effects of the six spices on flavour and aroma of meatballs as shown in Table 7.1.

Table 7.1 Combinations of spices in a Plackett and Burman experiment to study their effects on flavour and aroma of mutton-based meatballs

Run No.(or Treatment)	Level of Each Ingredient(1)						
	White Pepper	Garlic	Onion	Coriander	Fennel	Sesame Oil	Dummy
1	0.750(+)	0.750(+)	0.6(+)	0.2(-)	0.4(+)	0.25(-)	(-)
2	0.750(+)	0.750(+)	0.3(-)	0.4(+)	0.2(-)	0.25(-)	(+)
3	0.750(+)	0.375(-)	0.6(+)	0.2(-)	0.2(-)	0.50(+)	(+)
4	0.375(-)	0.750(+)	0.3(-)	0.2(-)	0.4(+)	0.50(+)	(+)
5	0.750(+)	0.375(-)	0.3(-)	0.4(+)	0.4(+)	0.50(+)	(-)
6	0.375(-)	0.375(-)	0.6(+)	0.4(+)	0.4(+)	0.25(-)	(+)
7	0.375(-)	0.750(+)	0.6(+)	0.4(+)	0.2(-)	0.50(+)	(-)
8	0.375(-)	0.375(-)	0.3(-)	0.2(-)	0.2(-)	0.25(-)	(-)

(1) The percentage of each ingredient was based on the total weight of meats (75% mutton lean and 20% pork lean) and fat (5% pork fat).

The mean ideal ratio scores of desirable flavour and aroma and undesirable flavour and aroma are given in Table 7.2.

Table 7.2 Mean ideal ratio scores for flavour and aroma of meatballs with different types and levels of spices in the Plackett and Burman experiment (1)

Characteristic	Treatment(2)							
	1	2	3	4	5	6	7	8
Desirable flavour and aroma	0.85 ± 0.04	0.84 ± 0.01	0.83 ± 0.02	0.78 ± 0.02	0.76 ± 0.03	0.80 ± 0.02	0.79 ± 0.01	0.77 ± 0.00
Undesirable flavour and aroma	0.82 ± 0.03	0.79 ± 0.03	0.82 ± 0.02	0.78 ± 0.01	0.68 ± 0.02	0.77 ± 0.01	0.77 ± 0.03	0.76 ± 0.04

(1) The scores were given by eight Thai panelists. All means were not significantly different at $p \leq 0.05$.
(2) Refer to Table 7.1 for treatment formulation.

There was a tendency that the meatballs with high levels of white pepper, garlic and onion had ideal ratio scores closer to the ideal of 1, especially treatment 1 with white pepper, garlic and onion all at their high levels.

The mean ideal ratio scores of the desirable flavour and aroma and undesirable flavour and aroma of the meatballs were then subjected to a Plackett and Burman design analysis. Every Plackett and Burman design includes, for each variable, the same number of runs at the high level and the low level. To calculate the effect of any input variable, one subtracts the average result at the low level of that variable from the average result at the high level of the same variable.

With eight runs or formulations, the effect of white pepper was calculated as (refer to Table 7.1):

$$\text{Effect (white pepper)} = \frac{[1 + 2 + 3 + 5]}{4} - \frac{[4 + 6 + 7 + 8]}{4}$$

where 1 = value of the output variable in run or formulation 1 and so on.

Similar calculations were repeated for each of the effects including that of the dummy variable. The dummy effect was used to estimate the variance of an effect.

$$V_{eff} = \frac{\Sigma [Ed]^2}{n}$$

where V_{eff} = variance of an effect
Ed = effect shown by a dummy
n = number of dummy variables, i.e. 1 in this experiment.

The standard error of an effect was calculated as

$$S.E._{eff} = \sqrt{V_{eff}}$$

The significance of each effect was determined by using the t-test.

$$t = \frac{\text{Effect}}{S.E._{eff}}$$

The calculated t-value was then compared with the tabulated value whose degree of freedom was equal to the number of dummy effects making up the error term. In this

experiment, the levels of significance used were > 50%. This was due to the reason that only a rough screening was needed to compare the effect of each ingredient on flavour and aroma of the meatballs.

The results are presented in Table 7.3.

Table 7.3 Main effects of spices on flavour and aroma of meatballs in the Plackett and Burman experiment

Characteristic	White Pepper	Garlic	Onion	Coriander	Fennel	Sesame Oil
Desirable flavour and aroma						
main effect	0.035	0.025	0.03	-0.01	-0.01	-0.025
t-test	1.750	1.250	1.50	-0.50	-0.50	-1.250
significance level	60%	50%	60%	n.s.	n.s.	50%
Undesirable flavour and aroma						
main effect	0.01	0.035	0.04	-0.045	-0.015	-0.02
t-test	0.33	1.170	1.33	-1.500	-0.830	-0.67
significance level	n.s.	50%	50%	60%	n.s.	n.s.

None of the spices had highly significant effects on desirable flavour and aroma and undesirable flavour and aroma of the meatballs. However, it appeared that white pepper, garlic and onion slightly improved the flavour and aroma of the mutton-based meatballs whereas coriander, fennel and sesame oil had an adverse effect. This was shown by the positive effects given by the former three spices and the negative effects given by the latter three spices.

In this screening experiment, the high levels of white pepper, garlic and onion were 0.75%, 0.75% and 0.6% respectively and the ideal ratio scores for desirable flavours and aroma were around 0.8. Therefore, in order to improve flavour and aroma of meatballs, the high levels of these spices had to be increased in further development. The high level of white pepper, however, was set at the same level (0.75%) because there were comments by some panelists that the meatballs were too hot. In addition, commercial meatballs in Thailand are normally made with a lower content of white pepper, normally at 0.1%. The high levels of garlic and onion were both raised to 0.8% which were close to the levels used in this experiment. The high level of garlic would be increased by an additional 0.05% and that of onion by an additional 0.2%. This was due to the reason that the flavour and aroma

of garlic is harsh and persistent but that of onion is mild and sweet. Therefore, the level of garlic was not substantially raised. It should be borne in mind, as suggested by Farrell (1985), that garlic (and possibly onion) should be used with extreme caution because of its intense aroma and disagreeable taste when used excessively. Although the Thai people use garlic and onion in cooking, they use these two spices only to add aroma and flavour into foods but do not use them excessively. In addition, processed meat products in Thailand are not made with too high levels of these spices , for example, fermented Thai style pork sausages (Nam) are made with 0.3% garlic. Therefore, the mutton-based meatballs should be made with not too high percentages of white pepper, garlic and onion if they are to be consumed by the Thais. The minimum levels of white pepper, garlic and onion were increased to 0.5%, 0.6% and 0.6% respectively.

7.4 EFFECTS OF ALL INGREDIENTS ON ACCEPTABILITY

This study aimed to determine the effects of the three texture improvers, viz. salt, tapioca starch and sodium tripolyphosphate (STPP) together with the three odour and flavour enhancers, viz. white pepper, garlic and onion on sensory attribute acceptability of the mutton-based meatballs.

7.4.1 Experimental Methods

From the past experiments, the levels of tapioca starch, salt and STPP were set at 2%-4%, 2.5%-3.0%, and 0.25%-0.30% respectively to yield meatballs with desirable textural characteristics. To attain a desirable odour and flavour, the levels of white pepper, garlic and onion were set at 0.5%-0.75%, 0.6%-0.8% and 0.6%-0.8% respectively.

A quarter fractional 2^6 factorial design was used. The sixteen treatments assigned for combinations of the six ingredients are presented in Table 7.4.

Table 7.4 Combinations of ingredients in a quarter fractional 2^6 factorial experiment to study their effects on sensory attribute acceptability of mutton-based meatballs

Run No. or Treatment	Code	Level of Each Ingredient (%) Tapioca Starch (A)	Salt (B)	STPP (C)	White Pepper (D)	Garlic (E)	Onion (F)
1	1	2.0(-)	2.5(-)	0.25(-)	0.50(-)	0.6(-)	0.6(-)
2	aef	4.0(+)	2.5(-)	0.25(-)	0.50(-)	0.8(+)	0.8(+)
3	bef	2.0(-)	3.0(+)	0.25(-)	0.50(-)	0.8(+)	0.8(+)
4	ab	4.0(+)	3.0(+)	0.25(-)	0.50(-)	0.6(-)	0.6(-)
5	ce	2.0(-)	2.5(-)	0.30(+)	0.50(-)	0.8(+)	0.6(-)
6	acf	4.0(+)	2.5(-)	0.30(+)	0.50(-)	0.6(-)	0.8(+)
7	bcf	2.0(-)	3.0(+)	0.30(+)	0.50(-)	0.6(-)	0.8(+)
8	abce	4.0(+)	3.0(+)	0.30(+)	0.50(-)	0.8(+)	0.6(-)
9	df	2.0(-)	2.5(-)	0.25(-)	0.75(+)	0.6(-)	0.8(+)
10	ade	4.0(+)	2.5(-)	0.25(-)	0.75(+)	0.8(+)	0.6(-)
11	bde	2.0(-)	3.0(+)	0.25(-)	0.75(+)	0.8(+)	0.6(-)
12	abdf	4.0(+)	3.0(+)	0.25(-)	0.75(+)	0.6(-)	0.8(+)
13	cdef	2.0(-)	2.5(-)	0.30(+)	0.75(+)	0.8(+)	0.8(+)
14	acd	4.0(+)	2.5(-)	0.30(+)	0.75(+)	0.6(-)	0.6(-)
15	bcd	2.0(-)	3.0(+)	0.30(+)	0.75(+)	0.6(-)	0.6(-)
16	abcdef	4.0(+)	3.0(+)	0.30(+)	0.75(+)	0.8(+)	0.8(+)

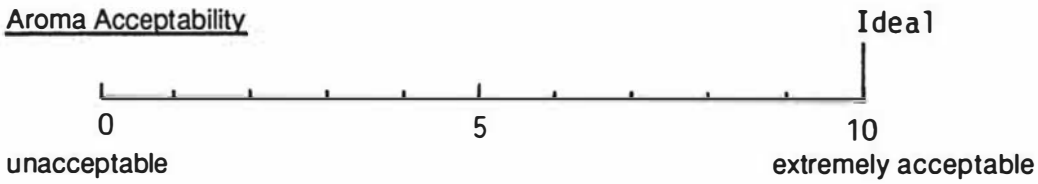
N.B. - The percentage of each ingredient was based on the total weight of meats (75% mutton lean + 20% pork lean) and fat (5% pork fat).

Two more treatments were added into the above experiment using the same combinations of ingredients as those in treatments 1 and 16. However, the mutton raw materials were different. The mutton used for every treatment in the above fractional factorial experiment was untrimmed frozen boneless mutton leg and the mutton used for the two additional treatments was a trimmed product from 90% chemically lean frozen boneless mutton.

The meatballs were made using the mutton raw materials and the proportions of the six ingredients given in Table 7.4. No replication was performed for each treatment.

The prepared meatballs were deep fried in soybean oil at 200 ± 5 C° for 2 minutes and served to the same eight Thai panelists. Each panelist was asked to assess the sensory attribute acceptability of the meatballs. The attributes were aroma, texture, flavour, and overall acceptability (see details of a questionnaire in Appendix 7.3). Each of the four

acceptability line scales was anchored at the 0-end with 'unacceptable' and at the 10-end with 'extremely acceptable'. Also the 'Ideal' was marked at the 10-end taking into account that the ideal product should have each attribute acceptability at this extreme value. An example of the scale used is given below.



Initial yield force was the only texture measurement in this present study since past experiments revealed that it was the most suitable measurement, compared to Warner-Bratzler shear and compression measurements, as it was very highly correlated with such sensory attributes as firmness, rubberiness and smoothness.

Analyses of the data were performed according to the methods in Chapter 4 (Section 4.3). In addition, the mean ideal ratio scores of the sensory attribute acceptability of the meatballs of all sixteen treatments (excluding the two additional treatments) were subjected to Yates' analysis which followed Cochran and Cox (1957). The Yates' algorithm, the defining contrasts, and the aliases are presented in Table 7.5.

Table 7.5 Yates' algorithm, the defining contrasts and the aliases in the quarter fractional 2^6 factorial experiment

Treatment Code	Defining Contrasts (ABCE,ABDF,CDEF) Effect:Aliases
1	-
a(ef)	A:BCE,BDF,ACDEF
b(ef)	B:ACE,ADF,BCDEF
ab	AB:CE,DF,ABCDEF
c(e)	C:ABE,ABCDF,DEF
ac(f)	AC:BE,BCDF,ADEF
bc(f)	BC:AE,ACDF,BDEF
abc(e)	ABC:E,CDF,ABDEF
d(f)	D:ABCDE,ABF,CEF
ad(e)	AD:BCDE,BF,ACEF
bd(e)	BD:ACDE,AF,BCEF
abd(f)	ABD:CDE,F,ABCEF
cd(ef)	CD:ABDE,ABCF,EF
acd	ACD:BDE,BCF,AEF
bcd	BCD:ADE,ACF,BEF
abcd(ef)	ABCD:DE,CF,ABEF

The ideal ratio scores for each sensory attribute acceptability were used to calculate for the total effect values by following the normal procedure of Yates' analysis (Yates, 1937). The total effect values were sequentially used to calculate for the sum of square (SS) values, the mean square (MS) values and the statistics F values to determine whether there were any significances of the effects.

7.4.2 Results of Fractional Factorial Experiment

The mean ideal ratio scores of sensory attribute acceptability and Instron initial yield forces are given in Table 7.6 (for all sixteen treatments using untrimmed mutton) and Table 7.7 (for additional two treatments using trimmed mutton).

Table 7.6 Mean ideal ratio scores of sensory attribute acceptability and Instron initial yield forces of meatballs made with untrimmed mutton in a quarter fractional 2^6 factorial experiment (1)

Run No. or Treatment (2)	Aroma Accept.	Texture Accept.	Flavour Accept.	Overall Accept.	Initial Yield Force (N)
1	0.78 ± 0.07	0.69 ± 0.08	0.69 ± 0.07	0.65 ±0.09	71.04 ± 5.59
2	0.74 ± 0.05	0.75 ± 0.06	0.78 ± 0.03	0.76 ±0.05	71.67 ± 3.27
3	0.79 ± 0.05	0.70 ± 0.07	0.76 ± 0.06	0.76 ±0.06	75.63 ± 3.12
4	0.83 ± 0.05	0.80 ± 0.07	0.81 ± 0.07	0.82 ±0.07	76.25 ± 3.75
5	0.77 ± 0.05	0.78 ± 0.06	0.76 ± 0.07	0.75 ±0.08	71.67 ± 3.27
6	0.88 ± 0.03	0.83 ± 0.04	0.84 ± 0.05	0.83 ±0.05	72.08 ± 4.16
7	0.83 ± 0.04	0.62 ± 0.07	0.70 ± 0.05	0.70 ±0.05	75.83 ± 2.11
8	0.78 ± 0.04	0.77 ± 0.04	0.76 ± 0.04	0.77 ±0.04	76.67 ± 3.46
9	0.74 ± 0.06	0.75 ± 0.07	0.80 ± 0.05	0.76 ±0.06	71.25 ± 5.43
10	0.83 ± 0.05	0.84 ± 0.03	0.86 ± 0.03	0.85 ±0.03	71.67 ± 3.52
11	0.78 ± 0.06	0.80 ± 0.04	0.81 ± 0.03	0.81 ±0.03	75.42 ± 2.85
12	0.82 ± 0.05	0.74 ± 0.06	0.76 ± 0.05	0.79 ±0.04	76.46 ± 4.29
13	0.81 ± 0.05	0.77 ± 0.06	0.80 ± 0.04	0.77 ±0.05	71.67 ± 3.27
14	0.75 ± 0.06	0.76 ± 0.05	0.72 ± 0.08	0.69 ±0.07	72.08 ± 2.99
15	0.81 ± 0.05	0.78 ± 0.04	0.81 ± 0.04	0.80 ±0.04	75.83 ± 3.69
16	0.79 ± 0.05	0.77 ± 0.06	0.81 ± 0.05	0.78 ±0.06	76.67 ± 4.94

(1) Values are means ± standard errors of the means between eight panelists for sensory attributes and between six meatball samples for initial yield force. All means were not significantly different at $p \leq 0.05$.

(2) Refer to Table 7.4 for each treatment combination.

Table 7.7 Mean ideal ratio scores of sensory attribute acceptibility and Instron initial yield forces of meatballs made with trimmed mutton (1)

Treatment (2)	Aroma Accept.	Texture Accept.	Flavour Accept.	Overall Accept.	Initial Yield Force (N)
1′	0.74 ± 0.06	0.69 ± 0.08	0.71 ± 0.06	0.72 ±0.06	70.42 ± 2.99
1	0.78 ± 0.07	0.69 ± 0.08	0.69 ± 0.07	0.65 ±0.09	71.04 ± 5.59
16′	0.87 ± 0.03	0.87 ± 0.03	0.86 ± 0.04	0.87 ±0.03	76.25 ± 3.64
16	0.79 ± 0.05	0.77 ± 0.06	0.81 ± 0.05	0.78 ±0.06	76.67 ± 4.94

(1) Values are means ± standard errors of the means between eight panelists for sensory attributes and between six meatball samples for initial yield force. All means were not significantly different at $p \leq 0.05$.

(2) Treatments 1′ and 16′ (trimmed mutton) used the same contents of the six ingredients as treatments 1 and 16 (untrimmed mutton) respectively.

There were no differences ($p \leq 0.05$) between the mean ideal ratio scores of sensory attribute acceptability and also between initial yield forces of meatballs with sixteen different combinations of the six ingredients. At the relatively close values of the low and the high levels of the ingredients used in this experiment, the panelists did not detect significant differences in the samples. Treatments 4,6 and 10 had all sensory attribute acceptability scores over 0.8. For overall acceptability, treatment 10 had a marginally higher score than the other two treatments.

When comparing mutton raw materials, there was a tendency that meatballs made with trimmed mutton received higher sensory attribute acceptability scores than those made with untrimmed mutton. There were comments by some panelists that they could detect connective tissue particles in the meatball samples.

Table 7.8 shows the results by Yates' analysis. All the main effects of the six ingredients and their two-factor interactions are given.

Table 7.8 Main effects of the six ingredients and their two-factor interactions in a quarter fractional 2^6 factorial experiment (1)

Ingredients (2)	Main Effect Aroma	Texture	Flavour	Overall	Two-Factor Interaction	Aroma	Texture	Flavour	Overall
A	0.01	0.05	0.03	0.04	AB	-0.01	0.00	-0.01	-0.01
B	0.02	-0.02	0.00	0.02	AC	-0.02	0.00	-0.01	-0.02
C	0.01	0.00	-0.01	-0.01	AD	0.00	-0.04	-0.04	-0.04
D	-0.01	0.03	0.03	0.03	BC	-0.02	-0.03	-0.01	-0.02
E	-0.02	0.03	0.04	0.03	BD	0.00	0.02	0.01	0.01
F	-0.01	-0.04	0.00	0.00	CD	-0.02	-0.01	-0.01	-0.03

(1) All main effects and two-factor interactions were not significant by the statistics F values at $p \leq 0.10$.

(2) A - tapioca starch
B - salt
C - sodium tripolyphosphate
D - white pepper
E - garlic
F - onion

In general, not any of the six ingredients had a significant effect on the sensory characteristics of the meatballs in these experiments. The main effects were very low and their statistics F values were not significant at 90% level of significance. The empirical equations relating the sensory attributes to the ingredients were also not significant.

However, the empirical equation relating the Instron initial yield force to tapioca starch, salt and STPP was significant. The equation excluding three spice terms, which were not significant, was:

Initial yield force = 45.8 + 0.33 (tapioca starch) + 8.91 (salt) + 7.78 (STPP)

(R - squared x 100 = 99.8%)

Once again, it was shown that as tapioca starch, salt and STPP contents increased, the initial yield force increased.

The correlation between the mean ideal ratio scores of some attribute acceptabilities were significant and are given in Table 7.9.

Table 7.9 Correlation coefficients between mean ideal ratio scores of sensory attribute acceptability of meatballs

Attribute	r	Significant At
Flavour - Texture	0.83	$p \leq 0.001$
Aroma - Overall	0.49	$0.1 \geq p > 0.05$
Texture - Overall	0.77	$p \leq 0.001$
Flavour - Overall	0.93	$p \leq 0.001$

Flavour was an attribute which had the highest correlation with overall acceptability and aroma had the lowest correlation. Cooking oil used in deep frying for preparation of the samples might have concealed the aroma of meatballs so that the panelists could hardly detect any difference by smelling, thus resulting in relatively low correlation coefficient between aroma and overall acceptability.

Regression analysis was performed, using mean ideal ratio scores, to relate overall acceptability rating, as dependent variable, with the different attribute ratings, individually, in pairs, and all three together as independent variables. The results are given in Table 7.10.

Table 7.10 Regression equations showing relationships between overall acceptability and different attribute acceptabilities

Attribute	Equation	R^2x100(%)	t-Ratio(1)
overall acc.	= 2.26 + 0.68 (aroma acc.)	18.3	0.87 n.s. 2.09 **
overall acc.	= 2.01 + 0.75 (texture acc.)	56.1	1.59 * 4.49 ****
overall acc.	= -0.34 + 1.03 (flavour acc.)	85.3	-0.39 n.s. 9.38 ****
overall acc.	= -1.28 + 0.48 (aroma acc.) + 0.68 (texture acc.)	65.7	-0.69 n.s. 2.22 *** 4.52 ****
overall acc.	= -1.77 + 0.25 (aroma acc.) + 0.96 (flavour acc.)	87.3	-1.57 * 1.80 ** 8.79 ****
overall acc.	= -0.34 - 0.02 (texture acc.) + 1.05 (flavour acc.)	84.2	-0.38 n.s. -0.10 n.s. 5.08 ****
overall acc.	= -1.80 + 0.25 (aroma acc.) + 0.03 (texture acc.) + 0.93 (flavour acc.)	86.3	-1.53 * 1.74 * 0.20 n.s. 4.53 ****

(1) t-Ratio is a ratio of each regression coefficient to its standard deviation. The first t-ratio relates to the first regression coefficient and so on.

ns = not significant

* = significant when $0.20 \geq p > 0.10$

** = significant when $0.10 \geq p > 0.05$

*** = significant when $0.05 \geq p > 0.02$

**** = significant when $p \leq 0.001$

It was shown that overall acceptability was more closely related to flavour than other attributes. Simone et al. (1960), in a study with bread, found that flavour responses appeared to be more closely related to overall ratings than either appearance or texture factors. Moskowitz and Chandler (1978) indicated that flavour varied in its importance to the consumer, depending on the product category. Nevertheless, on the whole, an acceptable flavour appeared to be of paramount importance compared to all other product characteristics.

7.4.3 Conclusion

From the results obtained in this experiment, not any of the combinations of the low and the high levels of the six ingredients resulted in meatballs with significant differences in sensory attribute acceptability scores.

The appropriate levels of the ingredients likely to yield mutton-based meatballs with good acceptance were chosen as 4% tapioca starch, 2.5% salt, 0.25% STPP, 0.75% white pepper, 0.8% garlic, and 0.6% onion, i.e. the formulation used for treatment 10 which had the highest overall acceptability ideal ratio score.

Tapioca starch was necessary for binding of water and also for providing smoothness. It was expected that the high level at 4% was necessary to maintain good and even smoothness especially if untrimmed mutton was used as raw material. A level of salt at 2.5% was expected to be enough to maintain desirable texture and flavour of the meatballs. Too much salt might have caused such adverse effects as 'too saltiness' and oxidative rancidity. Sodium tripolyphosphate at 0.25% was also expected to be enough to result in products with desirable texture.

The levels of the three spices were likely suitable since the strong aroma of garlic and the pungency of white pepper were expected to conceal the strong flavour and aroma of mutton. As the overall acceptability of this formulation had an ideal ratio score 0.85 and the aroma, texture and flavour acceptability were 0.83, 0.84, 0.86 respectively, it was decided that this formulation was acceptable for consumer testing.

7.5 TESTING OF THE SELECTED FORMULATION

The optimum formulation for mutton-based meatballs from the past experiment was further tested by the laboratory panel and by a small Thai consumer panel. The proportion of mutton lean was increased in the formulation in order to investigate whether meatballs with a higher content of mutton were acceptable to the Thai consumers.

7.5.1 Experimental Methods

This experiment was to study not only the acceptability by a laboratory panel but also the degree of liking and willingness of purchasing by a small household consumer panel of meatballs made with the predetermined optimum proportion of mutton (75%). In addition, two other proportions of mutton at 95% and 100% were concurrently tested to determine whether these new mixes yielded products with desirable attributes especially aroma and flavour and were acceptable to the Thai consumers. The proportions of meats and fat used are given in Table 7.11.

Table 7.11 Percentages of meats and fat used in meatballs

Treatment	Mutton Lean(%)	Pork Lean(%)	Pork Fat(%)
1	75	20	5
2	95	0	5
3	100	0	0

The meatballs were made according to materials and methods described in Chapter 4 (Sections 4.1.1 and 4.1.2 respectively). Untrimmed boneless mutton leg was used as mutton raw material. The meatballs were made, for each treatment, using various proportions of meats and fat as shown above but with the same contents of six ingredients; 4% tapioca starch, 2.5% salt, 0.25% STPP, 0.75% white pepper, 0.8% garlic and 0.6% onion, as selected in the last experiment.

The meatballs were tested by two types of sensory evaluation panel; a laboratory panel comprising the eight experienced Thai panelists and a household consumer panel comprising seventeen Thais who were students or working people and resided in the Palmerston North area.

For the laboratory panel, the meatballs were prepared for serving by deep frying in soybean oil at 200 ± 5 C° for 2 minutes or by cooking in boiling water (100 C°) for 2 minutes in order to determine whether different methods of cooking resulted in any difference in attribute acceptability. The questionnaire used for sensory evaluation was the same as the one used for the last experiment; Section 7.4.1 (see Appendix 7.3).

For the household consumer panel, the samples from each formulation were distributed, together with questionnaires, to 17 Thai consumers. In each questionnaire (see Appendix 7.4), a 7-point hedonic scale was provided. The categories used to describe the degree of liking were the ones used by Winger (1984), i.e. with bottom and top scores described as could not be worse - could not be better. The panelists were asked to assess the appearance, aroma, texture, flavour and overall liking. Moreover, willingness to purchase each meatball sample was asked. The categories used for this question were the ones used by Moskowitz (1983), i.e. definitely would not buy - definitely would buy.

The data obtained from the laboratory panel and the household consumer panel were subjected to analysis of variance as described in Chapter 4 (Section 4.3). The scores obtained for 'willingness of purchasing' were grouped in each category and the percentage based on the numbers of respondents who expressed their willingness to purchase for that category was calculated.

7.5.2 Laboratory Panel Results

The mean ideal ratio scores of sensory attribute acceptability for meatballs are presented in Table 7.12.

Table 7.12 Mean ideal ratio scores for sensory attribute acceptability of meatballs tested by the laboratory panel (1)

Method of Cooking	Attribute	Treatment(2) 1	2	3
Deep frying	Aroma	0.87	0.81	0.81
		(0.02)	(0.04)	(0.04)
	Texture	0.87	0.83	0.79
		(0.02)	(0.03)	(0.03)
	Flavour	0.86	0.80	0.86
		(0.03)	(0.03)	(0.03)
	Overall	0.89	0.80	0.83
		(0.01)	(0.03)	(0.03)
Boiling	Aroma	0.81	0.75	0.79
		(0.04)	(0.05)	(0.04)
	Texture	0.76	0.76	0.85
		(0.04)	(0.05)	(0.03)
	Flavour	0.85	0.82	0.80
		(0.03)	(0.04)	(0.03)
	Overall	0.83	0.80	0.80
		(0.03)	(0.04)	(0.03)

(1) All the mean values for each attribute acceptability in the same row were not significantly different ($p \leq 0.05$).
Numbers in parentheses are standard errors of the means of the ratio scores among the eight panelists.

(2) Refer to Table 7.11 for percentages of meats and fat used for each treatment.

It was shown that meatballs made with various proportions of mutton lean, pork lean and pork fat were not significantly different ($p \leq 0.05$) from each other in acceptability of each sensory attribute. This was true whether the meatballs were prepared for serving either by deep-frying or boiling. Meatballs made with pork lean (treatment 1) had higher ideal ratio scores in most attributes especially for aroma, flavour and overall acceptability than those without pork lean (treatments 2 and 3). This was likely due to the reason that pork reduced the extent of muttoniness in the products thus resulting in higher panelists' ratings for these attributes.

Deep frying slightly improved the overall acceptability of meatballs over boiling. In general, meatballs prepared for serving by deep frying received higher scores for all attributes but particularly texture than those prepared by boiling. Deep frying might be a suitable method for preparation of meatballs for consumption since cooking oil might add a little palatability to the products.

7.5.3 Household Consumer Panel Results

The mean scores for liking of sensory attributes of meatballs by hedonic scaling are given in Table 7.13.

Table 7.13 Mean hedonic scores for liking of sensory attributes of meatballs tested by a household consumer panel (1)

	Treatment (2)		
	1	2	3
Liking of appearance	4.76	4.82	5.00
	(0.25)	(0.29)	(0.24)
Liking of aroma	4.29	3.65	4.41
	(0.35)	(0.31)	(0.31)
Liking of texture	4.88	4.18	4.76
	(0.19)	(0.31)	(0.25)
Liking of flavour	4.59	4.12	4.53
	(0.31)	(0.28)	(0.23)
Overall liking	4.47	3.82	4.35
	(0.29)	(0.31)	(0.23)

(1) All the mean scores for each attribute in the same row were not significantly different ($p \leq 0.05$). Numbers in parentheses are standard errors of the means among the seventeen consumers. The hedonic scale was from 1 - could not be worse to 7 - could not be better.

(2) Refer to Table 7.11 for percentages of meats and fat used for each treatment.

It was likely, although not significantly different ($p \leq 0.05$), that meatballs made with pork lean (treatment 1) were regarded as better in texture, flavour and overall liking than those without pork (treatments 2 and 3). Treatment 1 received ratings of liking between 4 (neither like nor dislike) and 5 (like moderately) as did treatment with 100% mutton. Treatment 3 with 100% mutton received higher ratings in appearance and aroma than treatment 1.

The mean scores given by the six consumers, who had also participated in a laboratory panel, were calculated. It was interesting to note that mean scores for almost all liking attributes were in favour of treatment 1; i.e. the highest mean scores in liking of appearance, texture, flavour and overall liking among the three treatments. However, only the mean score for liking of aroma equalled that of treatment 3.

The numbers and percentages of the panelists who gave their willingness of purchasing meatballs are given in Table 7.14.

Table 7.14 Numbers and percentages of the consumers who expressed their willingness to purchase meatballs in a household consumer panel

Category	Treatment (1) 1 No.(%)	2 No.(%)	3 No.(%)
Definitely would buy	1 (6)	0 (0)	1 (6)
Probably would buy	6 (35)	4 (24)	5 (29)
Might or might not buy	5 (29)	5 (29)	5 (29)
Probably would not buy	2 (12)	2 (12)	6 (35)
Definitely would not buy	3 (18)	6 (35)	0 (0)
TOTAL	17 (100)	17 (100)	17 (99)

(1) Refer to Table 7.11 for percentages of meats and fat used for each treatment.

There were 41%, 24% and 35% of the respondents who expressed their willingness 'to buy' and 30%, 47% and 35% of the respondents who expressed their willingness 'not to buy' the meatballs in treatments 1, 2 and 3 respectively. Therefore, treatment 1, although not substantially different, was preferred in terms of willingness of purchasing to other treatments.

There were comments by some participants in the household consumer panel that meatballs, especially those made with higher percentages of mutton, still had muttony flavour. Nevertheless, there were a few participants who stated that meatballs from treatment 1 (with 75% mutton lean, 20% pork lean and 5% pork fat), after further development, would be accepted by the Thai consumers.

Most panelists suggested that meatballs could also be cooked by boiling in stock and eaten with noodles or by roasting or charcoaling and eaten with some sauces, e.g. sweet and sour chilli sauce. A few panelists suggested meatballs be cooked with curry or chilli paste. Also, a suggestion was made that ginger could possibly help to conceal strong odour and flavour of mutton.

7.5.4 Correlation of Laboratory and Household Consumer Panel Results

The means of the scores for each sensory attribute acceptability from all treatments in the laboratory panel were correlated with the means of liking scores for each attribute from all treatments in the household consumer panel. It was found that flavour acceptability (lab panel) significantly correlated ($0.1 \geq p > 0.05$) with liking of aroma (consumer panel) and also significantly correlated ($0.1 \geq p > 0.05$) with liking of flavour. Moskowitz (1985) indicated that the liking ratings assigned by the home use panel correlated fairly well with the liking ratings assigned by the research guidance panel.

7.5.5 Fat Contents of the Prepared Meatballs

The fat contents of the meatballs from treatments 1, 2 and 3 were 8.8%, 10.7% and 7.1% respectively. Therefore, it was suggested that fat content of meatballs be kept at a level not exceeding 10%. A number of researchers recommended that mutton fat content in processed meat products be at a level not exceeding 10% (refer to Chapter 5). In addition, this level seemed to be justifiable since commercial meatballs (made from very lean meat) in Thailand have approximately 3-4% fat.

7.5.6 Discussion and Conclusion

The results of both the laboratory panel and the household consumer panel showed that mutton-based meatballs were not perfectly accepted or liked by the Thais. The ideal ratio scores for sensory attribute acceptability given by the laboratory panelists were relatively high, i.e. greater than 0.85 for deep-fried samples of treatment 1. This might be due to the reason that the laboratory panelists were more experienced and they were already acquainted with tasting mutton-based meatballs, so they were quite satisfied with sensory attributes they assessed. However, consumer degree of liking for sensory characteristics of the same meatball samples were not really high, i.e. the hedonic scores were 4.29 - 4.88 for treatment 1 and 4.35 - 5.00 for treatment 3. These score intervals were still relatively low for the 7-point hedonic scale. Most participants in this household consumer panel were not experienced and were not acquainted with tasting mutton-based meatballs, therefore they still did not really like them thus resulting in their 'not high' ratings for meatballs' characteristics.

In general, the results obtained in both the laboratory panel and the household consumer panel supported selection of treatment 1, with 75% mutton lean, 20% pork lean, 5% pork fat as a suitable formulation for further development. Treatment 3, with 100% mutton lean, was another suitable candidate in view of exploiting mutton as a raw material.

However, when considering that the meatballs were developed for the consumers in Thailand who are not familiar with mutton flavour and aroma at all, it was expected that the lower the percentage of mutton the more acceptable the product.

7.6 FLAVOUR IMPROVEMENT OF THE OPTIMUM FORMULATION AND DEVELOPMENT OF A DIFFERENT PRODUCT FOR THE THAI MARKET

Commercial meatballs on the Thai market are very mildly spicy and they are not crumbed. It was, therefore, decided that the mutton-based meatball had to be developed as a unique product; being different from the products available in local markets, by adding a special kind of spice and making it look totally different. Ginger, another kind of spice which is also widely used in cooking Thai foods especially those made with meats and also suggested by the respondents in the household consumer panel, was used to improve the flavour and aroma of the meatballs (see the description of ginger in Appendix 7.1). Crumbing was used to improve the overall appearance and to give the crispy skin to the meatballs. It was also the objective of this investigation to determine the responses of the panelists to crumbing.

The results of both the laboratory panel and the household consumer panel still showed that the lower mutton lean content (75%) was suitable. Therefore this content, with the selected formulation of the six ingredients (refer to Section 7.5.1) were used. One group of the meatball samples had 0.6% ground ginger; an arbitrarily chosen level to be relatively close to the contents of other spices and not to give too much piquancy. This group of samples was compared to the control without ginger.

The meatballs were made by using the ordinary method of preparation but they were crumbed with the 'Super Gold' coloured bread crumbs bought from a supermarket; no name and address of the manufacturer was available. The two samples, i.e. one sample with ginger and another sample without ginger, were prepared for serving by deep frying and tested for preference. Four Thai panelists chose the sample they preferred.

It was found that all panelists preferred the meatballs with ginger to those without ginger. Comments were also given by the panelists during a discussion session. One panelist mentioned that there was a difference in one kind of spice in the two samples and this spice helped reduce muttoniness. Another panelist indicated that she could detect a difference in a kind of spice in the two samples but was not sure whether it was ginger. This spice

improved flavour and aroma of meatballs. In addition, most panelists commented that crumbing improved overall characteristics and it also added a crispy skin to the meatballs which they liked. Crumbing also gave a different or new image of the product, as meatballs on the Thai market are not sold crumbed.

7.7 OVERALL CONCLUSION

The results and information obtained from both the laboratory panel and the household consumer panel in New Zealand supported the choosing of 75% mutton lean, 20% pork lean and 5% pork fat as a suitable meat and fat formulation. However, it was found that a selected formulation of the six ingredients; 4% tapioca starch, 2.5% salt, 0.25% STPP, 0.75% white pepper, 0.8% garlic and 0.6% onion did not yield products which were perfectly accepted or liked by the Thais.

The crumbed meatballs made by using the selected formulation with an additional 0.6% of ginger were more preferred than those without ginger. Crumbing was also preferred by the Thai panelists. Therefore the previously described proportions of mutton lean, pork lean, pork fat; with the given contents of tapioca starch, salt, STPP, white pepper, garlic, onion and ginger were used as the starting formulation in the optimisation process. The meatballs were made spicy by adding various new kinds of spices. Also, they were crumbed with bread crumbs and fried for serving. This gave a completely new product for the Thai market.

Further development was necessary to improve characteristics of mutton-based meatballs especially for flavour and aroma. The next chapter discusses how characteristics of the products were optimised by using focus groups in Thailand to obtain the prototype formulation (Chapter 8). The developed product was then consumer-tested in the Bangkok area in order to obtain criteria in determining whether or not the Thai consumers would accept or like mutton-based meatballs (Chapter 9).

CHAPTER 8
OPTIMISATION OF THE FORMULATION USING FOCUS GROUPS

The new crumbed meatballs tested by the Thai consumers in New Zealand were liked slightly. It was decided that the formulation should be optimised in Bangkok using knowledgeable focus groups who understand the target consumers. The two focus groups were used to guide the product's sensory characteristics to the optimum formulation.

8.1 LITERATURE REVIEW

8.1.1 Focus Groups: Advantages and Disadvantages

Over the last three to five years, there has been an increased interest in the use of a group of techniques, generally termed qualitative research, by sensory workers involved in consumer testing. This group of techniques can be used as a means to uncover consumer attitudes towards products and can provide unique information to product development, and, in certain circumstances, is the only logical type of research to conduct (Marlow, 1987).

The most common form of qualitative research used is the focus group which involves recruiting six to twelve consumers, who are drawn from the population of interest, and conducting a semi-structured discussion using a moderator to guide the discussion (Cox et al., 1976; Fern, 1982; Hisrich and Peters, 1982; Crawford, 1983; Pramualratana et al., 1985). The discussion usually starts off with general questions which gradually become more specific and detailed as the session continues.

Interactions among participants is encouraged to stimulate the discussion. It has been recommended that participants are of similar status and share a common perspective on the topic under investigation for a given focus group session (Pramualratana et al., 1985). This helps minimise conflict and put the participants at ease. Focus groups are usually tape-recorded and later transcribed for analysis. The sessions generally last about one to two hours (Hisrich and Peters, 1982; Lai, 1987).

The skill of the moderator is vital to the success of the focus group and some of the key qualifications that moderators of focus groups must have are discussed in detail by Churchill (1983). Further descriptions of this technique are available from Zemke (1978), Churchill (1983), Egbert (1983), Diamond and Gagnon (1985), Pramualratana et al. (1985).

Lai (1987) reviewed extensively the literature about focus groups. The focus group interview was distinguished as a variation of the depth interview, and was noted as a session where a small number of individuals were brought together for an interview rather

than being interviewed one at a time; as in the depth interview (Hess, 1968). Marlow (1987) listed the advantages of focus groups, for use in product development, as:

* participants tell more about a topic, if encouraged to act spontaneously instead of reacting to questions (Dietz, 1975).
* they capitalise on the value of the group dynamics by encouraging participants to react to one another's ideas and thoughts.
* the moderator can challenge and probe for the most truthful responses, yielding a more in-depth accounting of consumers' thoughts and opinions.
* they are now respected methods for bringing out information that could be otherwise missed.
* they are fast and cheap; a focus group can be put together fairly quickly - in a matter of a few days.

In contrast, many criticisms, as summarised by Lai (1987), have been made against focus groups. These are:

* results cannot be generalised because samples are invariably small and never selected by probability methods; questions are not asked the same way each time; responses are not independent; results are difficult to quantify (Wells, 1974).
* personalities of the researchers and consumers are variables that have an important and unmeasured influence on the opinion expressed by the group member (Rosenberg, 1977).
* there are often discrepancies between what the group members say and how they actually behave in the market place, i.e. a lack of validity (Rosenberg, 1977).

These are addressed by Calder (1977) and Reynolds and Johnson (1978). The former author categorised the nature of qualitative research into exploratory, phenomenological, and clinical research depending on the type of knowledge desired. Focus groups used for the purpose of obtaining ideas fell within the exploratory research category (Aaker and Day, 1983). In this instance, the inability to generalise results was not critical. Although the personalities of the researchers and the consumers may influence the ideas obtained in focus groups, this should not influence the usefulness of the ideas created. Similarly, a lack of validity would not affect the quality of ideas obtained from focus groups. In fact, Reynolds and Johnson (1978) found that except in one instance, qualitative and quantitative findings were in agreement.

8.1.2 Applications of Focus Groups in Product Development

Focus groups can be applied for the product development process in numerous ways. Marlow (1987) included:

* helping in the development cycle by exploring consumer reactions to the product prototypes.
* determining the most appropriate wording for a questionnaire, based upon consumer-generated vocabulary.
* investigating consumers' true motivations and feelings.
* helping the researcher to step back and be objective about the product.
* explaining data from other sources.

The focus group technique has been recommended for acquiring information about the reactions to the product (ASTM, 1979; Crawford, 1983; Marlow, 1987).

8.2 USE OF FOCUS GROUPS IN BANGKOK

In Bangkok, two focus groups were used to investigate the responses to the meatballs made with the final formulation developed in New Zealand. If not acceptable to the Thais, it was expected that the focus groups would help guide the product's sensory characteristics until the prototype formulation was obtained for consumer testing.

Since there was limitation in time and available resources and facilities, it was decided to use, as members of the focus groups, professionals who could represent the consumers but were not 'general consumers' as the term is usually defined. These people, however, were consumers themselves and they might be regarded as 'expert consumers'. The main reason for choosing these groups of individuals was that they would possibly contribute technical ideas as to how the product could be improved. In addition, the focus group sessions started with sensory evaluation of the product by the ideal profile testing. This sensory testing requires 'experienced' or 'laboratory' sensory panelists to thoroughly understand the sensory attribute terms used in the questionnaires. It was also expected that these participants could follow the testing procedures without any major problems. There were two focus groups, one at Kasetsart University - the Kasetsart focus group, and the other at Chulalongkorn University - the Chulalongkorn focus group.

In the ideal profile testing, the floating ideal absolute scores were set by the members of the Kasetsart focus group in testing the New Zealand formulation and, based on the results obtained, the means of these floating ideal absolute scores were later used as the 'fixed' ideal in testing the improved formulation of the Kasetsart focus group. This procedure was also used with the Chulalongkorn focus group, i.e. they set their own ideal absolute scores which were then fixed for further testing. Since each focus group was homogeneous among its members only, it was decided that the members of each group worked with their own ideals.

8.3 MATERIALS AND EXPERIMENTAL METHODS

8.3.1 Raw Materials and Ingredients

Fresh boneless mutton legs were obtained from Waitaki International Limited at Feilding and were separately packed in polyethylene bags, frozen and kept in a freezer (-18 °C) for 1 week before being packed in chilly bins with dry ice and delivered to Bangkok, Thailand by air. The mutton legs were finally kept in a freezer (-18 °C) at the Department of Food Technology, Chulalongkorn University and later used in production of the meatballs.

Mutton raw material used in all experiments for the focus groups was the trimmed product. Trimming was done to assure that as little mutton fat and connective tissue as possible was left in the prepared product. Other raw materials and ingredients were as described in Chapter 4 (Section 4.1.1).

Bread crumbs and fresh eggs were used in crumbing of the meatballs. The crumbs were slightly gold coloured.

The basic formulation, obtained from the work in New Zealand, was 75% mutton lean, 20% pork lean, 5% pork fat; with 4% tapioca starch, 2.5% salt, 0.25% sodium tripolyphosphate (STPP), 0.75% white pepper, 0.8% garlic, 0.6% onion and 0.6% ginger (based on the total meats and fat weight).

8.3.2 Preparation of the Meatballs

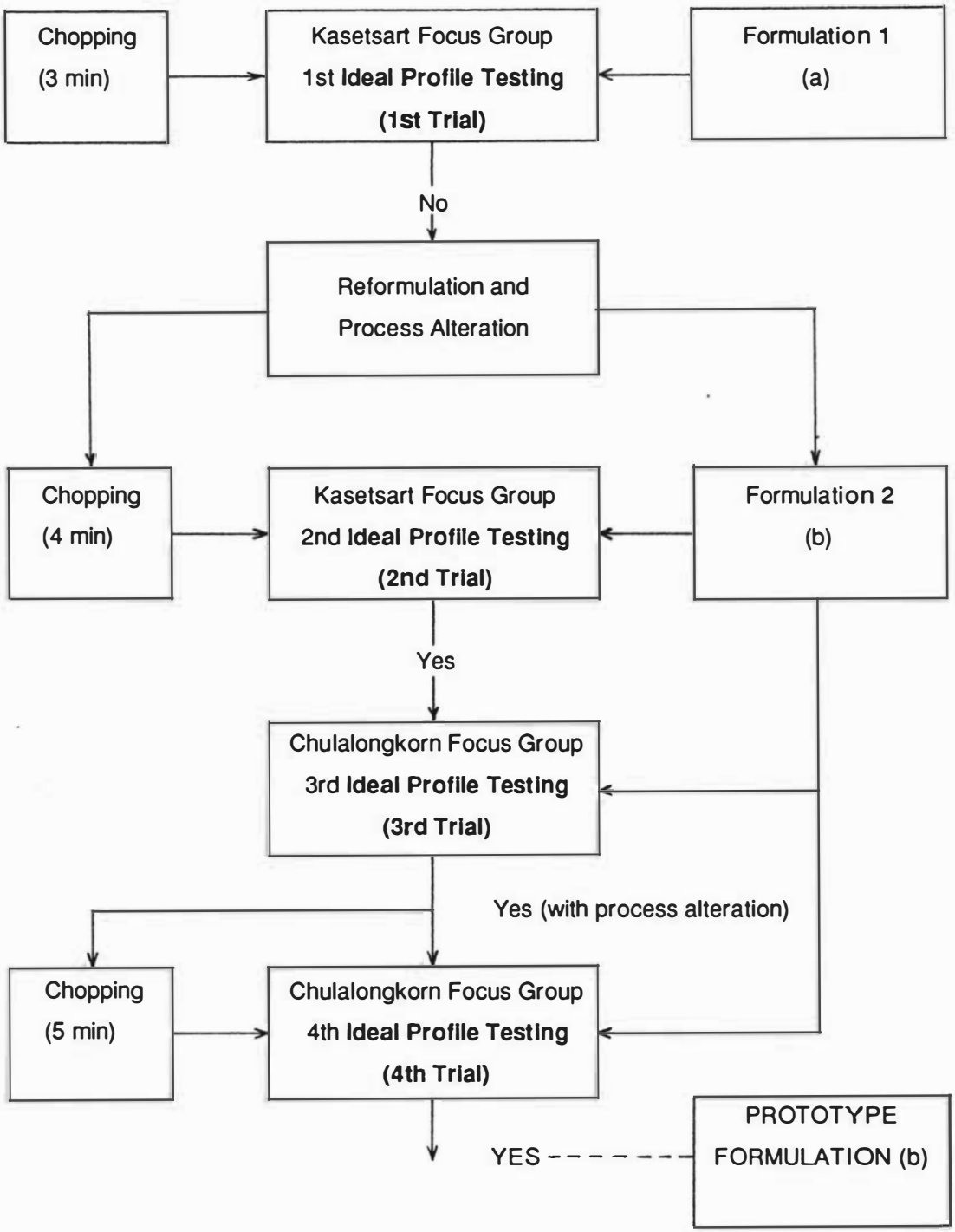
The meatballs were made according to the methods described in Section 4.1.2. In the sequence of focus groups and sensory evaluation used in this part of the research, alteration of the process was made to improve the characteristics of the meatballs. This was because the Scharfen bowl chopper and sausage stuffer were not available at the Food Technology Department, Chulalongkorn University. Instead, a National food processor, with the very high revolutions of its blades, was used. This equipment might result in too fine meat particles after chopping. Due to this expectation, a chopping time of 3 minutes was firstly used. This was reduced from 6 minutes, the chopping time normally used with the Scharfen bowl chopper in New Zealand. However, since the results from a series of trials showed that the meatballs were not rubbery enough, the chopping time was sequentially increased from 3 minutes to 4 minutes and then to 5 minutes. Making of the cylinders before being segmented and formed into balls was done by using a Kenwood food processor. Crumbing was done manually by dipping the balls into mixed egg white and yolk and rolling the balls in the bread crumbs.

8.3.3 Focus Groups and Sensory Evaluation

Focus groups were organised by firstly recruiting a homogeneous group of six academic staff at the Department of Home Economics, Kasetsart University, Bangkok, who were available, willing to help and had good experience in testing food products. This group of participants was chosen because it was expected that the staff in this department would be very experienced in cooking and eating many varieties of foods and therefore they could contribute ideas as to how the product could be improved. This group was regarded as the Kasetsart focus group.

A second focus group comprising six post-graduate students at the Department of Food Technology, Chulalongkorn University, Bangkok was later organised to retest the meatballs made with the altered formulation. The participants were competent and had good experience in testing food products and it was expected that they could also contribute some useful ideas in a panel discussion. This group was regarded as the Chulalongkorn focus group.

Figure 8.1 shows how the focus groups and sensory evaluations were performed, using the two groups of panelists, to optimise the formulation of mutton-based meatballs.



(a) formulation 1 : 0.75% white pepper, 0.8% garlic, 0.6% onion, 0.6% ginger (a final formulation from the New Zealand work).

(b) formulation 2 and prototype formulation : similar to formulation 1 but with 1.0% garlic and 0.8% onion.

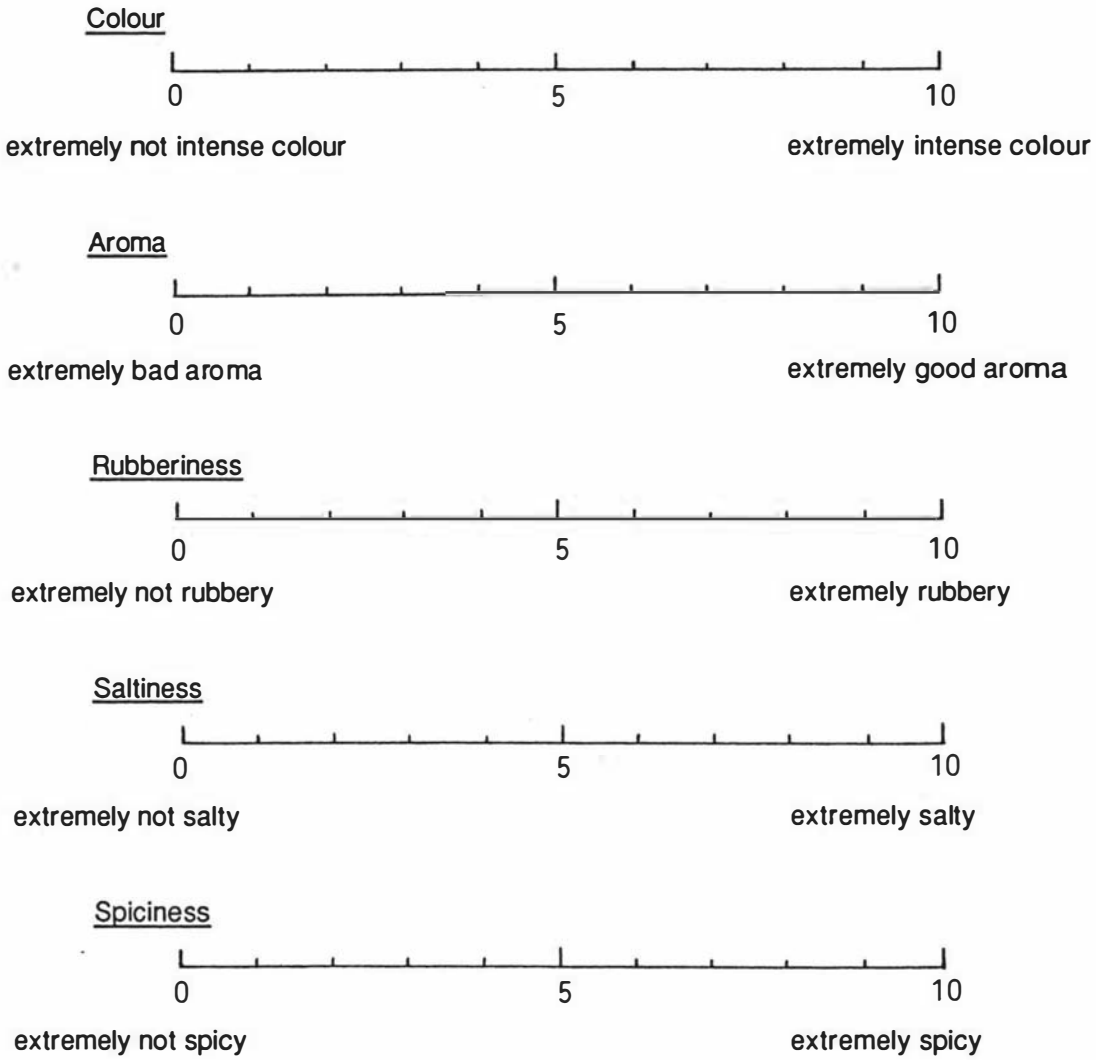
Figure 8.1 The flow of focus groups and sensory evaluations to optimise the formulation

A focus group session was started by sensory evaluation of the meatballs using the ideal profile testing (see Section 4.2.3.1). Organisation of the sensory testing followed the methods described in Section 4.2.3.5. The crumbed meatballs were prepared for serving by deep frying in soybean oil at 200 ± 5 °C. The sensory characteristics assessed by the participants included colour, aroma, rubberiness, saltiness, spiciness and overall acceptability. Although the participants were experienced, only a limited number of sensory attributes were used in sensory evaluation. It was expected that any participant could be at ease in following the procedure and concentrating only on the important attributes.

For texture, only rubberiness was used since it was the most important textural characteristic for the meatballs and the results in the early stage of development in New Zealand showed that rubberiness was highly correlated with firmness and smoothness. Moreover, there were higher correlations between rubberiness and the Instron objective test values than between firmness or smoothness and the same Instron values (refer to Section 6.3.1.8). Oiliness and juiciness were not included since they were not as important as rubberiness, and it was expected that the ideal ratio scores for these two characteristics would not change since the basic formulation, in particular the amounts of fat tissue and ice, was exactly the same throughout the tests as the one developed from the New Zealand work.

For flavour, saltiness and spiciness were included since it was desirable to determine the responses of the members in the focus groups to these two characteristics. If the products were not close enough to the ideals for these panelists, who were testing the products for the first time, changes in the levels of salt and spices had to be made. Muttoniness was not included because the panelists might have been biased if they had been told in advance about this characteristic.

The colour of the fried crumbed meatballs, the aroma and the overall acceptability were also assessed by the panelists. Scoring for colour, aroma, rubberiness, saltiness and spiciness was done by using the scales shown below. For overall acceptability, scoring was done by using a similar scale to the one shown in Appendix 7.3. Each panelist was asked to locate his or her own ideal on the line scale for each sensory attribute.



No training for the sensory ideal profile testing was organised for the panelists. This was due to restriction in time and available resources. The participants in the two focus groups were experienced people, therefore, it was expected that they could follow the instructions and understand the sensory terms used in the questionnaires clearly. If any problem arose, it was clarified by the author, as a moderator, to ensure that each panelist fully perceived, in the same manner, what he or she was required to do in the sensory evaluation.

Having finished each ideal profile testing, an open discussion was organised immediately. The panelists still had ideas of the product's eating qualities so they could contribute how the products could be improved or optimised in terms of the sensory characteristics. In addition, some topics related to the products were discussed in order to investigate the aspects which would probably be used in designing a questionnaire for the final consumer testing.

The two sessions of the Kasetsart focus group were held at the Home Economics Department, Kasetsart University and the two sessions of the Chulalongkorn focus group at

the Food Technology Department, Chulalongkom University. All sessions were held, in the panel rooms in both departments. Each room was well illuminated with fluorescent lamps and also with good ventilation. The participants evaluated the samples and contributed their ideas later while sitting around a table. The sensory evaluation sessions started at approximately 2.30 p.m.. The discussion session, moderated by the author, was tape recorded and it took approximately between a half and three quarters of an hour to complete it.

8.4 RESULTS AND DISCUSSION

8.4.1 Comparison of the Ideal Profiles

The ideal profiles, as represented by the mean ideal absolute scores, of the sensory attributes of the mutton-based meatballs given by the two focus groups are given in Table 8.1.

Table 8.1 The ideal profiles of the sensory attributes of the mutton-based meatballs by the two focus groups (1)

Attribute	Mean Ideal Absolute Score	
	Kasetsart Focus Group (1st Trial)	Chulalongkorn Focus Group (3rd Trial)
Colour	6.4	5.8
Aroma	8.1	9.3
Rubberiness	6.7	7.5
Saltiness	6.0	5.7
Spiciness	6.6	6.3

(1) These values were used as the 'fixed' ideals for the subsequent ideal profile testings; i.e. in the 2nd trial for the Kasetsart focus group and in the 4th trial for the Chulalongkom focus group.

The mean scores for 'ideal' saltiness and spiciness as perceived by the two focus groups were close; the difference being 0.3. In general, the members of both groups wanted the ideal meatballs to be salty and relatively spicy. Colour was another attribute which should be slightly intense in the perceptions of the members of both groups. However, the ideal aroma score should be high, over 8.0 for the Kasetsart focus group and even over 9.0 for the Chulalongkorn focus group. The ideal meatballs should also be relatively rubbery for both groups, but the Chulalongkorn focus group preferred the more rubbery product; the difference being 0.8.

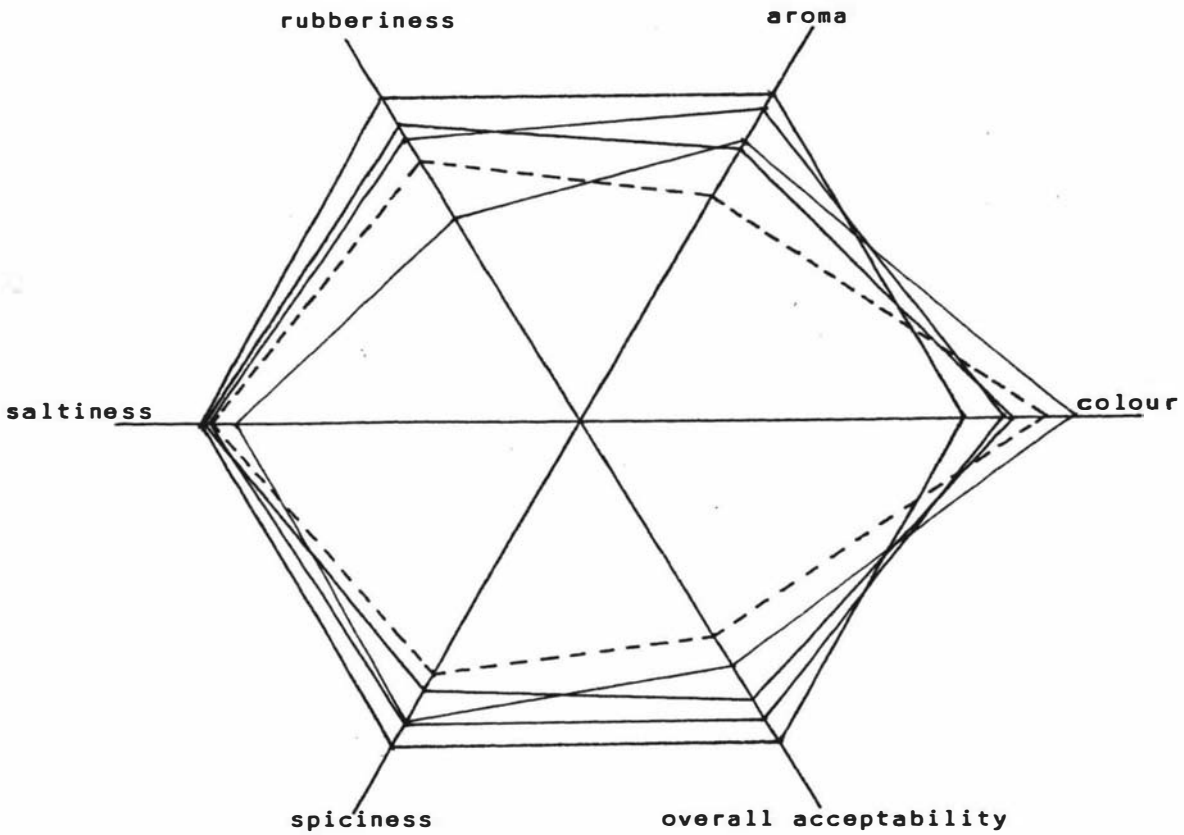
8.4.2 Improvement of Sensory Attributes by the Focus Groups

The mean ideal ratio scores (the product's score : the ideal absolute score) of the sensory characteristics of the meatballs, for all four sensory ideal profile testings (trials), were calculated and then used in plotting the ideal ratio scores for the four products. This is shown numerically in Table 8.2 and illustrated graphically in Figure 8.2.

Table 8.2 Mean ideal ratio scores of the sensory attributes of the meatballs tested in a sequence of focus groups (1)

Sensory Attribute	Kasetsart Focus Group		Chulalongkorn Focus Group	
	1st Trial	2nd Trial	3rd Trial	4th Trial
Colour	1.20 ± 0.03	1.12 ± 0.09	1.28 ± 0.07	1.11 ± 0.01
Aroma	0.69 ± 0.04	0.84 ± 0.10	0.86 ± 0.05	0.96 ± 0.02
Rubberiness	0.82 ± 0.05	0.92 ± 0.06	0.62 ± 0.07	0.88 ± 0.03
Saltiness	0.96 ± 0.09	0.99 ± 0.02	0.92 ± 0.08	0.98 ± 0.03
Spiciness	0.78 ± 0.18	0.84 ± 0.09	0.94 ± 0.06	0.94 ± 0.02
Overall Acceptability	0.67 ± 0.07	0.87 ± 0.07	0.77 ± 0.05	0.94 ± 0.01

(1) Values are means ± standard errors of the means between six panelists.



Key: _____ Ideal (1.0)

_ _ _ _ Kasetsart focus group, 1st trial (0.75% white pepper, 0.8% garlic, 0.6% onion, 0.6% ginger, 3 min chopping)

_____ Kasetsart focus group, 2nd trial (0.75% white pepper, 1.0% garlic, 0.8% onion, 0.6% ginger, 4 min chopping)

_____ Chulalongkorn focus group, 3rd trial (same as 2nd trial)

_____ Chulalongkorn focus group, 4th trial (same as 2nd and 3rd trials, 5 min chopping)

Figure 8.2 Profiles of the ideal ratio scores of the sensory attributes of the meatballs tested in a sequence of focus groups

The results showed the Kasetsart focus group was not satisfied with the sensory attributes of the meatballs in the first trial. The colour score was too high, and the aroma, spiciness and overall acceptability scores were too low. Rubberiness score was relatively high and saltiness was almost perfect.

From the sensory evaluation results and the ideas contributed by the participants in the first trial, all participants agreed that the meatballs were acceptable. However, they thought the

sensory characteristics could be improved. For flavour and aroma, they suggested that no other types of spices could be used. They said that hotness of the product was just right, therefore no more white pepper could be used especially if the product would be consumed by children. Most panelists suggested that higher amounts of garlic and onion could be used to improve the flavour and aroma.

Since saltiness of the meatballs was just right, it was expected that changing of the salt level could not be made. The levels of tapioca starch and STPP were also kept constant. It was shown that salt had the more pronounced effect on the texture of the meatballs. Therefore, alteration of the levels of the other two ingredients was not expected to substantially improve the textural characteristics of the meatballs. Instead, it was anticipated that the chopping time had to be increased. A little longer chopping time might help in comminuting the meats to a greater extent, thus resulting in more extracted salt soluble proteins which functioned in binding of meat particles. As a result, this might improve rubberiness.

Therefore, the amount of garlic was increased to 1% and that of onion to 0.8%. The chopping time was increased from 3 minutes to 4 minutes. The meatballs made by using the altered formulation and chopping time were tested again with the same focus group in the second trial. It was shown that the scores for aroma and overall acceptability were very much higher and those for rubberiness and spiciness were also increased. Increasing both garlic and onion contents and altering the chopping time improved all sensory characteristics.

This newly optimised formulation was retested with the Chulalongkorn focus group in the third trial. The products were acceptable to the participants for aroma, saltiness and spiciness. The colour was too intense and the rubberiness score was too low. The panelists in this focus group preferred the 'ideal' product to be more rubbery than the 'ideal' product as regarded by the members in the Kasetsart focus group (refer to Table 8.1). Therefore, they perceived and commented that the meatballs were not rubbery enough. To increase rubberiness, the chopping time was, therefore, raised to 5 minutes.

The meatballs made by using the same formulation but with the altered chopping time was tested again. The results from this fourth trial showed that all sensory attribute scores were very good; four of the six characteristics having the ideal ratio scores within 0.06 of 1.0 and the rubberiness score being at 0.88.

8.4.3 Ideas from the Kasetsart Focus Group

Most panelists agreed that the colour of the fried crumbed meatballs was too intense but they commented that this defect was not critical since it was rather related to the degree of doneness which might be differently liked by each individual.

For spiciness, the panelists drew the conclusion that no other types of spices should be used to improve flavour and aroma. A few panelists thought that coriander roots, which are commonly used in Thai foods especially meat dishes, would create further problems such as 'not-smooth' products if the roots had not been finely ground and additional microbiological load if the roots had not been hygienically cleaned.

Crumbing helped differentiate the product from local meatballs and gave the image of convenience food. It also improved the texture of the product since the panelists experienced something crispy during mastication and it helped conceal the unfamiliar meaty aroma. In addition, the crumbs gave good aroma to the meatballs.

The panelists indicated that frying was the most appropriate cooking method for the crumbed meatballs. However, if the meatballs were not crumbed, they could be prepared by boiling with soup stock, stir-frying with vegetables, charcoaling, and making into salad. The product could be consumed directly with cooked rice in any meals, breakfast, lunch, dinner, or as snacks.

Some ideas related to marketing of the product were also contributed by the participants. Having been informed that the price of the product would be higher than the prices of local meatballs, the panelists suggested that the meatballs be packed in retail-size packages with approximately 8-10 balls per pack so that the total price per pack should not be too high for ordinary consumers. All panelists mentioned that the product ought to be packed in a well-designed package with transparent plastic film covering one side of the package and there ought to be a label on the package. The places suitable as retail outlets were supermarkets. The product could be placed beside sausages in refrigerators. One panelist said that the product could be placed for sale in fresh markets as well.

The panelists wanted to have on the label the name and address of the manufacturer; the ingredients and additives, if any, and their percentages; net weight; expiry date and methods of use. Only one panelist mentioned about the emblem on the packages. This emblem is issued by the Food and Drug Administration, Ministry of Public Health. According to the Thai Food regulations, only 'controlled foods' should require such emblems. However, meatballs are not specified as controlled foods at the present time.

The name 'New Zealand meatballs' was considered appropriate if the product would be aimed for sale in the supermarkets because it would reflect the product's uniqueness. On the other hand, a few panelists commented that 'New Zealand' would possibly imply that the product was made of sheep meats. Therefore, in their opinion, it might not be suitable to use 'New Zealand' in the name of this product. A few panelists suggested if there was the indication that the product was from an overseas country, it might be more attractive to consumers than Thai names.

The panelists suggested that advertising planning and campaigning should be well performed to promote the product. Most panelists thought that advertising in television was the most appropriate, but of course, this would require a significantly high budget. Advertising on radio and in newspapers or magazines (especially women's magazines) should also be relatively effective. Only one panelist thought that communication among consumers themselves could also do the job.

8.4.4 Ideas from the Chulalongkorn Focus Group

Although most panelists wanted the meatballs to be rubbery, one said that she did not really want the product to be very rubbery because she was concerned that most local meatballs were made with borax, a chemical which helps make the meatballs with an exceptionally high rubberiness but is prohibited from use in food products due to its health hazard. Another panelist suggested that if hot boned meat was used, it would help in binding, thus resulting in rubbery meatballs. He also suggested that some food additives could be used to help in binding of meat particles. Regarding the texture of the meatball samples tested, the participants generally agreed that it was not absolutely necessary the product had to resemble local meatballs in its texture.

Crumbing helped give an image of a new product. The crumbed meatballs would be suitable for most time-conscious consumers as they would take a short time to prepare for ordinary meals or snacks. The panelists also mentioned that the size of the product was just right, i.e. about 3 cm in diameter for each ball. They thought that if the meatballs were smaller, they might be too dry after frying. The meatballs should be eaten when still warm in order to help enhance their flavour and aroma.

Some panelists said that if the developed meatballs were not too expensive, they might purchase these meatballs. However, the other panelists stated that they were not concerned with the price of the product. The product looked new and different so they would like to buy it. However, they warned that general consumers might not repurchase any newly-introduced products if they were not really good in their characteristics.

8.5 CONCLUSION

It was shown by the ideal profile testing results that inputs from the two focus groups, each comprised of a specific type of experienced members, were successfully used in guiding the optimisation process for the formulation of the meatballs. Ideas given by these participants helped improve sensory characteristics especially flavour and aroma. Only the contents of garlic and onion were raised, both by 0.2%, in the formulation developed in New Zealand. As a result of the focus groups, a prototype formulation was identified - 75% mutton lean, 20% pork lean, 5% pork fat; with 4% tapioca starch, 2.5% salt, 0.25% STPP, 0.75% white pepper, 1.0% garlic, 0.8% onion and 0.6% ginger (based on the total meats and fat weight).

This was subsequently used in a production trial to make the meatballs for the final consumer testing in the Bangkok area. The next chapter discusses the production trial of the crumbed meatballs made with the prototype formulation, and the consumer testing of the developed product.

CHAPTER 9
TESTING OF THE DEVELOPED PRODUCT

At this stage of the research project, a prototype formulation was developed and it was used in a production trial. The product was then tested by consumers in the Bangkok area. This was the final stage of the product development process in this study.

Consumer testing at this phase of the project was performed as a 'home use' test among several hundreds of respondents. Hedonic scaling was used to determine the degree of liking/disliking towards the mutton-based meatballs. Other information related to the developed product was also given by representatives of the households.

9.1 LITERATURE REVIEW

Test marketing (or market testing) has found widespread commercial acceptance (Lai, 1987). The purposes of conducting a test market are to test a new product or a new marketing plan under realistic market conditions to obtain a measure of sales or profit potential (Zikmund, 1982). The technique can also be used to improve advertising, promotion, and price, i.e. marketing strategies (Urban and Hauser, 1980).

Test marketing is a well established and recommended procedure for product testing in marketing texts (Rosenberg, 1977; Kotler, 1986), and numerous papers have been published on the subject (Stanton, 1967; Cadbury, 1975; Klompmaker et al., 1976). However, the market testing is carried out after the product has passed functional and consumer tests (Kotler, 1986). Therefore, it is essential that the product has successfully performed in the consumer tests before it is carried on to test marketing.

In product development, it is the consumer panelists who are important in determining acceptability. After a prototype product is developed and technically tested by the experienced judges, the product developer turns to the final judge, the consumer (Urban and Hauser, 1980). The success of a newly developed food product has always relied on acceptance by the consumers, therefore, formal studies of consumer acceptance or preference are very vital.

9.1.1 Consumer Tests

Consumer testing selects samples of consumers from the marketplace to determine whether they like or will buy the food (O'Mahony, 1986). Earle (1981) stated that various types of people have been used in consumer panels for food product testing. These people can be representative consumers in the target market or they can be randomly sampled.

Anderson (1981) noted that a large number of consumers, 200-300, was used for consumer testing in a market trial phase before the final product was released. Earle (1981) indicated that the 100-member consumer panel was used for testing acceptability of the product and the product attributes.

Gatchalian (1981) outlined the use of two types of consumer tests, the field test and the home use test, which could be used to measure the acceptance of the product. The field test involves evaluation of the product at the market site where consumers conglomerate. The goal is to determine product acceptance or preference in the actual purchase situation (Caul and Raymond, 1965). The field test may basically be either controlled as in a central location test or free-wheeling by random sampling of consumers as in a marketplace test. Home use test (or home placement method) allows for the products to be evaluated under natural use or home conditions (Eastlack, 1964).

Advantages and disadvantages of the two types of consumer tests for acceptance are summarised in Table 9.1.

Table 9.1 Advantages and disadvantages of field and home use tests

Field Test

Advantages

* maximum concentration of respondents.
* validity of the acceptance test is assured.
* great possibility for high returns of responses.
* quicker and more efficient.
* less costly and greater assurance that the product is actually evaluated.
* the central location type of field test is most useful; more samples for preference can be tested in a comparative situation.

Disadvantages

* the product is not consumed under the natural use situation; the decision of the respondents may be biased.
* especially in the marketplace test, the consumer's responses may be biased for or against the product depending on his/her physical or emotional state at the time of judgement.
* impossibility to allow for cumulative effect on consumers' reaction to the product.
* difficulty in obtaining representative population samples.

Home Use Test

Advantages

* natural use conditions, respondents can see how the product performs during actual home preparation.
* information about preference or acceptance can be based on stabilised reactions (from repeated use) rather than on first impression alone as in field tests.
* cumulative effect from repeated use can provide information regarding potentials of the repeat buyer.
* the economic level of target users can be identified.
* more questions and information can be obtained toward product's price, package label, etc., since the respondents have enough time to answer the questionnaire/interview.

Disadvantages

* can be very time-consuming.
* lengthy and expensive if including many households.
* greater possibility of non-responses.
* where four or more samples are involved, the test is impractical and may give misleading results.

From Gatchalian (1981)

9.1.2 Sensory Evaluation for Consumer Tests

Cooper (1981) indicated that consumer evaluation of the quality of any food product was based mainly on its sensory properties. Therefore, the sensory properties of a food are important, if not crucial, to its acceptance (Lai, 1987).

The vital role which sensory evaluation plays in product development has long been recognised (Dixon, 1970; Ellis, 1970; Blair, 1978; Civille, 1978; Erhardt, 1978; IFT, 1981; Radtke and Rodriguez, 1981). Sensory evaluation represents the first opportunity the product developer has for feedback on his or her product (Blair, 1978). Lai (1987) reviewed extensively the functions of sensory evaluation in the product development process.

According to the Institute of Food Technologists (IFT, 1981), a large number of untrained respondents selected to represent target or potential target population can be used to determine acceptance of the food product. Acceptance may be defined as (1) an experience, or feature of experience, characterised by a positive attitude; and/or (2) actual utilisation (e.g., purchase or eating). Acceptance may be measured by preference or liking for a specific food item (Amerine et al., 1965). In its simplest form, acceptability is inferred from scale ratings (IFT, 1981).

Scale ratings reflect respondents' perceived intensity of a specified attribute under a given set of conditions. Hedonic rating test is one type of rating test. It is used to measure the level of liking for food products by a population. It may be applied in testing for preference or acceptance, i.e. preference is inferred from hedonic ratings. The method relies on test subjects' capacities to report, directly and reliably, their feelings of like and dislike.

Several variations of the traditional nine-point word hedonic scale have been used effectively. These include: (1) a reduced number of rating categories, although not fewer than five is recommended; (2) a greater number of 'like' rating categories than 'dislike'; (3) omission of the 'neutral' rating category; (4) substitution of the verbal categories by caricatures representing degrees of pleasure and displeasure (facial hedonic scale); and (5) use of a non-structured, non-numerical line scale anchored with 'like' and 'dislike' on opposite ends (IFT, 1981).

Hedonic scale ratings are converted to numerical scores, and statistical analysis is applied to determine difference in degree of liking between or among samples. A hedonic rating test can yield both absolute and relative information about the test samples. Absolute information is derived from the degree of liking (or disliking) indicated for each sample, and relative information is derived from the direction and degree of difference between or among the sample scores.

9.2 SELECTION OF THE CONSUMER TESTING TECHNIQUE

With the developed meatballs, the most important aspects of the product were the sensory characteristics and the reaction of the consumers to the product. Because the development of the product was carried out mainly in New Zealand, general Thai consumer perceptions of and reaction to the product were not known. Information was also required on packaging, outlets for sale, product usage, buying, promotion, etc.

Sophisticated test marketing techniques such as laboratory test markets, controlled store tests and standard test markets were not appropriate in the final stage of this research. This was mainly because only the 'prototype' product was developed and it should be firstly consumer tested prior to being subjected to a test marketing. In addition, test marketing requires extensive planning and is normally organised by marketing professionals in consumer companies. Ordinary test marketing techniques also demand a large sum of money. All these criteria restricted performing the test marketing but rather led to the choosing of a consumer test as a valid technique for testing the developed meatballs.

The home use test was selected as a final consumer testing technique in this project. This was due to the reasons that:

* the developed product was aimed for a test under a natural home use condition.
* it provided a possibility to choose the economic levels of the target respondents.
* it gave a better attainment of more questions and information related to the product being tested.
* there was only one product sample to be tested. Therefore, the time and budget required to complete the test was not the major concern.

9.3 METHODS

9.3.1 The Production Trial

9.3.1.1 Raw Materials and Ingredients

The frozen boneless mutton legs used in the production trial were obtained from Waitaki International Limited, Feilding, New Zealand. The meat was delivered to Bangkok by sea. This took approximately one month. The meat was then stored in a freezer (-18 °C) at the Department of Food Technology, Chulalongkorn University for ca. 2 months before use. Boneless pork legs and pork backfat were purchased from a fresh market, the time after slaughtering being within 4 hours.

Other ingredients used in the production trial were the same as those used for making the meatballs tested in the previous focus groups.

9.3.1.2 Preparation of Raw Materials

The frozen boneless mutton legs were tempered in a chill room (4 °C) for 48 hours. The tempered boneless mutton legs, boneless pork legs and pork backfat were trimmed to remove, as much as possible, visible fat and/or connective tissue at the Department of Food Technology, Chulalongkorn University. The trimmed meats and fat were then cut into cubes of ca. 2.5 cm. The cut meats and fat were stored in a chill room for 18 hours before use in the production trial at the Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok.

9.3.1.3 Preparation of Meatballs

The production trial was divided into three batches, each 15 kg of meats and fat, due to the capacity of the chopper. The prototype formulation, obtained from the results of the focus groups (refer to Chapter 8), was used.

The cut meats and fat were separately ground through a Strommen meat grinder fitted with a 2 mm perforated plate. The ground meats and fat were then chopped with all dry ingredients and ice using a Muller Food Processing bowl chopper assembled with six high capacity knives. The mix was firstly chopped for 2 minutes. The machine was then stopped and the mix was manually scraped, from the lid and the rim of the bowl, with a plastic blade. To finish the chopping step, the mix was then chopped for an additional 1 minute until a paste like material was obtained. The final temperature of the mix after chopping was 16°C.

The chopped mix was then removed from the bowl chopper and manually formed into balls by a few skilled officials at the Department and the balls were immediately dropped into a rectangular cooker filled with hot water at 65-70 °C. The balls were cooked until they floated (8-9 minutes) and then recooked in another cooker at 80-85 °C until they refloated (1-2 minutes). The balls were then cooled in water at 25 °C until they refloated (1-2 minutes), and strained to remove water.

The prepared meatballs were then dipped into mixed egg white and yolk and rolled in bread crumbs. Twelve crumbed meatballs were separately packed into each polyethylene bag. There were 200 bags of meatballs ready for the distribution for the home use test next day. Approximately 1.5 kg of the crumbed meatballs were packed into a polyethylene bag for a proximate analysis. This was delivered to the Department of Science Services, Ministry of Science, Technology and Energy on the following day. All the prepared meatballs were immediately delivered to the Department of Food Technology, Chulalongkom University and stored in a chill room (4 °C) before being used for the home use testing, and the proximate analysis.

9.3.2 Consumer Testing

Consumer testing of the developed meatballs was done by a home-use test in the Bangkok area.

9.3.2.1 The Sample

There was only one sample given to each household. No attempt was made to compare the developed product with local meatballs. This was due to the reasons that the developed product was different from the commercial products available in the markets. The developed product was made from a new type of meat, was spicy, and was crumbed so it should not be compared directly to local meatballs. In addition, testing of one sample was suitable for a very large number of respondents since less time and a smaller budget was required for organising it. It was also suitable for general consumers who were not experienced in judging or doing sensory evaluation of food products. These consumers would feel at ease when required to assess several sensory attributes of only one product. Therefore, the chance of non-responses could be minimised.

The packages were not coded or labelled. There were 12 meatballs in each clear polythene bag and it was expected that 4 members in each household would have enough meatballs to test.

9.3.2.2 The Respondents

An attempt was made to give the sample of the meatballs to the prespecified target consumers, middle or upper class professional and business families. Random selection of the respondents could not be done because getting accessibility to local households in specific districts of the Bangkok area was extremely difficult.

The samples were given to two hundred households including 50 families of teachers in two different public schools (25 each), 25 families of office workers in the Thai Military Bank, 30 families of government officials in the Food and Drug Administration Department, Ministry of Public Health, 15 families of university staff in Chulalongkorn University Library, and 80 families of teachers and pupils in Chulalongkorn Demonstration School.

There were two groups of respondents who completed the questionnaires. One group of respondents was required to assess the product's characteristics. One member belonging to each specified age group was required to do the sensory evaluation. The age groups were classified into (1) children (10-12 years); (2) teenagers (13-19 years); (3) adults (20-40 years); and (4) the older people (>40 years). The age for children was specified "not

under 10 years" since it was expected that young children might not follow the instructions, might be reluctant in testing the product and had difficulty in filling the questionnaires and thus, there might be a possibility of obtaining unreliable results. Another group of respondents comprised the housewives. One housewive in each household was asked to answer the supplementary questionnaire.

9.3.2.3 The Questionnaires

A separate page was addressed to the leaders of the families. It contained information about the purposes of the consumer testing; how to prepare the meatballs for consumption; how the members of the families were required to fill in the questionnaires; the given time span to finish the test; how to store the sample if not tested immediately after receiving it; and finally, words of gratefulness. Two types of questionnaires accompanied this introductory page and the sample of the meatballs to each household.

The first type of questionnaire was for evaluating the liking/disliking perception of the consumers to the sensory characteristics of the developed product, namely liking of appearance, liking of aroma, liking of texture, liking of flavour and overall liking. A 7-point hedonic scale rating was used. The scale was classified into dislike very much, dislike moderately, dislike slightly, neither like nor dislike, like slightly, like moderately, and like very much. In the questionnaire, explanation of the sensory terms was provided so that all respondents knew the sensory characteristics they were assessing and they perceived all these attributes in the same manner. Sex, age, and career were also asked to attain some background of each respondent (see Appendix 9.1). The colour of this questionnaire was white.

A second type of questionnaire was also provided, but only to a housewife, for each household. Information related to buying, marketing and usage of the developed product was sought. Details of this questionnaire are given in Appendix 9.2. The colour of this supplementary questionnaire was pink. All questionnaires were in Thai.

9.3.2.4 Organisation of the Test

Two hundred bags of the meatballs were firstly given to six coordinators who were willing to help. These six people then distributed the meatball samples, from the centres where they work, to the respective families as mentioned previously. The distribution was made to these families who belonged to the target markets of the middle and upper classes. Every household received, together with a bag of meatballs, a set of questionnaires consisting of an introductory page; four copies of the sensory evaluation form, i.e. one for a member belonging to each age group (if any); and one questionnaire for a housewife.

The home use test started on November 9, 1987. When testing of the product was finished within two weeks, the six coordinators helped collect the questionnaires and returned them to the author. This method of distributing and collecting the samples and the questionnaires was expected to give a high percentage of returned responses.

9.3.2.5 Analyses of the Data

Hedonic ratings for sensory characteristics of the developed meatballs given by all respondents were converted into numerical scores by assigning 1 = dislike very much and 7 = like very much. These scores were then analysed for means and frequencies by the MINITAB statistical package (Ryan et al., 1976). Correlation and regression were also analysed by the MINITAB.

Other information related to the developed meatballs were summarised and presented, if applicable, in percentages.

9.4 RETURN FROM THE SURVEY

9.4.1 Returned Responses

Of the two hundred sets of questionnaires distributed, one hundred and sixty four sets were completed and retrieved. This gave the high return rate of 82%. This high percentage was achieved by distributing the questionnaires to the predetermined groups of target consumers.

There were one hundred and fifty nine housewives who responded to the supplementary questionnaires. However, some housewives did not answer all the questions. Therefore, the total number of the responses for some questions were less than 159.

9.4.2 Profile of General Respondents

In the 164 sets of questionnaires received, there were 488 resppondents who evaluated the product. There was a predominance of adults (20-40 years) amongst the respondents, with slightly more females than males (see Table 9.2). The figures reported by the UN (1985) showed similar trends for the urban population in Thailand.

Table 9.2 Profile of respondents in the home use test

Sex	Children (10-12 yrs)	Teenagers (13-19 yrs)	Adults (20-40 yrs)	Older People (>40 yrs)	Total
Male	54	37	72	55	218(44.7%) [48.5%]
Female	41	46	137	46	270 (55.3%) [51.5%]
Total	95 (19.5%) [13.4%]	83 (17.0%) [16.5%]	209 (42.8%) [45.1%]	101 (20.7%) [25.0%]	488 (100.0%) [100.0%]

Values in [ ] are adapted from UN data.

Careers of the respondents were also given and this is shown in Table 9.3.

Table 9.3 Careers of the respondents

Career	Age Group Children	Teenagers	Adults	Older People	Total
School pupils	95	55	-	-	150(30.8%)
University or college students	-	19	27	-	46(9.4%)
Government officials	-	1	63	35	99(20.3%)
Private companies	-	2	76	24	102(20.9%)
State enterprises	-	-	10	11	21(4.3%)
Others	-	6	33	31	70(14.3%)
Total	95 (19.5%)	83 (17.0%)	209 (42.8%)	101 (20.7%)	488(100.0%)

The majority of the respondents were professionals. These people work in government departments, private companies or state enterprises (45.5%). A large number of respondents were still studying in schools, colleges or universities (40.2%). The rest were those who normally stay at home or run their own businesses (14.3%).

9.4.3 Non-responses

There were thirty six sets of questionnaires which were not returned. The reasons for non-responses were not clearly identified. The period of time allowed for completing the test might not be long enough for some households. As indicated by Gatchalian (1981), the home use test could be time consuming and might require up to 1 month to finish. For this study, a period of two weeks was considered valid since the developed product was highly perishable and could not be kept for a long period of time unless stored in a freezer. In addition, there was only one sample for the respondents to test and there were not too many sensory characteristics of the meatballs to be assessed and the questionnaires, both to be filled in by members of the families and specifically by the housewife of each household, were not too complicated to follow. Therefore, it was decided not to wait longer to receive more sets of the completed questionnaires.

9.5 ACCEPTABILITY OF THE MEATBALLS

9.5.1 Liking by Age Group

The mean hedonic scores for the sensory attributes of the developed product as classified by age group and for the total sample are given in Table 9.4.

Table 9.4 Hedonic scores for sensory attributes of the developed meatballs by age group and for total sample(1)

Characteristic	Age Group (2)				Total Sample (n=488)
	Children (n=95)	Teenagers (n=83)	Adults (n=209)	Older People (n=101)	
Liking of Appearance	5.59 ± 0.14^{c}	4.96 ± 0.13^{a}	5.01 ± 0.09^{ab}	5.13 ± 0.14^{abc}	5.14 ± 0.06
Liking of Aroma	5.67 ± 0.15^{c}	5.19 ± 0.16^{abc}	4.98 ± 0.10^{a}	4.99 ± 0.13^{ab}	5.15 ± 0.07
Liking of Texture	5.59 ± 0.13^{c}	4.94 ± 0.16^{a}	5.06 ± 0.10^{ab}	5.38 ± 0.13^{abc}	5.21 ± 0.06
Liking of Flavour	5.55 ± 0.16^{c}	4.90 ± 0.18^{a}	4.96 ± 0.11^{ab}	5.19 ± 0.15^{abc}	5.11 ± 0.07
Overall Liking	5.59 ± 0.13^{bc}	5.19 ± 0.12^{ab}	5.04 ± 0.10^{a}	5.31 ± 0.12^{abc}	5.23 ± 0.06

(1) Values are means ± standard errors of the means calculated for the scores given by the corresponding number of the consumers.
(2) For the age group, values in the same row possessing one of the same letters in the superscripts were not significantly different at $p \leq 0.05$.

It was apparent that the developed meatballs were acceptable and all sensory attributes were liked most by children. This was shown by the highest mean hedonic scores between 5.55 - 5.67. The meatballs were also liked by the older people; the mean hedonic scores for all sensory attributes assessed were relatively high in the range of 4.99 - 5.38. Although the mean hedonic scores were not as high as those given by the children or the older group, the teenagers and the adults still liked the product; the lowest mean hedonic score was close to the 'like slightly' category. In general, the developed product was liked by consumers belonging to all age groups; the mean hedonic scores for overall liking were higher than 5, especially the one given by children was 5.59. These mean hedonic scores for overall liking were between like slightly and like moderately.

When considering the total number of consumers, the results showed that the consumers liked the developed product. The mean hedonic scores for all characteristics were high; the values being higher than 5.0 and between like slightly and like moderately.

9.5.2 Liking by Sex

The mean hedonic scores as classified by sex within the age group and for the total sample are shown in Table 9.5.

Table 9.5 Hedonic scores for sensory attributes of the developed meatballs by sex (1)

Characteristic	Age Group (2)								Total Sample (2)	
	Children		Teenagers		Adults		Older People			
	M	F	M	F	M	F	M	F	M	F
Appearance	5.63 (0.19)	5.54 (0.22)	5.30 (0.20)	4.91 (0.18)	5.07 (0.14)	4.99 (0.11)	4.98 (0.20)	5.30 (0.18)	5.18 (0.09)	5.11 (0.08)
Aroma	5.61 (0.21)	5.76 (0.21)	5.03 (0.26)	5.33 (0.20)	5.10 (0.16)	4.92 (0.13)	4.96 (0.17)	5.02 (0.20)	5.18 (0.10)	5.13 (0.09)
Texture	5.70 (0.17)	5.44 (0.18)	5.11 (0.24)	4.80 (0.21)	5.17 (0.16)	5.01 (0.13)	5.46 (0.19)	5.28 (0.19)	5.36 (0.09)	5.09 (0.09)
Flavour	5.63 (0.21)	5.44 (0.24)	5.03 (0.27)	4.80 (0.25)	5.13 (0.18)	4.87 (0.15)	5.31 (0.18)	5.04 (0.25)	5.28 (0.10)	4.97 (0.10)
Overall	5.70 (0.16)	5.44 (0.23)	5.24 (0.20)	5.15 (0.16)	5.13 (0.16)	4.99 (0.12)	5.35 (0.17)	5.26 (0.18)	5.34 (0.09)	5.13 (0.08)

(1) Values are means and standard errors of the means (in parentheses).
(2) Within each age group and for the total sample, means for all characteristics between male (M) and female (F) were not significantly different at $p \leq 0.05$.

It was interesting that male respondents generally gave higher hedonic scores for most sensory characteristics of the developed meatballs. This trend was shown for each age group. Male children gave the highest hedonic scores for most sensory attributes except for aroma. The scores given by this sub-group of consumers were between 5.61 - 5.70.

9.5.3 Frequencies of the Hedonic Scores

The frequencies of the hedonic scores given for each sensory characteristic of the developed meatballs were classified according to number of respondents belonging to each age group and to the total sample. The results for overall liking are presented in Table 9.6 (see details for other sensory attributes in Appendix 9.3).

Table 9.6 Frequencies of the hedonic scores for overall liking of the developed meatballs

Hedonic Score	Age Group: Children		Teenagers		Adults		Older People		Total Sample	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	0	0	0	0	6	2.9	1	1.0	7	1.4
2	4	4.2	0	0	10	4.8	3	3.0	17	3.5
3	4	4.2	8	9.6	14	6.7	5	4.9	31	6.3
4	11	11.6	14	16.9	23	11.0	9	8.9	57	11.7
5	11	11.6	21	25.3	56	26.8	32	31.7	120	24.6
6	43	45.3	34	41.0	87	41.6	39	38.6	203	41.6
7	22	23.1	6	7.2	13	6.2	12	11.9	53	10.9
Total	95	100.0	83	100.0	209	100.0	101	100.0	488	100.0

The results showed that the majority of the sample (approximately at 75%) from each age group and from the total sample gave 5 or higher hedonic rating scores for overall liking of the developed product.

When the number of the respondents who gave the scores for each category were plotted against the score in that category, the histograms showed, in general, that there was a unimodal distribution of the hedonic scores. The distribution was skewed to the higher scores. This trend was generally similar for each age group and for the total sample and also similar for each sensory characteristic. Figure 9.1 shows the histogram of the hedonic scores for overall liking of the developed product as assessed by the total sample.

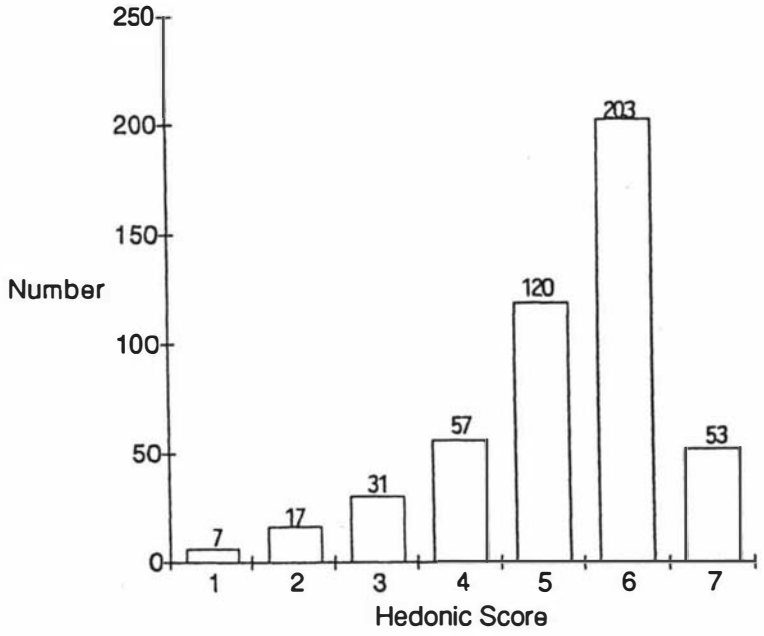


Figure 9.1 Histogram of hedonic scores for overall liking of the developed meatballs by total sample

9.5.4 Correlations between Sensory Attribute Liking and Overall Liking

The hedonic scores, given by respondents from each age group and from the total sample, for each sensory attribute were correlated with the hedonic scores for overall. The results are presented in Table 9.7.

Table 9.7 Correlation coefficients between each of four sensory attribute liking and overall liking within each age group and for total sample (1)

	Appearance	Aroma	Texture	Flavour
Children	0.55	0.51	0.61	0.76
Teenagers	0.60	0.47	0.52	0.71
Adults	0.55	0.66	0.75	0.77
Older People	0.49	0.51	0.72	0.72
Total Sample	0.55	0.58	0.69	0.75

(1) All correlation coefficients were significant at $P \leq 0.001$.

It was apparent that flavour was the sensory characteristic which was more highly correlated with overall liking than the other three attributes. This was applicable for all age group categories and for the total sample. There was a tendency that texture was the second attribute which was highest correlated with overall liking. Flavour and texture seemed to be the attributes which positively determined overall liking of the developed meatballs, more than appearance and aroma.

9.5.5 Relationships between Overall Liking and Sensory Attributes

The hedonic scores for overall given by respondents from the total sample were regressed against the hedonic scores for sensory attributes. This was done for one attribute, two attributes, three attributes and four attributes together. Some regression equations with significant coefficients showing these relationships are presented in Table 9.8.

Table 9.8 Regression equations showing relationships between overall liking and sensory attribute liking by total sample

Regression Equation			R^2x100(%)	t-Ratio (1)
Overall liking	= 2.11	+ 0.61 (flavour)	56.2	16.18
				25.02
	= 1.22	+ 0.35 (texture)	65.5	8.77
		+ 0.43 (flavour)		11.47
				16.01
	= 0.77	+ 0.20 (aroma)	68.9	5.27
		+ 0.29 (texture)		7.38
		+ 0.37 (flavour)		9.85
				14.09
	= 0.58	+ 0.11 (appearance)	69.7	3.75
		+ 0.16 (aroma)		3.62
		+ 0.26 (texture)		5.79
		+ 0.36 (flavour)		8.64
				13.73

(1) t-Ratio is a ratio of each regression coefficient to its standard deviation. The first t-ratio relates to the first regression coefficient and so on.
All t-ratio values were significant at $p \leq 0.001$.

It was shown, by comparing the relative weighting factors for the variables, viz. the coefficients in the equations, that flavour was the sensory characteristic which related more with overall liking than the other three attributes.

9.5.6 Comments on the Product

For preparation of the meatballs, 56.3% of the housewives indicated that they used one type or more of sauces when they and members of their households were testing the product. A large proportion (75.3%) used 'Sriracha' sauce (chilli sauce), and sweet and sour chilli sauce (normally used with charcoaled chicken). Smaller proportions used tomato sauce (18%), Maggi like (soy bean) sauce (11.2%), 'Buey-Chia' (sweet and sour plum, Chinese style) sauce (3.3%), 'Chid-Chow' (malt vinegar like, Chinese style) sauce (2.2%), and fish sauce with fresh chillies (1.1%). Therefore, the developed meatballs could be eaten with

different kinds of sauces and especially with the 'hot' chilli sauce as generally preferred by the Thais.

Comments were also given on the sensory attributes of the meatballs. In general, the meatballs were acceptable for most characteristics. The texture of the product was not fully satisfactory. Some consumers said that the meatballs were not rubbery enough when compared to local meatballs. Some respondents mentioned that the crumbed meatballs might be suitable for frying because the fried crumbs gave a crispy skin to the product. Some panelists said that crumbing ought to be improved since the outside crumbs were peeled off quite easily and the product might not be suitable for boiling. Of the 59 respondents who gave the comments, only 3 stated that they could detect unfamiliar meaty flavour and aroma but they did not identify the species of the meat.

An interesting point to note was the consumers' suggestion that, other than being round in shape, the product could be shaped like patties. This would help differentiate the product and it could be used in hamburgers or sandwiches which could be sold in fast food outlets. Or the product could be packed in well-designed packages and placed for sale in supermarkets. As a result, consumers could have different shapes to suit their needs.

9.6 BUYING INFORMATION

Three choices, related to the price of the meatballs, were given to the housewives. A majority of the respondents would buy the product at the price equal to or greater than those of local processed meat products (see Table 9.9).

Table 9.9 Buying intentions related to price

Price	Respondents No.	%
Less than prices of local processed meat products	41	27.5
Equal to prices of local processed meat products	73	49.0
Greater than prices of local processed meat products	35	23.5
Total	149	100.0

Almost half (47.8%) of the respondents indicated that they were willing to buy the meatballs. Approximately 16% were not willing to buy the product. The rest were those who might or might not buy it (see Table 9.10).

Table 9.10 Buying intentions

	Respondents No.	%
Definitely would buy	11	6.9
Probably would buy	65	40.9
Might or might not buy	58	36.5
Probably would not buy	17	10.7
Definitely would not buy	8	5.0
Total	159	100.0

The distribution of the housewives' intended frequency of purchase is shown in Table 9.11. Almost half (45.6%) of the respondents would buy the meatballs more often than once a fortnight. The rest were willing to buy the product less often.

Table 9.11 Distribution of frequency of purchase

	Respondents No.	%
More than once a week	9	5.7
Once a week	36	22.8
Once a fortnight	27	17.1
Once a month	44	27.8
Less than once a month	42	26.6
Total	158	100.0

The developed product was liked by the housewives and half of them indicated that they were willing to buy the product more often than once a fortnight. Approximately a quarter of these housewives were the keen buyers who even expressed their buying intentions with the price greater than those of local processed meat products.

9.7 MARKETING INFORMATION

Information related to marketing of the developed product was also given by the housewives.

9.7.1 Retail Outlets

The majority of the consumers (93%) wanted the developed product sold in supermarkets (see Table 9.12). Approximately a quarter (27%) wanted the product sold in fast food outlets and 17% in school or university canteens. Small proportions of the respondents wanted the product sold in restaurants, by street vendors, or at other places (fresh markets,

cooperatives). The consumers wanted this product sold at the 'up-market' places like supermarkets. This type of outlet is a common place where middle and upper classes go for their shopping.

Table 9.12 Retail outlets preferred for the developed meatballs

	Respondents (1) No.	%
Supermarkets	147	93.0
Fast food outlets	43	27.2
School or university canteens	26	16.5
Restaurants	11	7.0
Street vendors	7	4.4
Others	11	7.0

(1) Number and percentage were given out of the total number of respondents who answered the question, i.e. 158 housewives. More than one choice was permitted.

9.7.2 Packaging of the Developed Product

The highest proportion (63.5%) of the consumers wanted the meatballs packed in plastic trays covered with transparent plastic film. The second highest proportion (41.5%) preferred transparent plastic bags. A very small percentage wanted the product packed in other packages; e.g. loose pack, foam packages as normally used for packing hamburgers and the like in fast food outlets (see Table 9.13).

Table 9.13 Packaging of the meatballs

	Respondents (1) No.	%
Plastic trays with transparent plastic film	101	63.5
Transparent plastic bags	66	41.5
Others	5	3.1

(1) Number and percentage were given out of the total number of respondents who answered the question, i.e. 159 housewives. More than one choice was permitted.

A majority of the respondents wanted twelve balls or less to be packed in one package. Only a quarter wanted more than a dozen of the meatballs in one package (see Table 9.14).

Table 9.14 Number of balls preferred in a package

No. of balls	Respondents		
	No.	%	Cumulative %
8	7	4.4	4.4
10	57	35.8	40.2
12	51	32.1	72.3
16	9	5.7	78.0
20	35	22.0	100.0
Total	159	100.0	

For labelling, most consumers were very concerned about the ingredients and their contents used in the product and the expiry date. Smaller proportions of these consumers also preferred to know the name and address of a manufacturer, net weight, and nutritional values of the developed product. A small proportion wanted to know the country of the overseas manufacturer. Other information related to price, usage, food additives, storage method, manufacturing date, types of meats used, permission emblem from the Food and Drug Administration and name of the product was also needed by a minor proportion of the consumers (see Table 9.15).

Table 9.15 Information on the labels needed by the consumers

	Respondents (1)	
	No.	%
Expiry date	133	83.6
Ingredients and their contents	129	81.1
Name and address of the manufacturer	101	63.5
Net weight	95	59.7
Nutritional values	87	54.7
Country of a manufacturer (if from overseas)	60	37.7
Others	20	12.6

(1) Number and percentage were given out of the total number of respondents who answered the question, i.e. 159 housewives. More than one choice was permitted.

9.7.3 Promotion of the Developed Product

The consumers who participated in this 'home use' consumer testing wanted the developed meatballs to be promoted. The proportions of the respondents given for the suitable means of communication, in descending order, were: television > newspapers and magazines > personal conversation > radios > others (see Table 9.16). For other means, the consumers

thought that the product could be promoted by setting displays in supermarkets, giving free samples in fast food outlets or sending pamphlets about the product to households.

Table 9.16 Means of communication to promote the product

	Respondents (1) No.	%
Television	107	68.6
Newspapers, magazines	80	51.3
Personal conversation	60	38.5
Radios	25	16.0
Others	10	6.4

(1) Number and percentage were given out of the total number of respondents who answered the question, i.e. 156 housewives. More than one choice was permitted.

9.7.4 Estimation of Sales Potential

An attempt was made to roughly estimate the sales potential of the developed meatballs by using the information obtained from the questionnaires completed by the housewives and the secondary sources of data (see Appendix 9.4).

It was estimated that approximately 24-25 tonnes of meatballs would be purchased monthly by the target consumers in the Bangkok area. This quantity was related roughly to 18-19 tonnes of trimmed mutton which would be used as raw material.

This is of course the market potential, sales would take some years to reach this depending on distribution and promotion of the developed product. Sales of 10% should be achievable immediately, i.e. 2.4-2.5 tonnes per month or 1.8-1.9 tonnes of mutton. However, a test marketing is further needed to actually sell the meatballs in the target market. Then the reasonable and accurate market potential can be estimated.

9.8 CONCLUSION

Considering that the acceptability level was higher than 5 out of the full hedonic score of 7, the developed product was acceptable to the target Thai consumers. This was valid for the respondents of all age groups and for the total sample because the overall liking ratings given were all higher than 5. This 'home use' consumer testing revealed that a 'mutton-based' product could be made acceptable to the Thai people. The muttony aroma and flavour could be disguised. Flavour was the most important sensory characteristic which made the meatballs acceptable.

It was also shown that almost a quarter of the households participated in this consumer test would be definite buyers who really liked the meatballs and were willing to pay for the price higher than those of the local processed meat products in the Thai markets.

CHAPTER 10
DISCUSSION AND CONCLUSION

10.1 OVERALL DEVELOPMENT OF THE MUTTON-BASED MEATBALLS

Since the majority of the Thai people have never consumed a mutton-based processed meat product, the formulation played a vital role in the product's acceptance. By removing the major source of the strong muttony aroma and flavour - the fat, incorporating a minor proportion of pork, replacing the mutton fat with pork fat, using a few ingredients to improve the texture and some spices to conceal the strong and unfamiliar aroma and flavour of the mutton, the developed mutton-based meatballs were made acceptable to the target Thai consumers.

The developed product has relatively high protein and this is comparable to commercial meatballs in the Thai markets which have 15.3-17.7% protein. The product has higher fat content (8.0%) than commercial meatballs (2.8-3.6%). However, the product fat content is less than 10%, i.e. the maximum level of mutton fat in processed meat products recommended by numerous researchers. Determination of the fat contents of the meat and of the fatty raw materials showed that of the 8% fat in the product, the actual mutton fat content was only 2.8% which was very low. The fat content of the trimmed boneless mutton leg was only 3.7%. This very low value was obtained by extensive and careful trimming of the mutton raw material. Since the labour cost in New Zealand is high when compared to Thailand, a suggestion could, therefore, be made that the mutton raw material be trimmed in Thailand and the product then manufactured and sold.

Low quality mutton, i.e. with high fat content, is not suitable since very low mutton fat content in the final product is needed. If 'high fat' mutton is used as raw material, a process is essential to extract the fat before such mutton can be used for making meatballs for the Thais.

Table 10.1 presents the major specifications for the meatballs.

Table 10.1 Specifications for the meatballs

	Specification	
Product Concept	Product is a new processed meat product for the Thais. It is a Western style crumbed meatball made mainly from very low fat mutton. The product is different from local Thai meatballs in that it is more spicy. It has to be fried before consumption and can be eaten with various types of sauces.	
Product Characteristics		
Product Size	Weight 20 g; round shape 3 cm in diameter.	
Formulation	Meats and Fat	
	Mutton (trimmed mutton leg)	75%
	Pork (trimmed)	20%
	Pork fat (backfat)	5%
		100%
	Ingredients (based on total meats, and fat weight, i.e. 100)	
	Tapioca starch	4.00
	Salt	2.50
	Sodium tripolyphosphate	0.25
	White pepper	0.75
	Garlic	1.00
	Onion	0.80
	Ginger	0.60
	Ice	20.00
	Crumbing	
	Whole egg and bread crumbs (based on weight of prepared meatballs), %	10.00
Proximate analysis		
	Moisture, %	69.00
	Protein (Nx6.25), %	15.40
	Fat, %	8.00
	Crude fibre, %	0.19
	Ash, %	1.80
	Carbohydrates (by difference),%	5.61
	Calorific value, kilocalories/100g	156.00

10.2 THE FORMULATION PROCESS

The formulation process was very important in the successful development of the meatball product. The main parts of the formulation process were the study of the effects of mutton on texture and flavour.

For texture development, the addition of pork or beef in small amounts was beneficial in mutton-based meatballs. There was a tendency that meatballs containing pork were superior to the ones containing beef in textural characteristics. Therefore, pork, which has a lower price in the Thai markets than beef, was chosen to be incorporated with mutton. Pork fat resulted in meatballs with better texture than mutton fat. Therefore, the mutton was trimmed of fat and pork fat was added to replace the mutton fat. The suitable meats and fat formulation was identified as 75% mutton lean, 20% pork lean and 5% pork fat. Numerous researchers (Baliga and Madaiah, 1970; Selvarajah et al., 1974; Bushway et al., 1987) found that as high as 67% mutton could be used to make processed products with desirable textural attributes. In this study, a higher mutton content, 75%, was successfully used in the meatballs.

Since the meats and fat alone did not give meatballs with a desirable texture, tapioca starch, salt and phosphates were added. All these ingredients substantially improved the texture of the meatballs but the effects of salt were more pronounced. When the levels of salt and sodium tripolyphosphate were increased, the sensory scores for textural attributes and the objective test values, including the Instron values and the cook yield, also increased. These findings were in agreement with the work of many workers (Sherman, 1961; Schwartz and Mandigo, 1976; Neer and Mandigo, 1977; Theno et al., 1978; Field et al., 1984a; Field et al., 1984b; Brewer et al., 1984). An increase in tapioca starch content also increased the sensory scores for texture, the Instron values and the cook yield. Tapioca starch has not been widely used in processed meat products, but this study showed that tapioca starch, which is endogenously and readily available in Thailand, was very beneficial in development of an acceptable texture in the meatballs.

In the aroma and flavour development, it was found that trimming of mutton fat and addition of spices made the product acceptable. Maintaining the mutton fat content within the maximum level of 10% was recommended for desirable flavour in processed meat products by many researchers (Carpenter et al., 1966; Anderson and Gillet, 1974b; Wenham, 1974; Brennand and Mendenhall, 1981; Bartholomew and Osuala, 1986), but in this formulation it was reduced to 3% to give an acceptable product. White pepper, garlic, ginger and onion were found to be the most effective spices to cover the mutton flavour and aroma and give an attractive spicy flavour. The product was different from the local meatballs in that it was more spicy.

In this study, it was found that flavour was the most important sensory attribute in determining overall acceptability or liking of the meatball product. Texture was the second most important attribute. These two attributes were anticipated to be critical in development of the meatballs for the Thai consumers, and this was found to be true in the consumer test in Thailand.

10.3 USE OF EXPERIMENTAL DESIGNS IN FORMULATION

Experimental designs have long been used as essential tools for research in various disciplines. With the appropriate choosing of the designs, the results obtained from any experiment can be conclusive and the inference can be correctly drawn for that experiment. In this research, several experimental designs were used in the successive steps for the formulation development of the mutton-based meatballs. Table 10.2 outlines the experimental designs, the stages at which they were used, and the objectives during the formulation process.

Table 10.2 Experimental designs, stages, and objectives during the formulation process

Experimental Design	Stage	Objective
Mixture design	Selection of meat and fat	To determine type and level of another meat and another fat to be incorporated with mutton.
2^3 Factorial design	Texture development	To study the effects of tapioca starch, salt and sodium tripolyphosphate on the texture.
Plackett and Burman Design	Flavour development	To screen for suitable spices which were useful for flavour improvement.
Quarter 2^6 fractional factorial design	Flavour development	To study the effects of simultaneous use of the three texture improvers (tapioca starch, salt and sodium tripoly-phosphate) and the three flavour enhancers (white pepper, garlic and onion) on acceptability.

Each experimental design has its own merits. Its selection for use in the research was based on specific purposes and conditions at various stages of the development process. In this study, it was shown that the mixture design was very useful in the 'three component' situation.

The full factorial design was very beneficial for the texture development. Empirical equations relating the sensory ideal ratio scores or the objective test values to the contents of the three ingredients were obtained. These empirical equations, being regarded as true for the region in the factorial experiment, were used, together with the concept of the 'ideal' characteristics, to estimate the contents of these ingredients suitable for use in the meatballs. There have not been many published research articles concerning the use of the empirical equations, especially those relating the ideal ratio scores to the contents of the ingredients, in food formulation. Therefore, this study revealed the usefulness of the appropriate experimental design and the exploitation of the data for guiding the formulation development.

The Plackett and Burman design was shown to be appropriate for the preliminary stage of flavour development. It was effective for rapidly screening suitable spices.

It was shown that the quarter fractional factorial design was not as effective as the full factorial design. The latter gave results which were more distinctly defined or conclusive than those given by the former. In general, the lower the degree of the fraction, i.e. one quarter is considered as lower than one half, the less conclusive results will be obtained. This is due to the confounding of higher-order interactions with main effects and lower-order interactions, i.e. the alias terms. In this study, the inference could be conclusively drawn for the effects of tapioca starch, salt, and sodium tripolyphosphate on the texture. However, any decisive inference could not be drawn for the effects of these three texture improvers together with white pepper, garlic and onion on sensory attribute acceptability.

10.4 USEFULNESS OF CONSUMER INPUTS AND SENSORY EVALUATION

In this project, sensory panels were used in practically all stages of the product development process. It was essential that inputs from consumers had to be incorporated at many stages of development since the product was developed from meat unfamiliar to the Thai people. Table 10.3 shows types of panel and their sizes, sensory evaluation techniques and stages at which they were mainly used in this study.

Table 10.3 Types of panel and sensory evaluation techniques used in the project

Type of panel	Size (n)	Sensory Evaluation Technique	Stage
Laboratory panel	12	Ideal profile testing	Investigation on sensory properties of commercial Thai meatballs
Laboratory panel	8	Ideal profile testing	Formulation in New Zealand
Small household panel	17	Hedonic scaling	Testing for acceptance in New Zealand
Focus group panel	6	Ideal profile testing	Optimisation for the prototype formulation in Thailand
Home-use test panel	488	Hedonic scaling	Final testing for acceptance in Thailand

In this research two major types of sensory panels were used to develop the product. These were the laboratory panels and the household consumer panels and they were employed for use in the sensory evaluation tasks in Thailand and in New Zealand. The panels used in Thailand might be considered as 'true-consumer' panels but those used in New Zealand might be considered as 'pseudo-consumer' panels, as the members of the panels were not truly representative of the Thai consumers.

The laboratory panels were experienced or trained consumers and the ideal profile technique was the major sensory evaluation method. Its usefulness was initially shown in determining the ideal sensory characteristics of the meatballs, which were later used in guiding the formulation work in New Zealand.

It was at the formulation development stage in New Zealand that collaboration of the use of the laboratory panels with the ideal profile testing was more extensively employed. Although the panelists participating in the formulation process were pseudo-consumers, they worked reasonably well and they were very useful in guiding the development of the product. For example, the results from their assessment showed that meats and fat alone were not enough to yield the product with ideal textural attributes. This led to the texture development by using the added ingredients to improve the texture. The final formulation developed by the laboratory panel in New Zealand only needed a slight adjustment by the focus groups in Thailand.

The focus group technique, employing the laboratory panel comprised of the experienced participants and using the ideal profile testing, was used to improve the product's characteristics especially the aroma and flavour. Using the strategy of small panel size with the appropriate sensory method, the prototype formulation was determined.

Two household consumer panels were used in this study. These included the small Thai household consumer panel in New Zealand and the large home-use consumer panel in Thailand. The sensory evaluation method used for both panels was hedonic scaling which was suitable for general consumers who were not experienced in judging the sensory characteristics of food products. Using the hedonic scaling in the small household panel revealed that the intermediate product was not ready for a large scale consumer test. After the formulation had been optimised in Thailand, the hedonic scaling was used again, but with the very much bigger sample of consumers, to test for the acceptance of the product. As a consequence, it was shown that the product was successfully developed and acceptable to the target Thai consumers.

From this research, it is recommended that small groups of consumers be used at as many of the product development stages as possible. This strategy reduces the chance of spending excessive amounts of time and money. For example, if the intermediate product made by using the selected formulation had not been tested by a small household consumer panel in New Zealand, it might have passed to the consumer testing stage which required a large amount of resources and as a result, the product might have failed or might have not been acceptable to the consumers. Use of consumers at different stages is also suggested since it helps guide the development process extensively and provides useful information which can be used in the following stages of development. For example, information obtained from the focus groups were very helpful in designing the supplementary questionnaire to be completed by the housewives in the large scale 'home use' consumer testing.

At various stages of the development process, the sensory attribute scores of the product were assessed on the basis of different sensory evaluation methods. In addition, different characteristics of the product were evaluated by the panelists or the consumers depending on the purposes of each experiment performed at that stage. However, a summary was made on the ideal profile, as determined by the ideal absolute scores, of the sensory characteristics of the meatballs at two different stages of the development. Table 10.4 presents this summary.

It was shown that the ideal meatballs for the Thai consumers should be relatively rubbery and mildly salty. The commercial Thai meatballs, which do not have many kinds of spices, should not be too spicy. However, the developed product had spices other than the ones used in the commercial products to disguise the strong aroma and flavour of mutton. Therefore, the ideal score for spiciness of this type of product was much higher than the score for commercial products.

Table 10.4 A summary on the ideal profile as determined by the ideal absolute scores of the meatballs at two different stages of development

Sensory Attribute	Ideal Absolute Score		
		Intermediate Product (2)	
	Commercial Thai Meatballs (1)	Kasetsart Focus Group	Chulalongkorn Focus Group
Colour	7.8	6.4	5.8
Aroma	nd.	8.1	9.3
Firmness	8.0	nd.	nd.
Rubberiness	6.3	6.7	7.5
Smoothness	8.2	nd.	nd.
Juiciness	6.1	nd.	nd.
Oiliness	4.3	nd.	nd.
Saltiness	5.6	6.0	5.7
Spiciness	3.9	6.6	6.3

(1) The scores were determined for commercial meatballs in Thailand during the initial investigation stage.

(2) The scores were determined for the intermediate product during the optimisation stage by using focus groups.

nd. not determined.

Another comparison for the changes of sensory attribute scores was made for the hedonic ratings of the intermediate product evaluated by the small household consumer panel in New Zealand before the optimisation stage and of the final product evaluated by the 'home use' consumer test panel in Thailand. Table 10.5 shows this comparison.

Table 10.5 Comparison between hedonic scores of the sensory attributes of the intermediate product and the final product (1)

	Intermediate Product (n=17)	Final Product (n=488)
Liking of appearance	4.76 ± 0.25	5.14 ± 0.06
Liking of aroma	4.29 ± 0.35	5.15 ± 0.07
Liking of texture	4.88 ± 0.19	5.21 ± 0.06
Liking of flavour	4.59 ± 0.31	5.11 ± 0.07
Overall liking	4.47 ± 0.29	5.23 ± 0.06

(1) Values are means ± standard errors of the means calculated for the corresponding number of consumers.

Although the descriptions used for hedonic ratings were slightly different for both cases, the ratings were still based on the 7-point scales. It was obvious that the final product was liked very much more by the consumers than the intermediate product. This showed that the optimisation process by using small-sized focus groups was successful and yielded the prototype product which was acceptable.

10.5 SUBJECTIVE TESTS VS. OBJECTIVE TESTS

It was found that the Instron initial yield force was very highly correlated with the ideal ratio scores of the sensory texture characteristics of the meatballs; the correlation coefficients being higher than those given by the other Instron parameters. The initial yield force may be the most appropriate parameter for objectively assessing the texture of the product.

Researchers have also found correlations between the sensory and the instrumental evaluations in meat products. However, the sensory attribute scores were normally obtained from the unstructured linear scales (Voisey et al., 1975; Brady and Hunecke, 1985; Brady et al., 1985), the structured linear scales (Bouton et al., 1975) and the hedonic scales (Lee, 1983). No other published research papers have shown the correlations between the sensory ideal ratio scores and the Instron parameters. Therefore, this study revealed that the results obtained by this infrequently used subjective technique were also in agreement with the results obtained by the commonly used objective test.

10.6 RECOMMENDATION FOR FUTURE WORK

Although the final product was successfully developed and reasonably acceptable, there were some points to be suggested for the future work as follows:

* Other than developing the product by the formulation process, the meatballs may be made acceptable to the Thais by some other means. For example, the mutton can be upgraded by removing its strong flavour and aroma. To date, attempts have been made to deflavourise the mutton. This upgraded product can possibly be used as a sole source of raw material for the meatballs. There may be no need to conceal the strong flavour and aroma of mutton by using spices.
* The outside crumb of the product can be improved.
* Other aspects of the process development can also be studied. For example, using different type of mutton raw materials; the hot-boned and the cold-boned, may result in the meatballs with different sensory characteristics.
* A storage test of the developed product can be carried out. The product can be packed in different kinds of plastic films under normal atmosphere, vacuum or inert gas and stored at different chilled and frozen temperatures. The stored product can be tested physically, chemically and microbiologically.
* The product was only consumer tested in the final stage of this study. It was believed that test marketing was needed in order to attain some more data and information to justify whether the mutton-based meatballs could be launched and successfully survive in the competitive Thai markets.

10.7 EXECUTIVE SUMMARY

It has been shown in this study that a new acceptable processed meat product, crumbed spicy meatballs, could be successfully developed from sheepmeats, especially those with very strong aroma and flavour like mutton, for the Thai consumers. It was believed that the developed product was made acceptable by the following means:

* The mutton fat content was reduced by careful trimming of the fat tissue in the mutton raw materials. The removed mutton fat was replaced by pork fat (5%) which is preferred by the Thai people. The mutton fat content of the developed product was very low at 2.8%, the level which might be so low that it did not create the strong aroma and flavour unfamiliar to the Thais.
* Other than replacing the mutton fat with pork fat, pork (20%), a meat which is familiar and also preferred by the Thais, was also incorporated with mutton. Therefore, the relatively high proportion (75%) of mutton could be used in the product.
* The three ingredients, tapioca starch (4%), salt (2.5%) and sodium tripolyphosphate (0.25%) improved the texture.

* The spices, white pepper (0.75%), garlic (1.0%), onion (0.8%) and ginger (0.6%) improved the aroma and flavour.
* Other than being formed into balls, the product may be made into other shapes such as patties, nuggets, etc.

The final product was consumer tested in Bangkok, Thailand by 488 consumers for the target market of middle class and upper class professional and business Thai families and was acceptable to them. A very approximate sales potential was estimated as 2.5 tonnes per month which could increase to 25 tonnes per month. This would be equivalent to 1.9 tonnes and 19 tonnes of mutton respectively. A test market would have to be conducted to verify this sales potential.

10.8 CONCLUSION

Overall, it was found that the product was made acceptable by the formulation process. The mutton fat content was reduced by careful trimming of the fat tissue in the mutton raw materials. The removed mutton fat was replaced by pork fat which is preferred by the Thai people. This allowed for the relatively high proportion (75%) of mutton to be used in the meatballs. A minor proportion of pork, a meat which is familiar and also preferred by the Thais, was incorporated with the mutton. The three additives; tapioca starch, salt, and sodium tripolyphosphate improved the texture. The spices; white pepper, garlic, onion and ginger improved the aroma and flavour. In addition, the mutton fat content of the developed product was very low at 2.8%, the level which might be so low that it did not create the strong unfamiliar aroma and flavour to the Thais. All these criteria helped to result in the acceptable product. This was a new product, spicy crumbed meatballs, for the Thai market and did not resemble traditional meatballs.

In addition to the success of the developed product, this research also revealed that the advantages of using the ideal profile ratio scores with the laboratory panel were three fold. Firstly, it helped identify the ideal sensory characteristics of the meatballs. Secondly, it was exceptionally useful for guiding the formulation process. Thirdly, it helped optimise the product's characteristics to yield the prototype formulation which was successfully tested and accepted. The ideal profile ratio scoring technique is recommended for use with experienced laboratory panels and in collaboration with the appropriate experimental designs in the formulation process, not only for the meatball product studied in this research but also for other food products. On the other hand, the hedonic scaling is suitable for use with the inexperienced consumer panels to identify the acceptance of the product.

In this research, the objective test measurements as determined by the Instron texture meter especially the initial yield force, were also necessary in studying the texture of the

meatball product. It is recommended that the objective tests are concurrently used with the subjective tests in the development, especially for the formulation process, of food products. If correlated with the subjective tests, e.g. rubberiness with Instron initial yield force in this study, the objective test can replace the sensory test.

In conclusion, this research was successful in that a new meatball product was developed from an unknown meat, i.e. mutton, and was acceptable to the target Thai consumers. This product can be produced conveniently in ordinary meat plants and with existing technology available either in New Zealand or in Thailand. However, the product may be more suitably produced in Thailand since it was found that trimming of mutton raw materials, which would require extremely laborious work, was necessary to reduce the mutton fat content.

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Appendix 1.1 Average household expenditures in a 7-day period for food by region in Thailand 1986 (in baht)

	Bangkok	Central	Northern	North-Eastern	Southern
Percent of households	14.30	19.20	21.50	31.90	13.10
Average household size	3.80	4.20	3.90	4.90	4.20
			Bahts		
Food prepared at home	315.55	308.13	245.30	245.41	281.33
Grains and cereal products	58.07	76.78	72.63	79.94	69.03
Rice	44.20	60.95	29.72	31.18	53.69
Glutinous rice	1.40	1.94	34.39	44.56	1.36
Flour (rice,wheat, etc.)	0.41	0.84	0.35	0.24	0.75
Noodles	1.88	2.11	1.71	1.23	0.89
Bean curd and milk	1.47	0.65	0.34	0.05	0.24
Bread	2.17	1.17	0.81	0.46	1.14
Cake and pastries	5.42	8.39	5.06	1.99	10.72
Other cereal products	1.12	0.73	0.25	0.23	0.24
Meat and poultry	61.17	56.77	55.61	44.10	43.15
Fresh	(53.08)	(53.31)	(50.32)	(40.95)	(41.57)
Lean pork	23.29	30.21	23.70	8.36	17.99
Pork Fat	1.88	3.41	1.57	0.47	0.26
Sparerib	2.68	2.63	0.95	0.45	0.99
Other parts of swine	2.34	2.06	2.17	1.13	1.74
Beef and buffalo meat	7.06	5.83	8.62	9.94	9.42
Other parts of cattle and buffalo	0.98	0.37	1.03	1.52	1.57
Chicken	12.05	7.49	9.49	10.18	8.82
Duck	1.08	0.59	0.21	1.35	0.30
Frog	1.15	0.22	1.00	4.56	0.19
Others	0.57	0.50	1.58	2.99	0.29
Prepared	(9.09)	(3.46)	(5.29)	(3.15)	(1.58)
Roasted pork	1.19	0.33	0.66	0.16	0.35
Salted pork, ham, sausage	1.46	0.63	0.85	0.84	0.16
Salted and dried beef	1.59	0.30	0.34	0.44	0.07
Prepared fowl	3.18	1.39	1.35	1.00	0.51
Other prepared meat	1.67	0.81	2.09	0.71	0.49

Source: Adapted from a report prepared by the National Statistical Office, Office of the Prime Minister, 1986

Appendix 1.2 Number of buffalo, cattle and swine slaughtered and wholesale meat price in Bangkok, 1973-1982

Year	Slaughtered Totals			Wholesale Price		
	Buffalo	Cattle	Swine	Buffalo Meat	Beef	Pork
				Baht per kg		
1973	34,660	37,612	432,874	10.03	11.71	11.52
1974	20,521	21,226	433,494	8.51	12.17	17.11
1975	17,150	17,432	450,855	18.01	22.72	18.15
1976	28,249	27,565	657,134	17.57	23.77	17.69
1977	42,340	40,635	631,248	16.75	20.96	20.50
1978	41,552	39,747	955,847	16.89	19.96	17.50
1979	32,131	34,360	1,033,929	18.67	21.54	21.41
1980	25,645	21,629	712,333	20.49	23.73	25.24
1981	18,801	20,203	714,460	32.63	38.94	27.45
1982	19,616	20,252	767,463	32.19	39.49	23.51

Source: Department of Livestock Development, Ministry of Agriculture and Cooperatives (years 1976-1982 from Bangkok Metropolis Administration), 1983

Appendix 1.3 Number of buffalo, cattle, swine, and chicken in Thailand,1982-1986

Year	Buffalo	Cattle	Swine	Chicken
1982	5,388,139	4,442,885	4,913,521	62,050,822
1983	5,205,377	4,433,834	5,241,170	62,010,280
1984	5,118,913	4,408,026	5,343,036	64,370,895
1985	5,084,702	4,314,487	5,918,842	70,020,788
1986	4,980,794	4,351,461	5,872,520	87,324,420

Source: Department of Livestock Development, Ministry of Agriculture and Cooperatives, 1986

Appendix 3.1 Information concerning processed meat products sold in Bangkok supermarkets (1 NZ $ = 13 baht) (a)

	Wholesale Price (Baht/kg)	Retail Price (Baht/kg)	Sale Quantity (kg/month)	Type of Packaging Material	Method of Packing	Selling Condition	Days in Retail Shop
BEEF PRODUCTS							
meatball	50-60	60-70	200-300	plastic bag or loose	air or vacuum-pack	chilling or freezing	3-6
sliced dried spicy beef	173-185	230-240	20-80	plastic bag or loose	air pack	ambient	7-20
shredded and sweetened beef	173-180	230	30-60	plastic bag or loose	air pack	ambient	7-20
beef patty (for hamburger)	60-85	75-100	20-30	plastic bag	air pack	chilling or freezing	4-7
meatloaf	not specified	90-110	5	plastic bag or loose	air pack	chilling	7
veal sausage	not specified	85-110	30	plastic bag or loose	air pack	chilling or freezing	7
salami	not specified	210	5	plastic bag or loose	air pack	chilling or freezing	7

Appendix 3.1 (continued)

	Wholesale Price (Baht/kg)	Retail Price (Baht/kg)	Sale Quantity (kg/month)	Type of Packaging Material	Method of Packing	Selling Condition	Days in Retail Shop
varieties of canned beef	varied prices	varied prices	varied quantity	can	vacuum-pack	ambient	1-2 yr
PORK PRODUCTS							
meatball	63.75	60-75	150-180	plastic bag or loose	air or vacuum-pack	chilling or freezing	3-7
varieties of ham	varied prices	varied prices	varied quantity	plastic bag or loose	air or vacuum-pack	chilling or freezing	3-10
bacon	55-70	65-90	30-200	plastic bag or loose	air or vacuum-pack	chilling or freezing	3-7
sai krok priew (fermented Thai-style sausage)	not specified	80	50	plastic bag or loose	air pack	ambient	3-7
moo yor (Thai-style emulsion sausage)	66-79	80-120	15-100	plastic wrap	air pack	chilling or freezing	3-30

Appendix 3.1 (continued)

	Wholesale Price (Baht/kg)	Retail Price (Baht/kg)	Sale Quantity (kg/month)	Type of Packaging Material	Method of Packing	Selling Condition	Days in Retail Shop
Chinese sausage	95	120	40-200	plastic bag or loose	air or vacuum-pack	ambient	7-30
pork floss	180-190	240	40-100	plastic bag or loose	air pack	ambient	14-30
dried and sliced pork	173-180	230-250	20-70	plastic bag or loose	air pack	ambient	7-30
varieties of canned pork	varied prices	varied prices	varied quantity	can	vacuum-pack	ambient	1-2 yr
bologna	50-64	60-70	60-80	plastic bag or loose	air or vacuum-pack	chilling or freezing	5-7
cocktail	50-64	60-80	60-200	plastic bag or loose	air pack	chilling or freezing	3-7
frankfurter	64-85	70-100	20-80	plastic bag or loose	air pack	chilling or freezing	3-7
vienna	50-64	60-80	30-150	plastic bag or loose	air pack	chilling or freezing	3-7

Appendix 3.1 (continued)

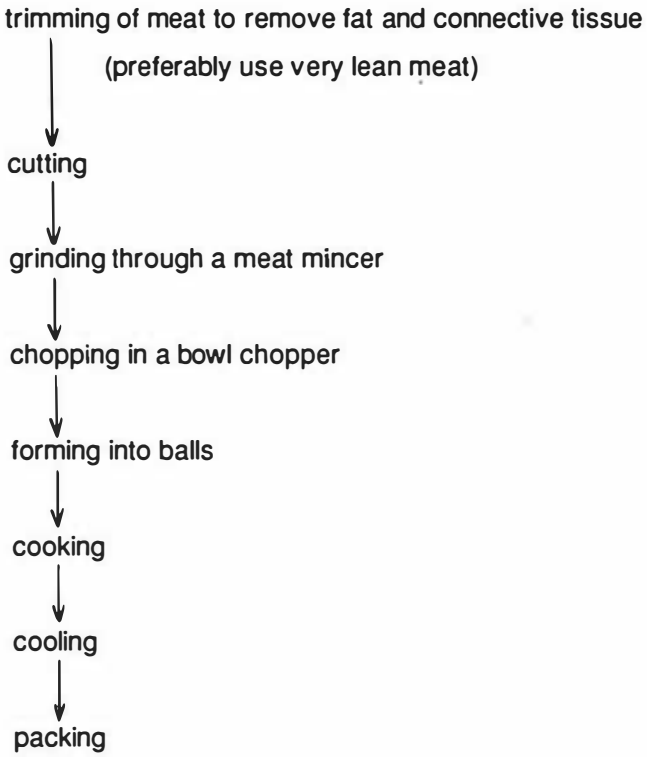
	Wholesale Price (Baht/kg)	Retail Price (Baht/kg)	Sale Quantity (kg/month)	Type of Packaging Material	Method of Packing	Selling Condition	Days in Retail Shop
stuffed pork leg	100	110	30-40	plastic bag	air pack	chilling	4-5
smoked pork leg	94	110	20-30	plastic bag	air pack	chilling	4-5

(a) The information was collected in late 1984.

Appendix 3.2 Processing steps for production of four groups of the meat products

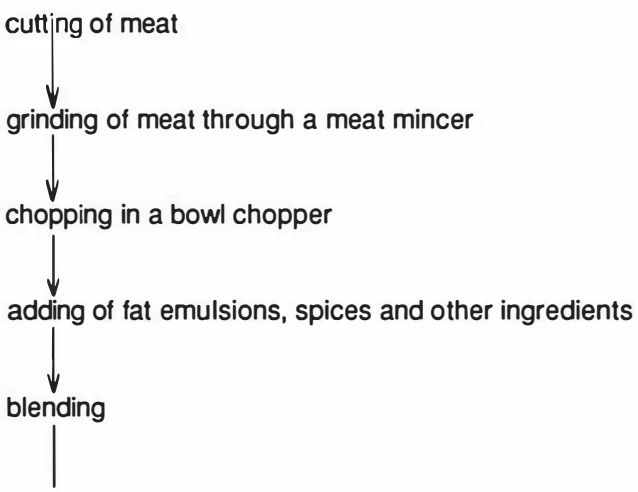
Meatballs

The major processing steps are shown in the following diagram (in brief).

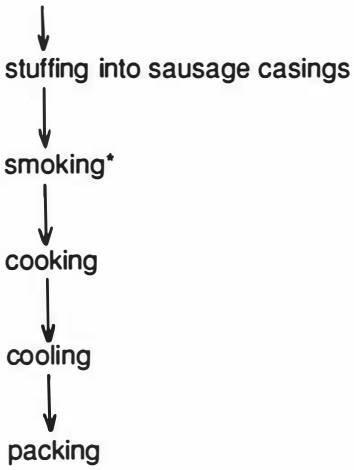


Sausage

Sausages are produced using various methods; all varying to a certain degree. However, basically the same major processing pattern is utilized as shown in the following diagram (in brief).



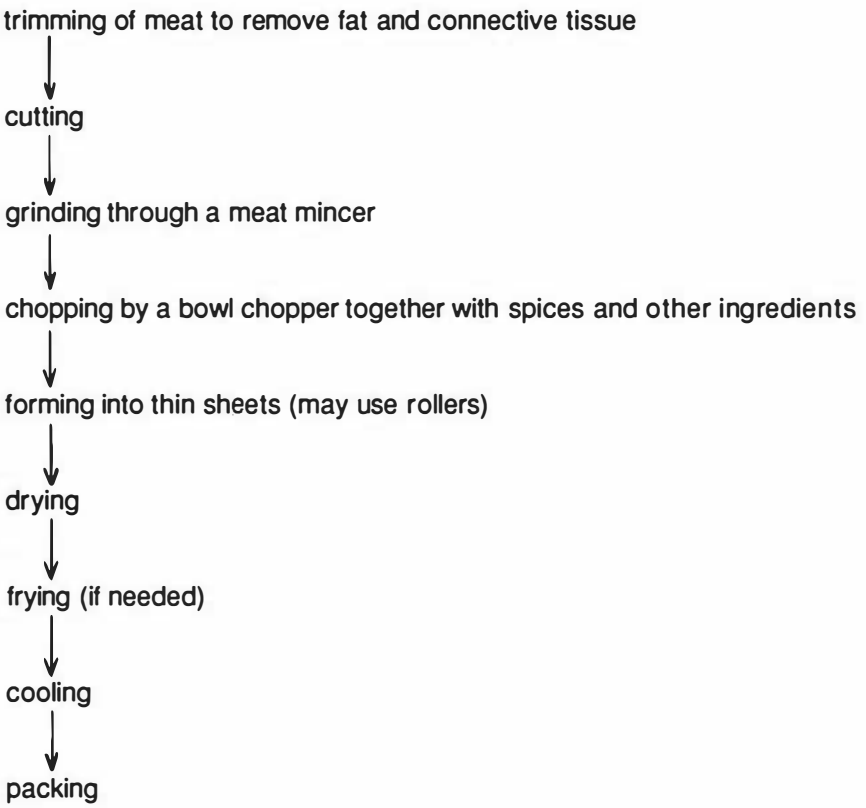
Appendix 3.2 (continued)



* Smoking is omitted if non-smoked sausages are produced.

Dried Meat

There are many methods for making dried meat; all varying to a certain extent. Principally, however, they follow the same major processing pattern. For instance, sliced and dried spicy meat is made in the following method (in brief).

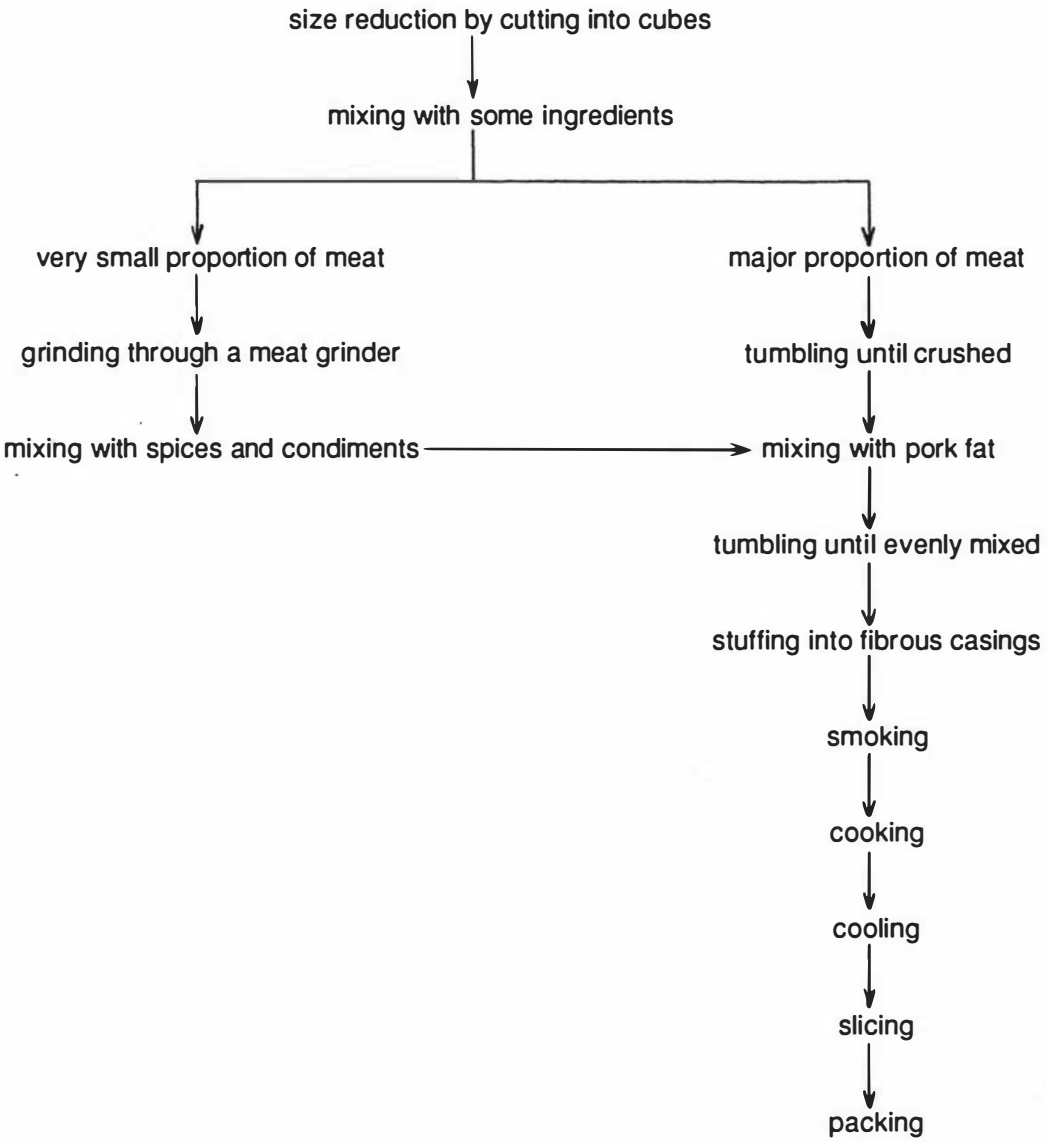


Appendix 3.2 (continued)

N.B. Fresh meat, trimmed of fat and connective tissue, may be sliced to make thin films; thus, grinding and chopping steps may be omitted and replaced by mixing meat with spices and other ingredients after slicing.

Pressed-Ham

The following diagram shows processing of pressed-ham (in brief).



Appendix 3.3 Food additives allowed in meat products in Thailand

(1) L-Ascorbic Acid

The maximum amount is 500 mg/kg (ppm). This is to be used singly or in combination with iso-ascorbic acid, sodium ascorbate or sodium iso-ascorbate (calculated as ascorbic acid) but not more than 500 mg/kg when used together.

This acid is allowed to be used in such products as canned corned beef, cooked cured ham, luncheon meat, etc.

(2) Sodium Citrate

This substance is to be used in suitable amount and in such products as luncheon meat, cooked cured ham, etc.

(3) Sodium Nitrate or Potassium Nitrate

Sodium nitrate or potassium nitrate is allowed to be used as preservative in such a product as cooked cured ham with the maximum amount of 500 mg/kg.

(4) Sodium Nitrite or Potassium Nitrite

Sodium nitrite or potassium nitrite is allowed to be used as preservative in such products as cooked cured ham with the maximum amount of 125 mg/kg, but with the maximum amount of 50 mg/kg in canned corned beef.

(5) Glucono Delta Lactone

This substance is allowed to be used in such products as cooked cured chopped meat and luncheon meat with the maximum amount of 3,000 mg/kg.

(6) Sodium Polyphosphate

This substance is allowed to be used in such products as cooked cured ham, cooked cured chopped meat, luncheon meat. The maximum amount allowed to be used is 3,000 mg/kg. This is to be used singly or in combination with sodium phosphate, tribasic or sodium phosphate, dibasic or sodium phosphate monobasic or potassium phosphate, tribasic or potassium phosphate, dibasic or potassium phosphate, monobasic (calculated as phosphorus pentoxide) but not more than 3,000 mg/kg when used together.

The use of other food additives which are not specified in the Ministerial Regulations must be in accordance with the purpose of each food additive to be used in each kind of food and with the amount agreeable by the Food and Drug Administration.

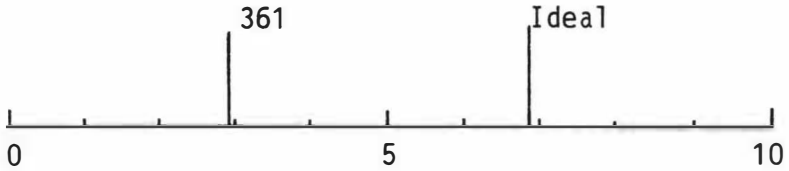
Appendix 3.4 A questionnaire used for an investigation on sensory properties of commercial products

Sensory Evaluation Questionnaire (translated from Thai)

Name _____

Date _____

You have received _____ samples (numbers of samples given) of a processed meat product coded with _____ (a sequence of three digit random numbers given). Please mark a vertical line on a horizontal line scale at a point where you think the ideal product should locate for each of its sensory characteristics. Then, mark another vertical line at a point where you think the sample you are evaluating should locate comparing it with the ideal you have given. Please see an example below.

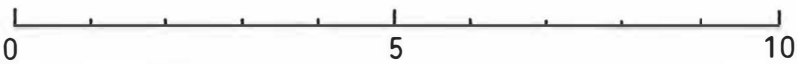


extremely not salty extremely salty

The above sample shows that you perceive that the ideal product should be relatively salty, but the sample you are evaluating is relatively not salty.

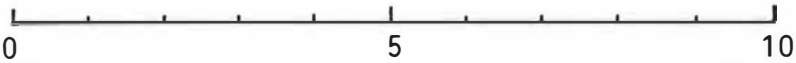
Please evaluate the samples and give the scores for each sensory attribute of the samples by making the vertical lines as shown in the example.

Colour



extremely not intense colour extremely intense colour

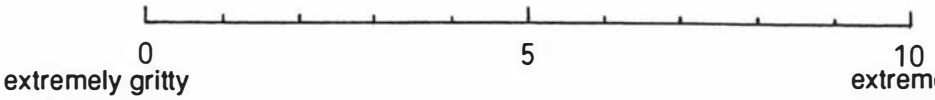
Firmness



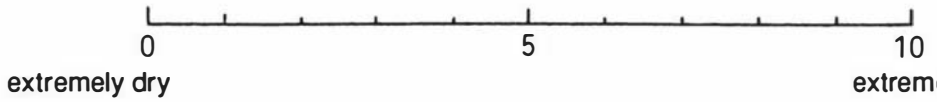
extremely soft extremely firm

Appendix 3.4 (continued)

Smoothness



Juiciness



Oiliness

Saltiness

Spiciness

Comments: _____

_____

_____

_____

Appendix 3.5 Formulations and methods for preparation of the four groups of processed meat products

Vienna Sausage

The formulations used for this sausage according to proportions of beef and mutton were as follows:

Formulation	Beef (g)	Mutton (g)	Pork Fat (g)	Ice (g)
1	500	0	150	150
2	250	250	150	150
3	0	500	150	150

Ingredients used for each formulation were as follows:

sugar	10.0 g	mace powder	0.60 g
salt	12.0 g	nutmeg powder	0.20 g
corn flour	23.0 g	garlic powder	0.75 g
milk protein (sodium caseinate)	10.8 g	sodium nitrite	0.05 g
		sodium ascorbate	0.15 g
white pepper	3.5 g	sodium hexametaphosphate	0.50 g

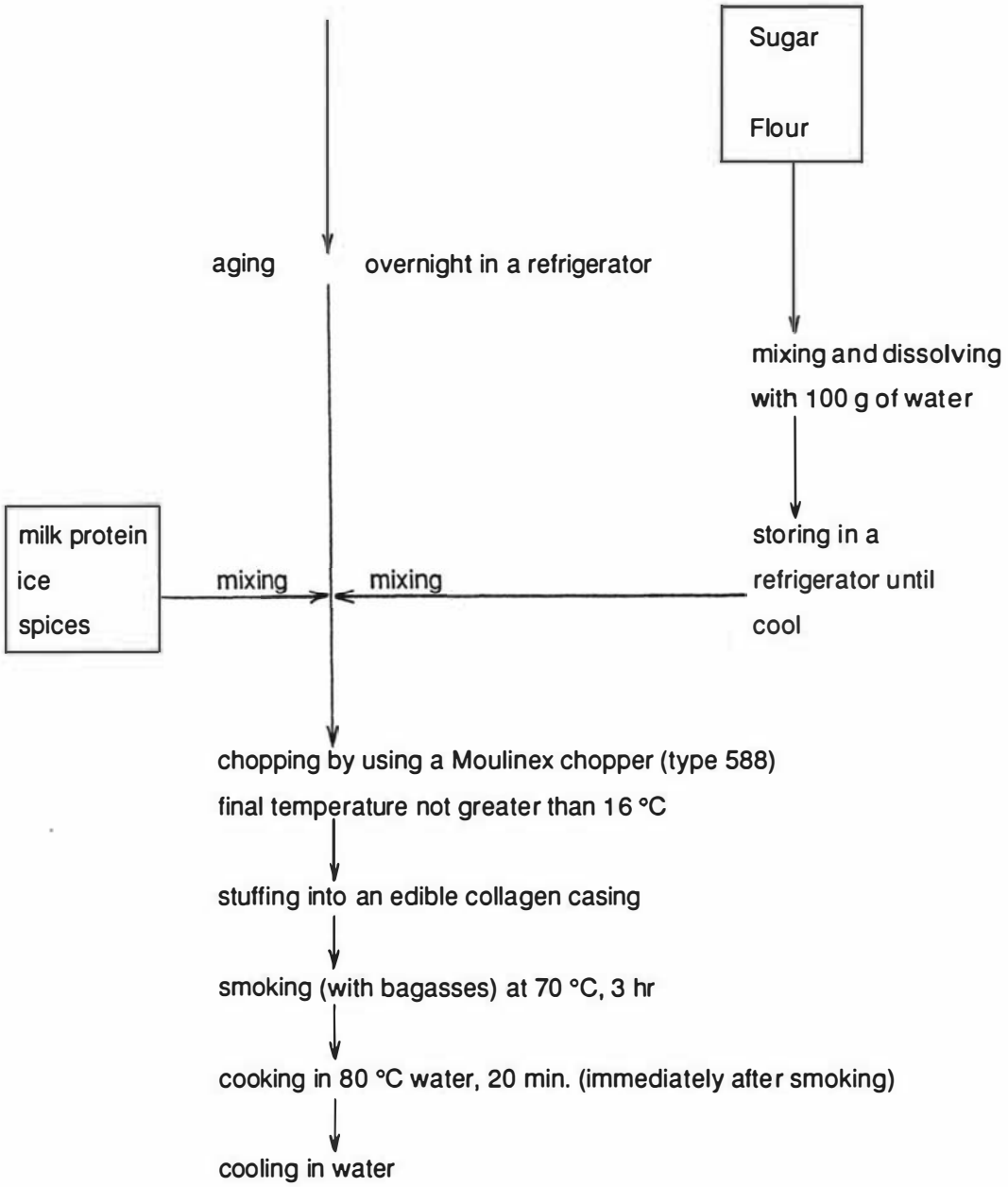
Processing of this product was as follows:

grinding of beef, mutton, or pork fat through a Kenwood mincer (model KNM6) with a 4.0 mm perforated plate

(twice

- firstly mincing each kind of meat or pork fat separately
- secondly, using a mixture of ground meat and ground pork fat together with salt, sodium nitrite, sodium ascorbate, sodium hexametaphosphate)

Appendix 3.5 (continued)



Cocktail Sausage

The formulations used for this sausage according to proportions of pork and mutton were as follows:

Formulation	Pork (g)	Mutton (g)	Pork Fat (g)	Ice (g)
1	500	0	150	150
2	250	250	150	150
3	0	500	150	150

Appendix 3.5 (continued)

Ingredients used for each formulation were as follows:

sugar	7.0 g	mace powder	0.60 g
salt	12.0 g	nutmeg powder	0.20 g
corn flour	23.0 g	garlic powder	0.75 g
milk protein (sodium caseinate)	10.8 g	sodium nitrite	0.05 g
		sodium ascorbate	0.15 g
white pepper	3.5 g	sodium hexametaphosphate	0.50 g

Processing of this product was similar to that of vienna sausage except that the smoking step was omitted.

Meatball

The formulations used for this product according to proportions of beef and mutton were as follows:

Formulation	Beef (g)	Mutton (g)	Ice (g)
1	500	0	100
2	0	500	100

Ingredients used for each formulation were as follows:

sugar	5 g
salt	15 g
tapioca starch	5 g
white pepper	1 g
sodium hexametaphosphate	2 g

Processing of this product was as follows:

trimming of beef (or mutton) to remove fat and connective tissue

↓

cutting into cubes (3/4 inch)

↓

grinding through a Kenwood mincer (twice)

↓

Appendix 3.5 (continued)

↓

chopping by using a Moulinex chopper together with ice, and a mixture of salt, sugar, tapioca starch, white pepper and sodium hexametaphosphate

↓

hand-forming into balls

↓

cooking in 65-70 °C water for 9 min.

↓

cooking in 85-90 °C water for 1 min.

↓

cooling in water

Spiced and Dried Meat

Mutton (500 g) was solely used in manufacturing of this product. Ingredients used in production were as follows:

sugar	106.24	g
salt	11.61	g
allspice	4.98	g
fennel seed	3.65	g
soy sauce	15.00	ml

Processing of this product was as follows:

trimming of mutton to remove fat and connective tissue

↓

grinding through a Kenwood mincer (twice)

↓

chopping by using a Moulinex chopper together with a mixture of the other ingredients

↓

forming into thin films (3-4 mm thick)

↓

drying in tray dryer at 47.5 °C, 6 hr

↓

pan frying using vegetable oil, 2-3 min

Appendix 3.5 (continued)

Pressed-Ham

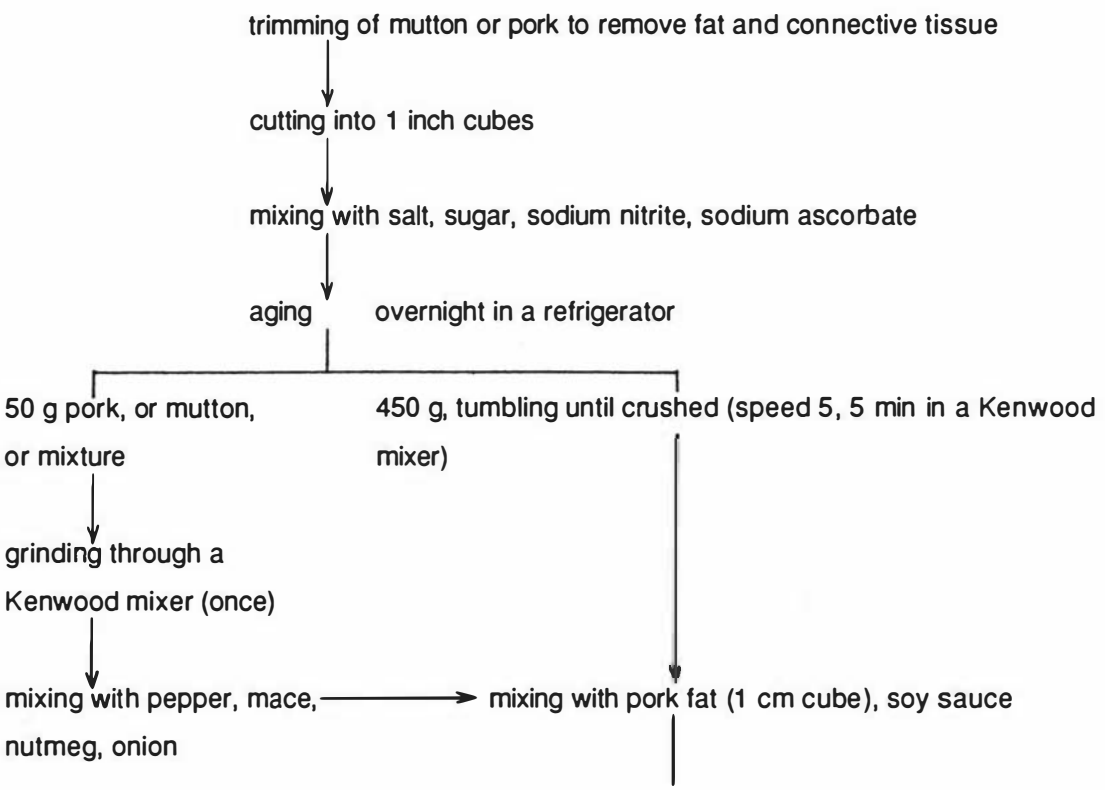
The formulations used for this product according to proportion of pork and mutton were as follows.

Formulation	Pork (g)	Mutton (g)	Pork Fat (g)
1	500	0	50
2	250	250	50
3	0	500	50

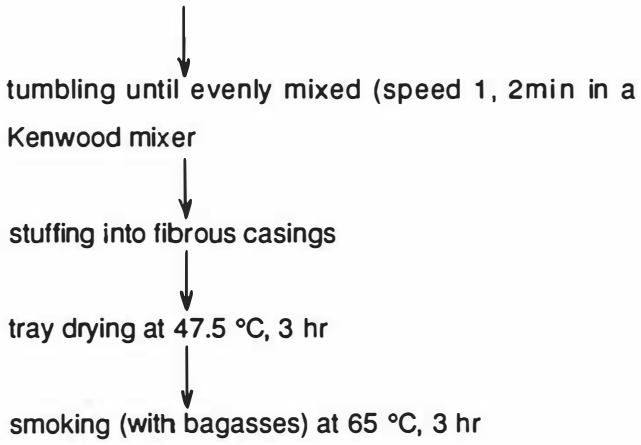
Ingredients used for each formulation were as follows.

sugar	12.5 g	chopped onion	5 g
salt	12.5 g	soy sauce	12.5 g
white pepper	1 g	sodium nitrite	0.05 g
mace powder	1.5 g	sodium ascorbate	0.15 g
nutmeg powder	1.5 g		

Processing of this product was as shown below.



Appendix 3.5 (continued)



Appendix 3.6 Summary of variations of ideas obtained from the brainstorming

Type	Variations of Ideas
Meatball	
	texturised vegetable protein and mutton meatball
	onion mutton meatball
	tomato mutton meatball
	garlic mutton meatball
	pepper mutton meatball
	goulash flavoured mutton meatball
	lasagna flavoured mutton meatball
	satay flavoured mutton meatball
	smoked mutton meatball
	liquid smoked mutton meatball
Dried Mutton	
	satay flavoured dried mutton
	spiced and dried mutton
	marinaded dried mutton (with brown sugar, ginger and sherry)
	roasted and dried mutton
	dried mutton with mince sauce
	mutton stick
	mutton floss
Sausage	
	mutton sausage with sweet corn
	mutton sausage with kumara (sweet potato) leaf
	mutton sausage with pea
	mutton sausage with baked bean and tomato
	mutton sausage with curry
	spiced mutton sausage
	corned mutton sausage
	texturised vegetable protein and mutton sausage (smoked)
	liver and mutton sausage (spiced and smoked)
	smoked mutton sausage
	liquid smoked mutton sausage

Appendix 3.7 Sequential screening of variations of ideas

Variations of Ideas	Screening Factor				
	Process-ing	Storage Life	Sensory Attributes and Accept-ability	Market Potential	Overall
Meatball					
- texturised vegetable protein and mutton meatball	P	P	F	F	F
- onion mutton meatball	P	P	F	F	F
- tomato mutton meatball	P	P	F	F	F
- garlic mutton meatball	P	P	P	P	P
- pepper mutton meatball	P	P	P	P	P
- goulash flavoured mutton meatball	P	P	F	F	F
- lasagna flavoured mutton meatball	P	P	F	F	F
- satay flavoured mutton meatball	P	P	P	P	P
- smoked mutton meatball	P	P	P	P	P
- liquid smoked mutton meatball	P	P	P	P	P
Dried Mutton					
- satay flavoured and dried mutton	P	P	P	P	P
- spiced and dried mutton	P	P	P	P	P
- marinaded and dried mutton (with brown sugar, ginger and sherry)	P	P	F	F	F

Appendix 3.7 (continued)

- roasted and dried mutton	P	P	F	F	F
- dried mutton with mint sauce	P	P	F	F	F
- mutton stick	P	P	P	P	P
- mutton floss	F	P	F	F	F
Sausage					
- with sweet corn	P	P	F	F	F
- with kumara leaf	P	P	F	F	F
- with pea	P	P	F	F	F
- with baked bean and tomato	P	P	F	F	F
- with curry	P	P	F	F	F
- spiced mutton sausage	P	P	P	P	P
- corned mutton sausage	P	P	F	F	F
- texturised vegetable protein and mutton sausage (smoked)	P	P	P	P	P
- liver and mutton sausage (spiced and smoked)	P	P	P	P	P
- smoked mutton sausage	P	P	P	P	P
- liquid smoked mutton sausage	P	P	P	P	P

P - Pass

F - Fail

Appendix 3.8 Checklist screening

Variations of Ideas	Factor*							Total Score
	A	B	C	D	E	F	G	
	20	18	16	14	12	10	10	100
Meatball								
garlic mutton meatball	10	12	10	7	7	6	8	60
pepper mutton meatball	10	12	10	7	7	6	8	60
satay flavoured mutton meatball	12	12	12	5	8	6	7	62
smoked mutton meatball	15	13	13	6	10	6	7	70
liquid smoked mutton meatball	15	13	13	5	10	6	8	70
Dried Mutton								
satay flavoured and dried mutton	14	16	13	4	10	8	7	72
spiced and dried mutton	15	16	14	4	10	8	7	74
mutton stick	13	14	12	6	9	8	7	69
Sausage								
spiced mutton sausage	14	13	12	8	8	6	8	69
texturised vegetable protein and mutton sausage (smoked)	13	13	12	6	8	6	6	64
liver and mutton sausage (spiced and smoked)	14	13	12	9	7	6	6	67

Appendix 3.8 (continued)

smoked mutton sausage	16	13	13	6	8	6	7	69
liquid smoked mutton sausage	16	13	13	5	8	6	8	69

* Factor
A - suitable sensory attributes
B - acceptable storage life
C - export market potential
D - retail price in Thai supermarkets
E - fit into eating habits
F - convenience
G - ease of processing and packaging

Appendix 3.9 Formulations and methods for preparation of the meat patties used in the triangle test

Formulation	Beef (g)	Mutton (g)	Salt (g)
100% beef (standard)	1000	0	24
100% mutton	0	500	12
25% beef + 75% mutton	125	375	12
50% beef + 50% mutton	250	250	12

Methods for preparation of the meat patties were as follows:

Mincing of trimmed mutton or beef through a Bauknecht mincer (model AL21) with a 10 mm perforated plate

↓

mixing of mutton and/or beef together with salt by a Kenwood Chef (model A701A)

↓

forming into patties manually

↓

pan frying at 165 °C for 3 min

Appendix 3.10 Formulations of the meat patties to study the effects of spices using the triangle test

Formulation	Beef (g)	Mutton (g)
25% beef + 75% mutton	120	360
50% beef + 50% mutton	240	240

Ingredients used for each formulation were as follows:

sugar	28.80 g
salt	5.76 g
allspice	1.64 g
coriander	3.00 g
fennel	3.00 g
garlic	1.64 g
ginger	1.64 g
soy sauce	14.40 g

Appendix 3.11 Formulations used to investigate the effects of mutton fat and beef fat on sensory attributes and acceptability of the three products

Based on 1 kilogram of the total meat (mutton and beef) weight, the following ingredients were used in each formulation of the products:

Meatball

ice	200 g
salt	30 g
sugar	10 g
tapioca starch	10 g
white pepper	10 g
garlic	10 g
tetrasodium pyrophosphate	4 g

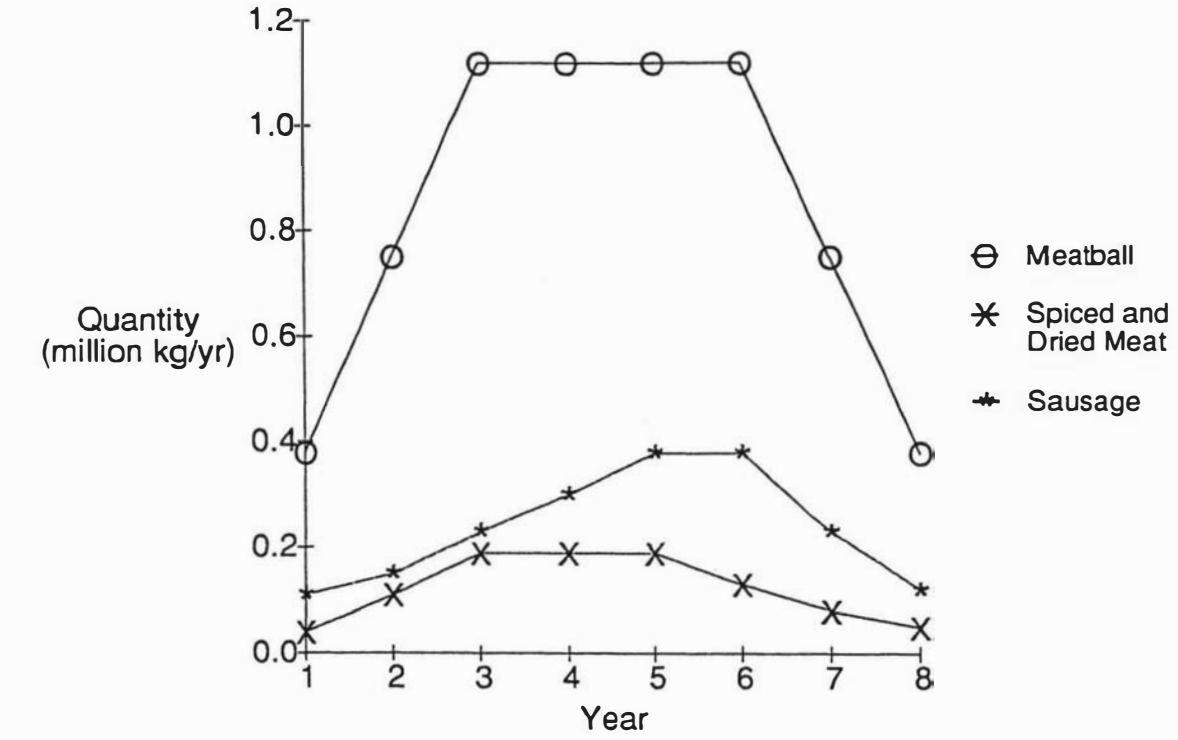
Sausage

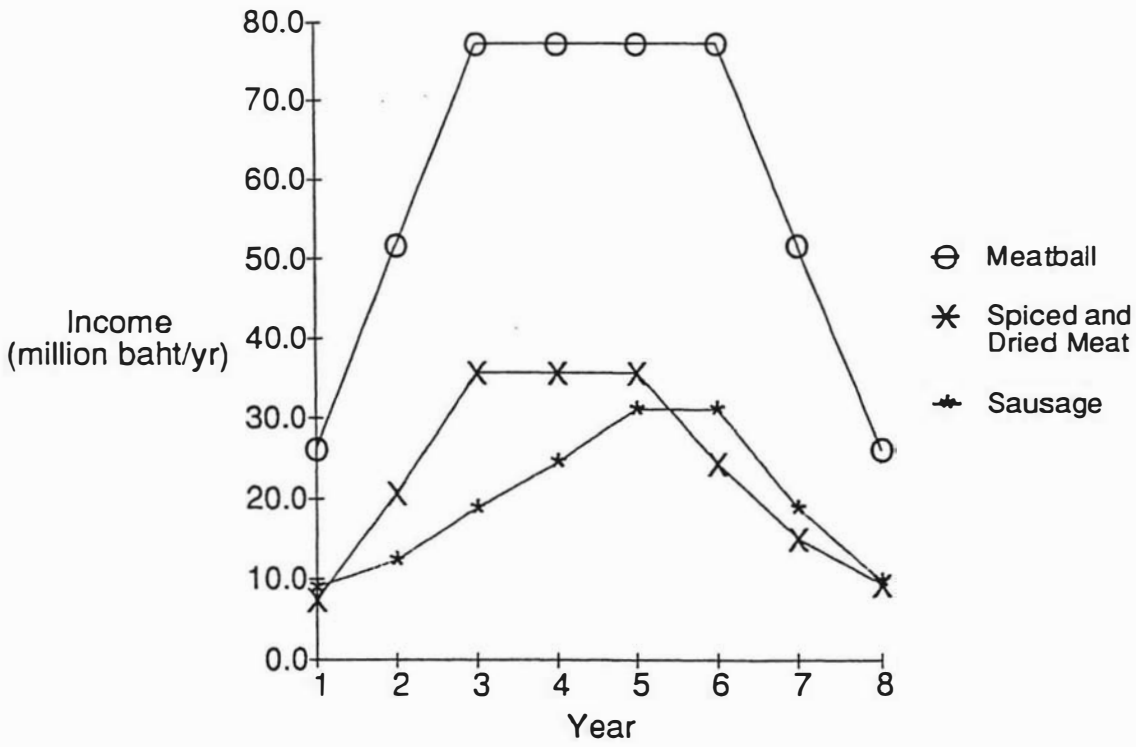
ice	300.0 g
salt	20.0 g
sugar	15.0 g
corn flour	10.0 g
sodium caseinate	10.0 g
white pepper	7.0 g
garlic	1.5 g
mace	1.5 g
nutmeg	0.5 g
sodium nitrite	0.1 g
sodium ascorbate	0.3 g
tetrasodium pyrophosphate	1.0 g

Spiced and Dried Meat

sugar	75.00 g
salt	12.50 g
allspice	2.50 g
coriander	3.75 g
fennel	3.75 g
garlic	1.00 g
ginger	1.00 g
soy sauce	20.00 g

Appendix 3.12 Estimated annual sales potential of the three screened mutton-based processed meat products





Appendix 3.13 Cash outfow and cash inflow over eight years of the three screened mutton-based processed meat products

Meatball

Year	Cash Outflow (baht)				Cash Inflow		
	Research and Dev.Cost	Fixed Capital Cost	Working Capital Cost	Sales Qty. (million kg)	Sales Revenue (million baht)	Total Product Cost (baht)	Net Revenue (baht)
0	216429	1094118					
1			193080	0.38	26.22	23940000	2280000
2				0.75	51.75	47250000	4500000
3				1.12	77.28	70560000	6720000
4				1.12	77.28	70560000	6720000
5				1.12	77.28	70560000	6720000
6				1.12	77.28	70560000	6720000
7				0.75	51.75	47250000	4500000
8				0.38	26.22	23940000	2280000

Spiced and dried meat

Year	Cash Outflow (baht)				Cash Inflow		
	Research and Dev. Cost	Fixed Capital Cost	Working Capital Cost	Sales Qty. (million kg)	Sales Revenue (million baht)	Total Product Cost (baht)	Net Revenue (baht)
0	216429	1023529					
1			180623	0.04	7.52	6840000	680000
2				0.11	20.68	18810000	1870000
3				0.19	35.72	32490000	3230000
4				0.19	35.72	32490000	3230000
5				0.19	35.72	32490000	3230000
6				0.13	24.44	22230000	2210000
7				0.08	15.04	13680000	1360000
8				0.05	9.40	8550000	850000

Appendix 3.13 (continued)

Sausage

Year	Cash Outflow (baht)				Cash Inflow		
	Research and Dev. Cost	Fixed Capital Cost	Working Capital Cost	Sales Qty. (million kg)	Sales Revenue (million baht)	Total Product Cost (baht)	Net Revenue (baht)
0	216429	1082353					
1			191003	0.11	9.02	8250000	770000
2				0.15	12.30	11250000	1050000
3				0.23	18.86	17250000	1610000
4				0.30	24.60	22500000	2100000
5				0.38	31.16	28500000	2660000
6				0.38	31.16	28500000	2660000
7				0.23	18.86	17250000	1610000
8				0.12	9.84	9000000	840000

Appendix 3.14 Net present value of the three screened mutton-based processed meat products at 16% rate of interest

Meatball

Year	0	1	2	3	4	5	6	7	8	Total
Investment cash flow	1,310,547	193,080								
Present value factor	1.0000	0.8621								
Investment present value	1,310,547	166,454								1,477,001
Revenue from sales		26,220,000	51,750,000	77,280,000	77,280,000	77,280,000	77,280,000	51,750,000	26,220,000	
Total product costs		23,940,000	47,250,000	70,560,000	70,560,000	70,560,000	70,560,000	47,250,000	23,940,000	
Profit before tax		2,280,000	4,500,000	6,720,000	6,720,000	6,720,000	6,720,000	4,500,000	2,280,000	
Tax at 50%		1,140,000	2,250,000	3,360,000	3,360,000	3,360,000	3,360,000	2,250,000	1,140,000	
Profit after tax		1,140,000	2,250,000	3,360,000	3,360,000	3,360,000	3,360,000	2,250,000	1,140,000	
Present value factor		0.8621	0.7432	0.6407	0.5523	0.4761	0.4104	0.3538	0.3050	
Earning present value		982,794	1,672,200	2,152,752	1,855,728	1,599,696	1,378,944	796,050	347,700	10,785,864
Net present value										9,308,863

Appendix 3.14(continued)

Spiced and dried meat

Year	0	1	2	3	4	5	6	7	8	Total
Investment cash flow	1,239,958	180,623								
Present value factor	1.0000	0.8621								
Investment present value	1,239,958	155,715								1,395,673
Revenue from sales		7,520,000	20,680,000	35,720,000	35,720,000	35,720,000	24,400,000	15,040,000	9,400,000	
Total product costs		6,840,000	18,810,000	32,490,000	32,490,000	32,490,000	22,230,000	13,680,000	8,550,000	
Profit before tax		680,000	1,870,000	3,230,000	3,230,000	3,230,000	2,210,000	1,360,000	850,000	
Tax at 50%		340,000	935,000	1,615,000	1,615,000	1,615,000	1,105,000	680,000	425,000	
Profit after tax		340,000	935,000	1,615,000	1,615,000	1,615,000	1,105,000	680,000	425,000	
Present value factor		0.8621	0.7432	0.6407	0.5523	0.4761	0.4104	0.3538	0.3050	
Earning present value		293,114	694,892	1,034,731	891,965	768,902	453,492	240,584	129,625	4,507,305
Net present value										3,111,632

Appendix 3.14(continued)

Sausage

Year	0	1	2	3	4	5	6	7	8	Total
Investment cash flow	1,298,782	191,003								
Present value factor	1.0000	0.8621								
Investment present value	1,298,782	164,664								1,463,446
Revenue from sales		9,020,000	12,300,000	18,860,000	24,600,000	31,160,000	31,160,000	18,860,000	9,840,000	
Total product costs		8,250,000	11,250,000	17,250,000	22,500,000	28,500,000	28,500,000	17,250,000	9,000,000	
Profit before tax		770,000	1,050,000	1,610,000	2,100,000	2,660,000	2,660,000	1,610,000	840,000	
Tax at 50%		385,000	525,000	805,000	1,050,000	1,330,000	1,330,000	805,000	420,000	
Profit after tax		385,000	525,000	805,000	1,050,000	1,330,000	1,330,000	805,000	420,000	
Present value factor		0.8621	0.7432	0.6407	0.5523	0.4761	0.4104	0.3538	0.3050	
Earning present value		331,909	390,180	515,764	579,915	633,213	545,832	284,809	128,100	3,409,722
Net present value										1,946,276

Appendix 3.15 Proximate composition of vienna, cocktail sausages and meatballs

Product	Protein (%)	Fat (%)	Moisture (%)	Salt (as % NaCl)	$NaNO_2$ (mg/kg)	$NaNO_3$ (mg/kg)
Vienna	13.6 - 15.7	17.4 - 26.5	53.6 - 59.4	1.07 - 1.25	3.02 - 64.16	42.23 - 182.09
Cocktail	12.5 - 15.6	19.7 - 26.8	51.8 - 58.9	1.00 - 1.09	34.99 - 65.42	24.10 - 145.18
Meatball *	15.3 - 17.7	2.8 - 3.6	73.3 - 74.9	1.52 - 1.88	nd	nd

nd = not determined ($NaNO_2$ and $NaNO_3$ are not common ingredients in commercial meatballs).

* = determined at Department of Food Technology, Chulalongkorn University.

Source: Other figures were summarised from analyses by Department of Medical Science, Ministry of Public Health, 1984.

Appendix 5.1 Sensory evaluation questionnaire for the meatballs

Name _____

Date _____

You have received _____ (no.) meatball samples. Please test the samples in the following sequence _____ (sequence of the random three digit coded samples given) and fill in details related to sensory characteristics of the samples. Please consider carefully only for the characteristics given; do not consider flavour, colour, appearance or other sensory characteristics.

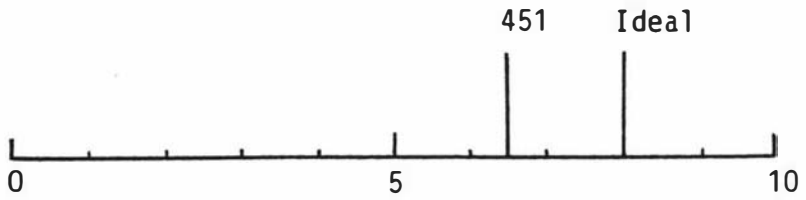
1. If the following characteristics and scores are given:

	Score
extremely soft, extremely gritty, extremely not rubbery, extremely dry, extremely not oily	1
very soft, very gritty, very not rubbery very dry, very not oily	2
moderately soft, moderately gritty, moderately not rubbery, moderately dry, moderately not oily	3
slightly soft, slightly gritty, slightly not rubbery, slightly dry, slightly not oily	4
slightly firm, slightly smooth, slightly rubbery, slightly juicy, slightly oily	5
moderately firm, moderately smooth, moderately rubbery, moderately juicy, moderately oily	6
very firm, very smooth, very rubbery, very juicy, very oily	7
extremely firm, extremely smooth, extremely rubbery, extremely juicy, extremely oily.	8

If you have perceived that the sample is extremely juicy, you should give a score of 8; but that the sample is extremely dry, you should give a score of 1.

Appendix 5.1 (continued)

2. Please mark a vertical line across a horizontal line at the point which best reflects your perception of each characteristic comparing it with the ideal score given. See the example below.



extremely soft extremely firm

The following description is given for each sensory characteristic you are required to assess:

firmness - a textural property manifested by a resistance to deformation by applied force during mastication.

smoothness - a textural property manifested by an absence of detectable solid particles during mastication.

rubberiness - a textural property manifested by a tendency to recover from deformation after removal of the deforming force.

juiciness - a textural property producing the sensation of a progressive increase in the free fluids in the oral cavity during mastication.

oiliness - a textural property producing the sensation of the presence of thin immiscible liquid in the oral cavity.

Please test all samples in the sequence given above and fill in the following questions:

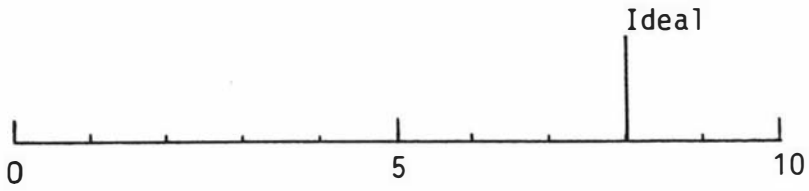
A firmness

A.1 Give the score as explained in 1.

Sample	Score
_____	_____
_____	_____
_____	_____

Appendix 5.1 (continued)

A.2 Mark a vertical line as explained in 2.



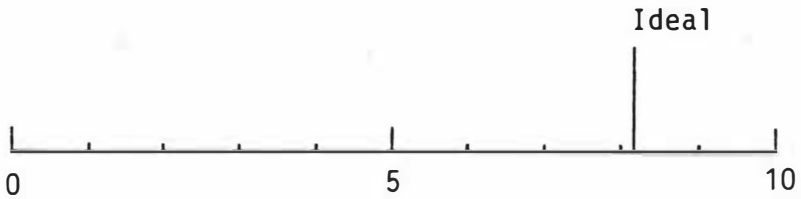
extremely soft extremely firm

B smoothness

B.1

Sample	Score

B.2



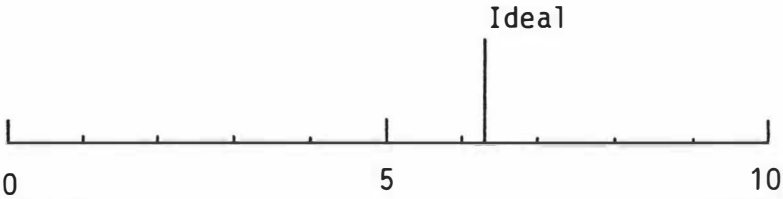
extremely gritty extremely smooth

C rubberiness

C.1

Sample	Score

C.2



extremely not rubbery extremely rubbery

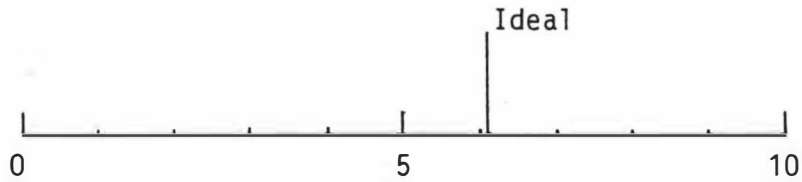
Appendix 5.1 (continued)

D juiciness

D.1

Sample	Score
_____	_____
_____	_____
_____	_____

D.2



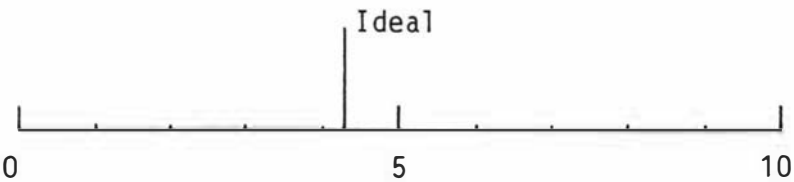
extremely dry — extremely juicy

E oiliness

E.1

Sample	Score
_____	_____
_____	_____
_____	_____

E.2



extremely not oily — extremely oily

Comments: _____

_____

_____

_____

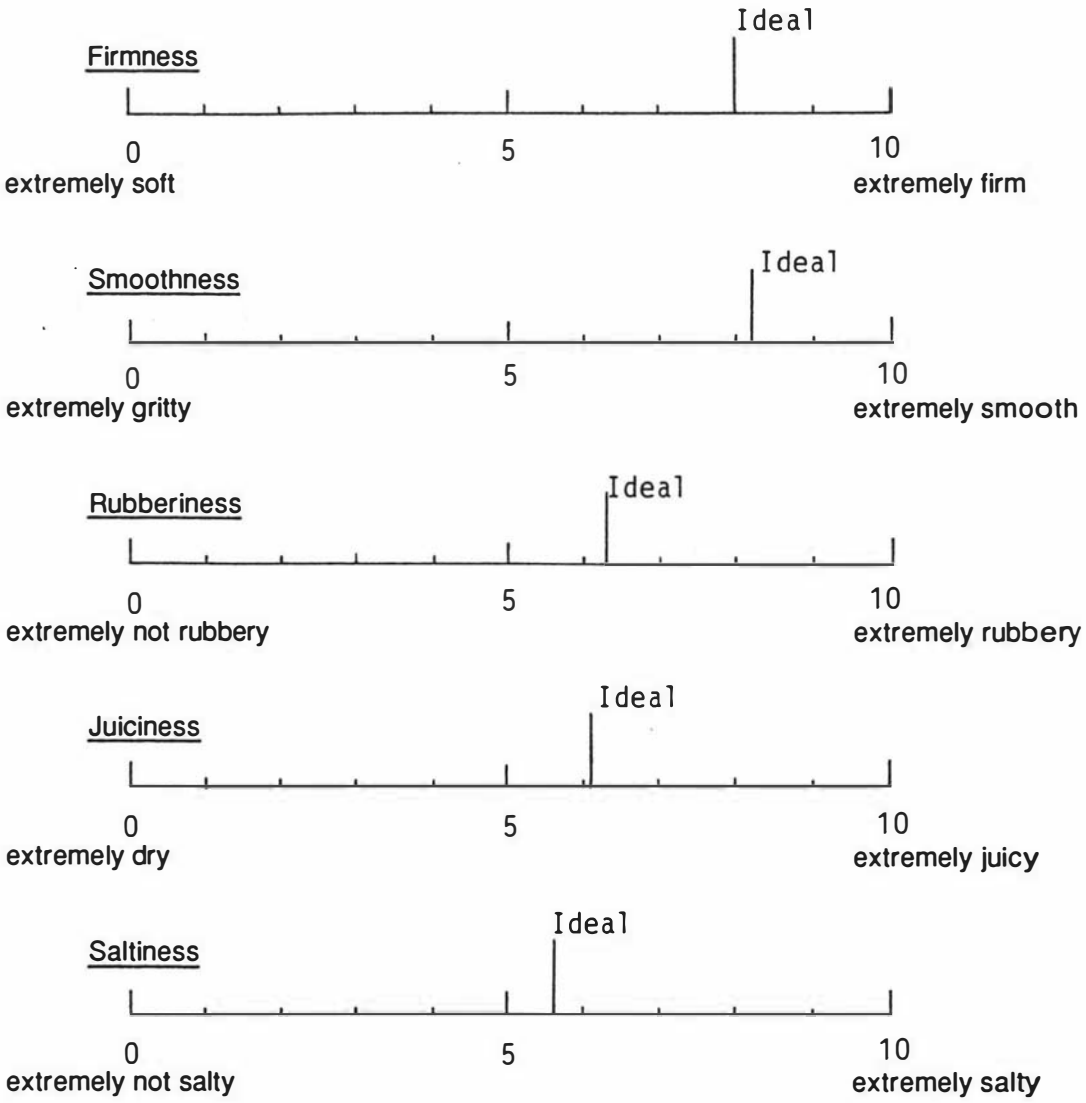
Appendix 6.1 A questionnaire used in sensory evaluation of the meatballs with tapioca starch, salt and sodium tripolyphosphate

Sensory Evaluation Questionnaire

Name _____

Date _____

You have received _____ (no.) meatball samples. Please test the samples in the following sequence _____ (sequence of the random three digit coded samples given) and mark a vertical line across a horizontal line at the point which best reflects your perception of each characteristic of the samples comparing it with the ideal score given. For muttoniness, you are also required to give your own ideal score.



Appendix 6.1 (continued)

Muttoniness

0 5 10

extremely not muttony extremely muttony

Comments: _____

_____

_____

_____

Appendix 6.2 Ideal ratio scores for sensory attributes of the meatballs as affected by tapioca starch, salt and STPP contents (1)

Attribute	Treatment (2)							
	1	2	3	4	5	6	7	8
firmness	0.55 ± 0.06^{a}	0.54 ± 0.04^{a}	0.89 ± 0.03^{b}	0.91 ± 0.02^{b}	0.54 ± 0.05^{a}	0.55 ± 0.02^{a}	0.88 ± 0.07^{b}	0.88 ± 0.01^{b}
smoothness	0.64 ± 0.04^{a}	0.68 ± 0.08^{a}	0.95 ± 0.01^{b}	0.94 ± 0.01^{b}	0.59 ± 0.01^{a}	0.62 ± 0.03^{a}	0.93 ± 0.01^{b}	0.95 ± 0.0^{b}
rubberiness	0.55 ± 0.03^{a}	0.51 ± 0.02^{a}	0.93 ± 0.02^{b}	0.99 ± 0.04^{b}	0.51 ± 0.0^{a}	0.56 ± 0.02^{a}	0.96 ± 0.02^{b}	0.98 ± 0.04^{b}
juiciness	1.12 ± 0.05^{ab}	1.13 ± 0.08^{b}	1.00 ± 0.05^{ab}	0.95 ± 0.03^{a}	1.07 ± 0.01^{ab}	1.01 ± 0.02^{ab}	0.97 ± 0.02^{ab}	0.96 ± 0.01^{ab}
saltiness	0.64 ± 0.02^{a}	0.63 ± 0.02^{a}	1.06 ± 0.0^{b}	1.05 ± 0.0^{b}	0.68 ± 0.03^{a}	0.65 ± 0.01^{a}	1.04 ± 0.01^{b}	1.00 ± 0.01^{b}
muttoniness	4.75 ± 0.17^{c}	4.52 ± 0.19^{c}	2.88 ± 0.07^{b}	2.95 ± 0.05^{b}	2.98 ± 0.08^{b}	3.25 ± 0.09^{b}	2.09 ± 0.17^{a}	2.22 ± 0.21^{a}

(1) The scores were given by eight Thai panelists. Values are means ± standard errors of the means between two replications. Any two means within the same row possessing one of the same letters in the superscripts are not significantly different at $p \leq 0.05$.

(2) Refer to Table 6.1 for each treatment formulation.

Appendix 6.3 Objective test values for the meatballs as affected by tapioca starch, salt and STPP contents (1)

Objective Test	Treatment (2)							
	1	2	3	4	5	6	7	8
pH before cooking	6.19 ± 0.0^{c}	6.20 ± 0.0^{d}	6.16 ± 0.0^{a}	6.17 ± 0.0^{b}	6.35 ± 0.0^{g}	6.36 ± 0.0^{h}	6.33 ± 0.0^{e}	6.34 ± 0.0^{f}
pH after cooking	6.45 ± 0.0^{c}	6.46 ± 0.01^{c}	6.30 ± 0.0^{a}	6.32 ± 0.01^{b}	6.51 ± 0.0^{e}	6.51 ± 0.0^{e}	6.48 ± 0.0^{d}	6.49 ± 0.0^{d}
cook yield (%)	92.6 ± 0.01^{a}	97.0 ± 0.37^{bc}	97.9 ± 0.29^{cd}	98.9 ± 0.5^{de}	96.7 ± 0.35^{b}	99.0 ± 0.15^{de}	99.2 ± 0.35^{e}	99.7 ± 0.05^{e}
compression force (N)	10.97 ± 0.55^{a}	12.87 ± 0.06^{b}	21.56 ± 0.05^{e}	28.26 ± 0.55^{g}	15.16 ± 0.0^{c}	18.62 ± 0.23^{d}	24.77 ± 0.45^{f}	32.30 ± 0.37^{h}
compression slope (N/mm)	1.70 ± 0.03^{a}	1.92 ± 0.05^{a}	3.59 ± 0.02^{d}	3.97 ± 0.04^{e}	2.22 ± 0.11^{b}	2.71 ± 0.09^{c}	3.70 ± 0.02^{d}	4.71 ± 0.01^{f}
W-B shear force (N)	6.20 ± 0.05^{a}	8.13 ± 0.11^{b}	11.09 ± 0.0^{d}	12.50 ± 0.31^{e}	8.68 ± 0.03^{b}	9.71 ± 0.13^{c}	12.37 ± 0.13^{e}	14.25 ± 0.03^{f}
W-B shear slope (N/mm)	0.45 ± 0.02^{a}	0.55 ± 0.01^{b}	0.69 ± 0.01^{d}	0.77 ± 0.0^{e}	0.56 ± 0.02^{b}	0.62 ± 0.01^{c}	0.65 ± 0.02^{cd}	0.75 ± 0.01^{e}
initial yield force (N)	11.31 ± 0.58^{a}	12.40 ± 0.11^{a}	54.17 ± 0.21^{d}	62.09 ± 0.42^{f}	19.19 ± 0.13^{b}	22.40 ± 0.11^{c}	58.65 ± 0.32^{e}	68.23 ± 0.31^{g}

(1) Values are means ± standard errors of the means between two replications. Any two means within the same row bearing one of the same letters in the superscripts are not significantly different at $p \leq 0.05$.

(2) Refer to Table 6.1 for each treatment formulation.

Appendix 7.1 Descriptions of the spices used in the experiments

The descriptions of some spices used in the experiments as described by Farrell (1985) are as follows:

Pepper (Piper nigrum Linn), either white or black, comes from the same climbing, perennial vine. The white pepper is the dried kernels of the fruits which are gathered after having just turned slightly yellow, whereas the black pepper kernels are picked while still immature and green. White pepper is much less pungent than black pepper but of finer flavour with less harshness. Black pepper or one of its extractives is used in practically all meat seasonings, like those for bologna, frankfurter, fresh pork sausage, pepperoni, salami, pressed ham, meat loaf, meatballs.

Garlic (Allium sativum Linn) is a small, hardy, perennial, bulbous plant of the Amaryllidaceae family, closely allied to the common onion. Garlic is almost odourless until its tissue becomes abraded or cut, at which time, the enzymes react very quickly to produce allicin (C_3H_5-S-S-C_3H_5) and this breaks down to allyl disulfide, the characteristic odour of garlic. Dehydrated garlic powder, or one of its many commercial forms like diced, minced, or granulated, has a very strong, persistent aroma and taste. Dehydrated garlic is used extensively in condiments and meat seasonings. It should be used with extreme caution because of its intense odour and disagreeable taste when used excessively.

Onion (Allium cepa Linn) is a biennial plant of the Amaryllidaceae family. Onion contains a volatile oil, fixed oil, protein, cellulose, sugars, minerals, etc. Dehydrated onion is used commercially in a great many prepared meat seasonings, such as German bologna, bologna, frankfurter, meat loaf, meatballs.

Coriander (Coriandrum sativum Linn) is a strong, odiferous, hardy annual plant of the parsley family. The round coriander fruit is brownish-yellow in colour and about 4 mm in diameter with straight and curving indistinct ridges. The flavour resembles a mixture of caraway, cumin, sage and lemon peel. The flavour could also be described as warm, spicy, aromatic, sweet, fruity, slightly balsamic, roselike with a pleasant fruity aftertaste. Coriander in one of its forms has been used commercially as meat seasonings for bologna, frankfurter, liver sausage, pork luncheon meat and Polish sausage.

Appendix 7.1 (continued)

Fennel (Foeniculum vulgare Miller) is a pleasantly scented perennial herb whose fruits or seeds are greenish-yellow-brown, varying in size up to 1 cm long, laterally compressed, slightly curved, oval in shape with five ridges and a large single resin canal under each furrow. The aroma of fennel resembles anise or licorice but with a slight camphoraceous note. The flavour is similarly licorice-like, sweet with a slightly bitter aftertaste. Fennel seed or one of its extractives is used commercially in seasonings for prepared meats such as pepperoni, hot Italian sausage and sweet Italian sausage.

Sesame (Sesamum indicum Linn) is an annual herb whose fruits are four-sided, oblong shape pods, containing small, creamy-white seeds, varying in size up to 3.5 mm in length and shaped like a compressed oval. The aroma is faintly nutty, as is the flavour, but these attributes are accentuated after the seeds are baked or toasted, at which time they take on a delicate, almond-like flavour and aroma. The fixed oil content of sesame seed ranges from 45 to 65%. It resists oxidative rancidity. Sesame seed contains no perceptible volatile oil.

Ginger (Zingiber officinale Roscoe) is the lilylike, herbaceous plant which bears stems up to 120 cm tall. The plant propagates by the splitting of the rhizomes. The rhizomes are irregular, varying from tan to pale brown in colour, have an agreeable, aromatic, slightly pungent odour and a pungent biting taste. The use of freshly ground ginger will add zest to almost any sweet meat, seafood or poultry dish. Chinese chefs use it often since they learn from their ancestors that a little ginger enhances even the most insipid dish. The spice goes well in oriental dishes and on most meats and marinades for beef, lamb, pork, veal, poultry and fish. Ginger has a tendency to round out some flavours while at the same time accenting others; it contributes a freshness to foods which other spices do not.

Appendix 7.2 A questionnaire used for sensory evaluation in a Plackett and Burman design experiment

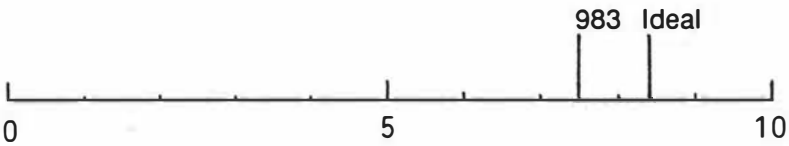
Sensory Evaluation Questionnaire (Translated from Thai)

Name _____

Date _____

You have received _____ (No.) meatball samples coded with _____ _____ (a sequence of random three digit coded samples given).

You are required to mark a vertical line across a horizontal line scale comparing each characteristic with the ideal score given as shown in the following example.



extremely lacking desirable flavour and aroma

extremely having desirable flavour and aroma

Suggestions for characteristics are as follows:

1. Desirable Flavour and Aroma

A characteristic which the meatballs should have and by which you may consider flavour and aroma of spices or any pleasant flavour and aroma you like.

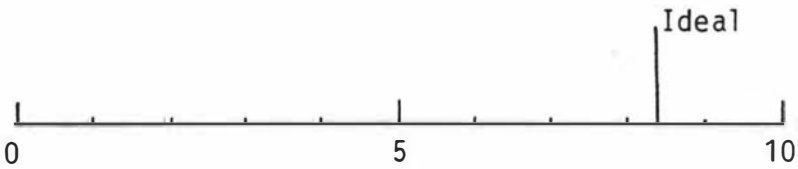
2. Undesirable Flavour and Aroma

A characteristic which the meatballs should not have and by which you may consider presence and extent of unfamiliar or unpleasant flavour and aroma.

Appendix 7.2 (continued)

Please test all samples and fill in the following questions.

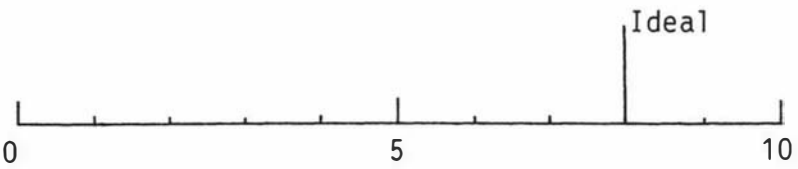
Desirable flavour and aroma



extremely lacking desirable flavour and aroma

extremely having desirable flavour and aroma

Undesirable flavour and aroma



extremely having undesirable flavour and aroma

extremely lacking undesirable flavour and aroma

Comments: _____

_____

_____

_____

Appendix 7.3 A questionnaire used for sensory evaluation in the fractional factorial experiment

Sensory Evaluation Questionnaire (Translated from Thai)

Name _____

Date _____

You have received _____ (No.) meatball samples coded with _____ _____ (a sequence of random three digit coded samples given). Please test the samples by firstly smelling, then eating and give the acceptability score for each characteristic in the following sequence.

1. Aroma Acceptability

When you smell the sample, decide how much each sample is acceptable for its aroma.

2. Texture Acceptability

When you bite and masticate until the sample is ready for swallowing, decide how much each sample is acceptable for its texture.

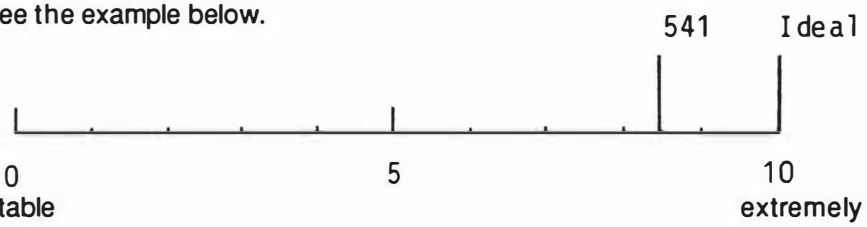
3. Flavour Acceptability

When you bite, masticate and swallow the sample, decide how much each sample is acceptable for its flavour.

4. Overall Acceptability

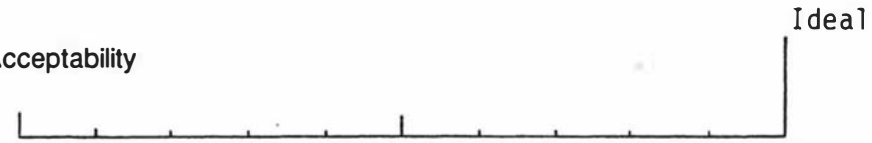
When you decide by considering all the characteristics above together, how much each sample is acceptable.

When you have tested the samples, please mark a vertical line across a horizontal line scale at the point which best reflects your impression for each sensory attribute acceptability; taking into account that 0 (zero) is an 'unacceptable' point and 10 is an 'extremely acceptable' point and the 'Ideal' score for each characteristic locates here. Please see the example below.



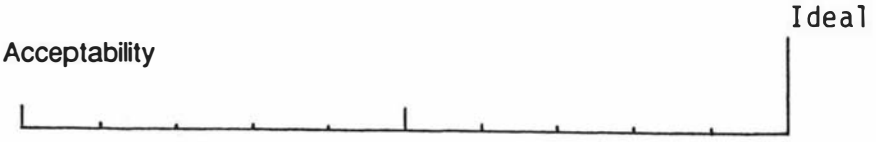
Appendix 7.3 (continued)

Aroma Acceptability



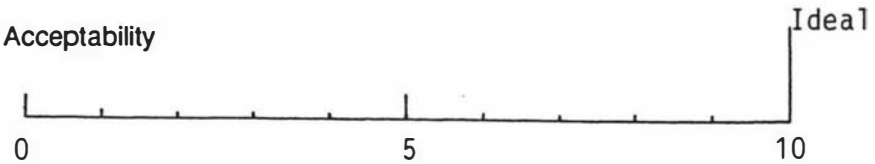
unacceptable extremely acceptable

Texture Acceptability



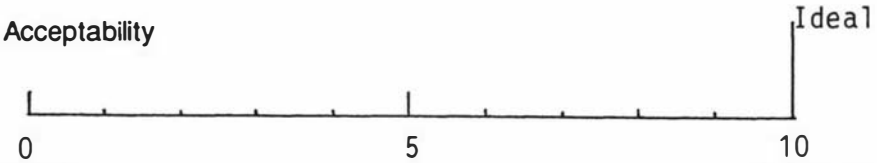
unacceptable extremely acceptable

Flavour Acceptability



unacceptable extremely acceptable

Overall Acceptability



unacceptable extremely acceptable

Comments: _____

_____

_____

_____

Appendix 7.4 A questionnaire used for a household consumer panel
(Translated from Thai)

I am developing meatballs which are a new product. These meatballs are designed for sale in Thailand and we would like the opinions of the Thais on these products. However, all members of your household are welcomed to test the products but only those who are Thais are required to fill in the questionnaires. I have three samples of meatballs for you to test and I should like you to tell us which product(s) you think would be suitable for sale in Thailand.

You will have approximately 2 weeks to test these three samples. Therefore, take your time to prepare and test them. I would like to remind you that you are requested to test each sample separately and in the order _____, _____, _____.

Please read the questionnaire carefully before you start cooking the meatballs.

Instruction:
Please cook meatballs (as many balls as you like) from each coded sample (only one sample at one time) by frying in new cooking oil until they are well cooked and their outer colour is golden brown. Make sure you cook each sample in exactly the same manner as you do for the others, e.g. use identical cooking time. Then eat the meatballs with your usual meal. After you have finished eating, please complete the questionnaire. Tell us your degree of liking/disliking for the appearance, aroma, texture, flavour and overall liking of each sample by marking ✓ in ☐ provided. Also your comments are invited. They will be useful to us in making the ideal products for Thais.

Use the yellow questionnaire for sample No. _____
blue questionnaire for sample No. _____
pink questionnaire for sample No. _____

Keep in mind that you are the judge and are the only one who can tell what you like. An honest expression of your personal feeling will help us to decide.

Thank you very much in advance for your kind co-operation.

Contents in each coloured questionnaire
Sample No. _____

Appendix 7.4 (continued)

Marking √ in ☐ provided in order to express your degree of liking/disliking for each of the following characteristics for this sample.

1. Liking of Appearance

could not be better	☐
like very much	☐
like moderately	☐
neither like nor dislike	☐
dislike moderately	☐
dislike very much	☐
could not be worse	☐

Comments: _____

2. Liking of Aroma

could not be better	☐
like very much	☐
like moderately	☐
neither like nor dislike	☐
dislike moderately	☐
dislike very much	☐
could not be worse	☐

Comments: _____

3. Liking of Texture

could not be better	☐
like very much	☐
like moderately	☐
neither like nor dislike	☐
dislike moderately	☐
dislike very much	☐
could not be worse	☐

Comments: _____

Appendix 7.4 (continued)

4. Liking of Flavour

could not be better	☐
like very much	☐
like moderately	☐
neither like nor dislike	☐
dislike moderately	☐
dislike very much	☐
could not be worse	☐

Comments: _____

5. Overall Liking

could not be better	☐
like very much	☐
like moderately	☐
neither like nor dislike	☐
dislike moderately	☐
dislike very much	☐
could not be worse	☐

Comments: _____

6. Willingness of Purchasing

Considering everything, would you buy the sample?

definitely would buy	☐
probably would buy	☐
might or might not buy	☐
probably would not buy	☐
definitely would not buy	☐

7. Other comments:_____

General Questions (in a separated sheet)

8. Did you have any difficulties in preparing the meatball samples?

Yes ☐ No ☐

If Yes, please state what the difficulties were (use space provided below).

_____

_____

Appendix 7.4 (continued)

9. What other methods do you think could be used to prepare for consumption the meatball samples you have tested?

_____

_____

10. Personal Data

10.1 Name _____

10.2 Sex Male ☐ Female ☐

10.3 Age Group ☐ 10-14 ☐ 15-20 ☐ 21-30
☐ 31-40 ☐ 41-50 ☐ >50

10.4 Occupation (fill in the first and/or second space(s) if applied)

in New Zealand _____

in Thailand _____

10.5 Time in New Zealand _____ years _____ months

Appendix 9.1 A questionnaire used for hedonic rating in a home use test

Sensory Evaluation Form (Translated from Thai)

Please eat this sample; a new product which contains meats and other ingredients and has sensory characteristics different from local meatballs. You are required to give your perception of sensory characteristics of the sample by answering the following questions.

For Question 1, please mark √ in only one ☐ provided to express your degree of liking/disliking for each sensory characteristic of the product.

There are a number of sensory characteristics you will evaluate. They are:

* Liking of Appearance: This characteristic is reflected by how much you like the product by consideration of what you can evaluate by your eyesight, e.g. size, shape, and colour.

* Liking of Aroma: This characteristic is reflected by how much you like, by sniffing through your nose, the aroma or smell of the product.

* Liking of Texture: This characteristic is reflected by how much you like the product by consideration of what you perceive in your mouth starting from cutting, masticating until swallowing it.

* Liking of Flavour: This characteristic is reflected by how much you like the product by consideration of what you perceive, including taste and smell, in your oral cavity.

* Overall Liking: This characteristic is reflected by how much you like the product by overall consideration of all above characteristics.

Please be careful that you evaluate all characteristics of the product.

Appendix 9.1 (continued)

1. Sensory Characteristics

1.1 Liking of Appearance

- ☐ like very much
- ☐ like moderately
- ☐ like slightly
- ☐ neither like nor dislike
- ☐ dislike slightly
- ☐ dislike moderately
- ☐ dislike very much

1.2 Liking of Aroma

- ☐ like very much
- ☐ like moderately
- ☐ like slightly
- ☐ neither like nor dislike
- ☐ dislike slightly
- ☐ dislike moderately
- ☐ dislike very much

1.3 Liking of Texture

- ☐ like very much
- ☐ like moderately
- ☐ like slightly
- ☐ neither like nor dislike
- ☐ dislike slightly
- ☐ dislike moderately
- ☐ dislike very much

1.4 Liking of Flavour

- ☐ like very much
- ☐ like moderately
- ☐ like slightly
- ☐ neither like nor dislike
- ☐ dislike slightly
- ☐ dislike moderately
- ☐ dislike very much

Appendix 9.1 (continued)

1.5 Overall Liking

- ☐ like very much
- ☐ like moderately
- ☐ like slightly
- ☐ neither like nor dislike
- ☐ dislike slightly
- ☐ dislike moderately
- ☐ dislike very much

2. Personal Data

2.1 Sex: ☐ Male ☐ Female

2.2 Age Group: ☐ 10-12 ☐ 13-19 ☐ 20-40 ☐ >40

2.3 Career: ☐ school pupil ☐ college or university student ☐ government official ☐ private company ☐ state enterprise ☐ other (please specify) _____

Appendix 9.2 A supplementary questionnaire used in a home use test

A Questionnaire only for a Housewife (Translated from Thai)

1. Please remember that this product is not similar to local meatballs. The product is more specific or unique and made from very expensive and 'not-readily available' meat. The product has the outside skin. Taking these aspects into consideration, would you buy the product at the price (mark only one √).

☐ less than
☐ equal to
☐ greater than

the prices of processed meat products, i.e. meatballs, sausages, etc. which are sold locally.

2. Having considered all characteristics, please mark only one √ in a box provided below to express your willingness to purchase this product.

☐ definitely would buy
☐ probably would buy
☐ might or might not buy
☐ probably would not buy
☐ definitely would not buy

3. If this product is available for sale, at what places would you like it to be sold? You may mark more than one √.

☐ supermarkets
☐ restaurants
☐ fast food outlets
☐ street vendors
☐ canteens in schools, colleges, universities
☐ others, please specify_____

Appendix 9.2 (continued)

4. If you will buy this product, how often do you think you will buy it?
Mark only one √.

- ☐ more than once a week
- ☐ once a week
- ☐ once a fortnight
- ☐ once a month
- ☐ less than once a month

5. In what type of package do you think this product should be packed?
You may mark more than one √.

- ☐ transparent plastic bags
- ☐ plastic trays covered with transparent plastic film
- ☐ others, please specify_____

6. Regarding question 5, how many balls in one package do you think suitable? Mark only one √.

- ☐ 8 balls
- ☐ 10 balls
- ☐ 12 balls
- ☐ 16 balls
- ☐ 20 balls

7. When you buy this product, what information that you need to know should be shown on the label? You may mark more than one √.

- ☐ name and address of manufacturer
- ☐ manufacturer's country (if from an overseas country)
- ☐ net weight
- ☐ ingredients and their contents
- ☐ nutritional values
- ☐ expiry date
- ☐ others, please specify_____

Appendix 9.2 (continued)

8. What means of the following communication do you think suitable for promoting sales of this product? You may mark more than one √.

- ☐ personal conversation
- ☐ newspapers, magazines
- ☐ radios
- ☐ television
- ☐ others, please specify_____

9. When you and members of your household tested this product, did you use any types of sauces?

☐ Yes ☐ No

If yes, please specify it; i.e. tomato sauce, chilli sauce (Sriracha sauce), sweet and sour chilli sauce for charcoaled chicken, Maggi-like sauce, or others (please specify)

_____

10. Do you have any further suggestions or comments related to this product? Please explain.

_____

_____

_____

_____

Appendix 9.3 Frequencies of hedonic scores for four sensory characteristics of the developed meatballs

Appearance

Hedonic Score	Age Group: Children		Teenagers		Adults		Older People		Total Sample	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	3	3.2	0	0	3	1.5	2	2.0	8	1.6
2	0	0	1	1.2	5	2.4	2	2.0	8	1.6
3	4	4.2	8	9.7	9	4.3	6	5.9	27	5.5
4	12	12.6	25	30.1	59	28.2	24	23.8	120	24.6
5	12	12.6	14	16.9	45	21.5	17	16.8	88	18.0
6	40	42.1	29	34.9	69	33.0	37	36.6	175	35.9
7	24	25.3	6	7.2	19	9.1	13	12.9	62	12.8
Total	95	100.0	83	100.0	209	100.0	101	100.0	488	100.0

Aroma

Hedonic Score	Age Group: Children		Teenagers		Adults		Older People		Total Sample	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	2	2.1	1	1.2	7	3.3	1	1.0	11	2.3
2	2	2.1	1	1.2	5	2.4	1	1.0	9	1.8
3	4	4.2	11	13.3	21	10.1	10	9.9	46	9.4
4	11	11.6	15	18.1	36	17.2	25	24.7	87	17.8
5	10	10.5	12	14.4	51	24.4	23	22.8	96	19.7
6	35	36.9	26	31.3	61	29.2	31	30.7	153	31.4
7	31	32.6	17	20.5	28	13.4	10	9.9	86	17.6
Total	95	100.0	83	100.0	209	100.0	101	100.0	488	100.0

Appendix 9.3 (continued)

Texture

Hedonic Score	Age Group: Children		Teenagers		Adults		Older People		Total Sample	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	0	0	1	1.2	7	3.3	1	1.0	9	1.8
2	1	1.1	4	4.8	9	4.3	3	3.0	17	3.5
3	7	7.4	12	14.5	22	10.5	9	8.9	50	10.2
4	8	8.4	10	12.1	11	5.3	7	6.9	36	7.4
5	23	24.2	19	22.9	61	29.2	22	21.8	125	25.6
6	31	32.6	29	34.9	75	35.9	42	41.6	177	36.3
7	25	26.3	8	9.6	24	11.5	17	16.8	74	15.2
Total	95	100.0	83	100.0	209	100.0	101	100.0	488	100.0

Flavour

Hedonic Score	Age Group: Children		Teenagers		Adults		Older People		Total Sample	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	2	2.1	6	7.2	13	6.2	3	3.0	24	4.9
2	1	1.1	1	1.2	8	3.8	3	3.0	13	2.7
3	10	10.5	11	13.3	16	7.7	9	8.9	46	9.4
4	12	12.6	9	10.8	25	12.0	11	10.9	57	11.7
5	7	7.4	18	21.7	55	26.3	26	25.7	106	21.7
6	31	32.6	26	31.3	60	28.7	29	28.7	146	29.9
7	32	33.7	12	14.5	32	15.3	20	19.8	96	19.7
Total	95	100.0	83	100.0	209	100.0	101	100.0	488	100.0

Appendix 9.4 Estimation of sales potential of the developed meatballs

According to the official statistics, there were 393,176 households in the municipality of the Bangkok area.

Of this number, there were 33% which belonged to the middle and higher income classes.

Therefore, there were 0.33 x 393,176 = 129,748 households of target consumers.

According to the information given by the housewives, 47.8% of them would buy the product (refer to Table 9.10).

Therefore there were 0.478 x 129,748 = 62,020 households who would buy the product.

Assume that all these households would buy the product once a fortnight (from Tables 9.10 and 9.11).

Therefore, there were 2 x 62,020 = 124,040 purchases per month.

Assume that one purchase would be 10 balls. Therefore, there would be 10 x 124,040 = 1,240,400 balls purchased per month.

This was equal to $\frac{20 \times 1,240,400}{1,000}$ = 24,808 kg of product per month, i.e. 1 ball weighed approximately 20 g.

This quantity was roughly related to 0.75 x 24,808 = 18,606 kg of trimmed mutton per month which would be used as raw material, i.e. 75% of mutton in the formulation of the developed product. This figure might be regarded as the optimistic one.

However, if consider that only 23.5% of the households (refer to Table 9.9) were definite buyers, there were 0.235 x 129,748 = 30,490 households who would buy the product.

Assume that these households would buy the product once a week (from Table 9.11).

Therefore, there were 4 x 30,490 = 121,960 purchases per month.

Similarly, $\frac{20 \times 10 \times 121,960}{1,000}$ = 24,392 kg of product per month would be purchased.

This quantity was roughly related to 0.75 x 24,392 = 18,294 kg of trimmed mutton raw material per month.

Questionnaire Used in Consumer Test in Thailand

แบบสอบถามเกี่ยวกับผลิตภัณฑ์เนื้อสัตว์แปรรูป

เรียนท่านเจ้าของบ้าน

ข้าพเจ้า นาย นินนาท ชินประหัษฐ์ อาจารย์ภาควิชาเทคโนโลยีทางอาหาร คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย และกำลังศึกษาขั้นปริญญาเอกอยู่ ณ มหาวิทยาลัยแมสซี่ย์

ข้าพเจ้ากำลัง พัฒนา ผลิตภัณฑ์ เนื้อสัตว์ แปรรูป ชนิดใหม่ เพื่อจำหน่ายในประเทศไทย จึงขอทราบความคิดเห็น ของท่าน เกี่ยวกับผลิตภัณฑ์นี้ ในการนี้ สมาชิกทุกคนในบ้านของท่าน สามารถทดสอบผลิตภัณฑ์ได้ แต่ขอให้สมาชิก ที่มีอายุ อยู่ในช่วงกลุ่มอายุที่ต้องการเท่านั้น (มีกลุ่มอายุกำหนดอยู่ในแบบฟอร์มที่แนบมา) เป็นผู้กรอกแบบสอบถาม และสมาชิกในบ้านท่านเพียง 1 คน จากแต่ละกลุ่มอายุเท่านั้น (ถ้ามี) ที่จะเป็นผู้กรอก นอกจากนั้นขอให้ แม่บ้าน (ซึ่งโดยทั่วไปเป็น ภรรยา เจ้าของบ้าน) กรอกแบบสอบถามสัมภาษณ์ที่แนบมาให้ท่านอีก 1 ชุดด้วย แต่ถ้าท่านใส่ดก็ขอให้ท่านเป็นผู้กรอกเอง

โปรดศึกษาแบบสอบถามอย่างละเอียดรอบคอบก่อนที่จะเตรียมผลิตภัณฑ์เพื่อรับประทาน

* <u>คำอธิบาย</u> *

โปรดเตรียมผลิตภัณฑ์ (จำนวนมากน้อยตามชอบ แต่ขอให้เพียงพอกับจำนวนสมาชิกที่จะทดสอบผลิตภัณฑ์) โดยการทอดในน้ำมันท่วมอาหารที่ใหม่ๆ และใช้ไฟไม่แรงจนเกินไป จนกระทั่งผลิตภัณฑ์สุกทั่วถึงดี และสังเกตุจากสีผิวหน้าหลังทอด จากนั้นรับประทานผลิตภัณฑ์ที่ทอดแล้วนี้กับ อาหารมื้อใดๆ ก็ได้ที่ท่านรับประทานตามปกติ และถ้าท่านชอบ ก็อาจจะรับประทานผลิตภัณฑ์กับ น้ำซ้อสปรุงรสหรือ น้ำจิ้มชนิดใดก็ได้

ในเวลาที่ ผู้ทดสอบทุกคนรับประทานผลิตภัณฑ์อยู่ ก็ขอให้ กรอกแบบสอบถาม โดยตอบคำถามแต่ละข้ออย่างรอบคอบ สมาชิกแต่ละคนในครอบครัวของท่าน ซึ่งได้ทดสอบผลิตภัณฑ์ และมีอายุอยู่ในกลุ่มอายุตามเกณฑ์ที่กำหนด ๑ (ดังอธิบายข้างต้น) จะเป็นผู้กรอกแบบสอบถาม เพียงคน 1 ชุด ต่อ 1 คน

ท่านจะมีเวลาประมาณ ๔ สัปดาห์ ในการทดสอบและกรอกแบบสอบถาม ข้าพเจ้าจะรวบรวมแบบสอบถามทุกชุด กลับคืนในวันที่ ๒๓ พฤษภาคม ๒๕๓๐ ดังนั้นขอให้ใช้เวลาตามสบาย ภายใน ๒ สัปดาห์ ในการเตรียมและทดสอบผลิตภัณฑ์นี้

* <u>คำเตือน</u> *

โปรดระลึกว่า ถ้าท่านยังไม่ทดสอบทันที หลังจากที่ได้รับผลิตภัณฑ์ ก็ขอให้เก็บเอาไว้ในช่องน้ำแข็ง ในตู้เย็นของท่านก่อน เมื่อจะทดสอบจึงนำผลิตภัณฑ์มาทำให้ละลายก่อนนำมาทอด

ท่านสิ้นเปลืองเวลาของท่าน และสมาชิกในบ้านเพื่อทดสอบผลิตภัณฑ์ จะมีส่วนช่วยให้งานวิจัยของข้าพเจ้าบรรลุผลตามความมุ่งหมาย ข้าพเจ้าขอขอบพระคุณล่วงหน้า มา ณ โอกาสนี้

แบบประเมินผลทางประสาทสัมผัส

ขอให้ท่านรับประทานผลิตภัณฑ์นี้ ซึ่งเป็นผลิตภัณฑ์ใหม่ (ประกอบด้วยเนื้อและส่วนผสมอื่นๆ) ที่มีลักษณะทางประสาทสัมผัสแตกต่างจากผลิตภัณฑ์ลูกชิ้นที่มีขายในตลาดทั่วไป แล้วให้ความคิดเห็นเกี่ยวกับลักษณะต่างๆ ทางประสาทสัมผัสของผลิตภัณฑ์โดยตอบคำถามต่อไปนี้

สำหรับข้อ 1 โปรดทำเครื่องหมาย ✓ ใน □ (ทำเพียง 1 เครื่องหมายสำหรับลักษณะแต่ละอย่าง) เพื่อที่จะแสดงระดับความชอบ/ไม่ชอบที่ท่านมีต่อลักษณะแต่ละอย่างของผลิตภัณฑ์

ลักษณะทางประสาทสัมผัสที่ท่านจะทดสอบมีหลายลักษณะ ซึ่งอธิบายได้ดังนี้

ความชอบลักษณะปรากฏ หมายถึง ท่านชอบผลิตภัณฑ์โดยพิจารณารวมถึงสิ่งที่ท่านสามารถใช้ประสาทสัมผัสได้ทางสายตา เช่น ขนาด รูปร่าง สี มากน้อยเพียงใด

ความชอบกลิ่น หมายถึง ท่านชอบผลิตภัณฑ์โดยพิจารณากลิ่นที่ท่านรับได้ทางจมูกมากน้อยเพียงใด

ความชอบเนื้อสัมผัส หมายถึง ท่านชอบผลิตภัณฑ์โดยพิจารณารวมถึงความรู้สึกที่ท่านรับได้ในช่องปากตั้งแต่ท่านเคี้ยวจนกลืนผลิตภัณฑ์มากน้อยเพียงใด

ความชอบรสชาติ หมายถึง ท่านชอบผลิตภัณฑ์โดยพิจารณารวมถึงความรู้สึกที่ท่านรับได้ด้วยอวัยวะรับรสชาติในช่องปากโดยเฉพาะลิ้นมากน้อยเพียงใด

ความชอบทั้งหมด หมายถึง ท่านชอบผลิตภัณฑ์โดยพิจารณารวมๆ ถึงลักษณะทางประสาทสัมผัสทั้งหมดข้างต้นแล้วมากน้อยเพียงใด

ขอให้ท่านตรวจสอบว่าได้ทำครบทุกข้อ เพื่อมิให้มีปัญหาในการวิเคราะห์ผล

1. ลักษณะทางประสาทสัมผัสของผลิตภัณฑ์

1.1 ความชอบลักษณะปรากฏ

- □ ชอบมาก
- □ ชอบปานกลาง
- □ ชอบเล็กน้อย
- □ เฉยๆ
- □ ไม่ชอบเล็กน้อย
- □ ไม่ชอบปานกลาง
- □ ไม่ชอบมาก

1.2 ความชอบกลิ่น

- □ ชอบมาก
- □ ชอบปานกลาง
- □ ชอบเล็กน้อย
- □ เฉยๆ
- □ ไม่ชอบเล็กน้อย
- □ ไม่ชอบปานกลาง
- □ ไม่ชอบมาก

1.3 ความชอบเนื้อสัมผัส

- ☐ ชอบมาก
- ☐ ชอบปานกลาง
- ☐ ชอบเล็กน้อย
- ☐ เฉยๆ
- ☐ ไม่ชอบเล็กน้อย
- ☐ ไม่ชอบปานกลาง
- ☐ ไม่ชอบมาก

1.4 ความชอบรสชาติ

- ☐ ชอบมาก
- ☐ ชอบปานกลาง
- ☐ ชอบเล็กน้อย
- ☐ เฉยๆ
- ☐ ไม่ชอบเล็กน้อย
- ☐ ไม่ชอบปานกลาง
- ☐ ไม่ชอบมาก

1.5 ความชอบทั้งหมด

- ☐ ชอบมาก
- ☐ ชอบปานกลาง
- ☐ ชอบเล็กน้อย
- ☐ เฉยๆ
- ☐ ไม่ชอบเล็กน้อย
- ☐ ไม่ชอบปานกลาง
- ☐ ไม่ชอบมาก

2 ข้อมูลส่วนตัว

2.1 เพศ ☐ ชาย ☐ หญิง

2.2 กลุ่มอายุ ☐ 10-12 ☐ 13-19 ☐ 20-40 ☐ >40

2.3 อาชีพ

- ☐ นักเรียน ☐ นักศึกษา
- ☐ ข้าราชการ ☐ บริษัทเอกชน
- ☐ พนักงานรัฐวิสาหกิจ
- ☐ อื่นๆ (โปรดระบุ) _____

แบบสอบถาม เฉพาะสำหรับแม่บ้าน

1. โปรดระลึกว่า ผลิตภัณฑ์นี้ไม่เหมือน กับลูกชิ้นที่ท่านหาซื้อได้ทั่วๆไป ในท้องตลาด ผลิตภัณฑ์มีลักษณะ เฉพาะตัวมากกว่า โดยทำจากเนื้อที่หาซื้อได้ยาก และมีราคาแพง และมีเปลือกหุ้มรอบนอก เมื่อพิจารณาตามนี้แล้ว ท่านคิดว่า มีความเป็นไปได้ที่ท่านอาจจะซื้อผลิตภัณฑ์ในราคาที่ (กา ✓ เพียง 1 ช่อง)

☐ น้อยกว่า
☐ เท่ากันทีเดียว
☐ มากกว่า

ราคาของผลิตภัณฑ์เนื้อแปรรูปที่มีขายทั่วๆไป เช่น ลูกชิ้น ไส้กรอก ฯ.

2. โปรดกา ✓ ใน ☐ ข้างล่างนี้ (เพียง 1 ช่อง) เพื่อแสดงว่าท่านพึงพอใจที่จะซื้อผลิตภัณฑ์มากน้อยเพียงใด เมื่อท่านพิจารณาลักษณะต่างๆ ของผลิตภัณฑ์ทุกอย่างรวมกัน

☐ จะซื้อแน่นอน
☐ อาจจะซื้อ
☐ อาจจะซื้อหรือ อาจจะไม่ซื้อ
☐ อาจจะไม่ซื้อ
☐ จะไม่ซื้อแน่นอน

3. ถ้าผลิตภัณฑ์นี้จะมีจำหน่าย ตามสถานที่ต่างๆ ท่านต้องการให้มีจำหน่าย ณ ที่ใดบ้าง (อาจกา ✓ ได้มากกว่า 1 ช่อง)

☐ ซุปเปอร์มาร์เก็ต
☐ ตลาดสด
☐ ร้านอาหารประเภท ฟาสต์ฟู้ด
☐ หาบเร่ รถเข็น
☐ โรงอาหารใน โรงเรียน, วิทยาลัย, มหาวิทยาลัย
☐ อื่นๆ โปรดระบุ _____

4. ถ้าท่านจะซื้อผลิตภัณฑ์ ท่านจะซื้อบ่อยเพียงใด (กา ✓ เพียง 1 ช่อง)

☐ มากกว่า 1 ครั้ง ต่อ สัปดาห์
☐ 1 ครั้ง ต่อ สัปดาห์
☐ 1 ครั้ง ต่อ 2 สัปดาห์
☐ 1 ครั้ง ต่อ เดือน
☐ น้อยกว่า 1 ครั้ง ต่อ เดือน

5. ท่านคิดว่าผลิตภัณฑ์ควรจะบรรจุ ในลักษณะประเภทใด (อาจกา ✓ มากกว่า 1 ช่อง)

☐ ถุงพลาสติกมองเห็นผลิตภัณฑ์ภายใน
☐ กล่องพลาสติก และมีแผ่นฟิล์มพลาสติกหุ้มมองเห็นผลิตภัณฑ์ภายใน
☐ อื่นๆ โปรดระบุ _____

6. สืบเนื่องจากข้อ 5 ท่านคิดว่าขนาดบรรจุ ต่อ 1 ถุง หรือ 1 ถาด ควรเป็น (ทำ ✓ เพียง 1 ช่อง)

- ☐ 8 ลูก
- ☐ 10 ลูก
- ☐ 12 ลูก
- ☐ 16 ลูก
- ☐ 20 ลูก

7. เมื่อท่าน ซื้อผลิตภัณฑ์นี้ ท่านอยากจะให้มีข้อความใดๆ บ้างระบุอยู่บน ฉลาก (อาจทำ ✓ มากกว่า 1 ช่อง)

- ☐ ชื่อและที่อยู่ของผู้ผลิต
- ☐ ประเทศของผู้ผลิต (ถ้ามาจากต่างประเทศ)
- ☐ น้ำหนักสุทธิ
- ☐ ส่วนประกอบของผลิตภัณฑ์ และน้ำหนัก
- ☐ คุณค่าทางโภชนาการ
- ☐ ส่วนผสมอาหาร
- ☐ อื่นๆ โปรดระบุ _____

8. ท่านคิดว่าวิธีการหรือสื่อใดๆ ต่อไปนี้ ที่จะช่วยในการส่งเสริมการจำหน่าย ผลิตภัณฑ์ (อาจทำ ✓ มากกว่า 1 ช่อง)

- ☐ การบอกเล่าส่วนตัว
- ☐ หนังสือพิมพ์, นิตยสาร
- ☐ วิทยุ
- ☐ โทรทัศน์
- ☐ อื่นๆ โปรดระบุ _____

9. เมื่อท่าน และสมาชิกในบ้าน ทดลองผลิตภัณฑ์ ได้ใช้น้ำซอสปรุงรสหรือน้ำจิ้มหรือไม่

☐ ใช้ ☐ ไม่ใช้

ถ้าใช้ โปรดระบุชนิด (เช่น ซอสมะเขือเทศ ซอสพริก(ศรีราชา) น้ำจิ้มแบบน้ำจิ้มไก่ย่าง ซอสปรุงรสแบบแม็กกี้ หรือ อื่นๆ โปรดระบุ _____

10. ท่านมีข้อเสนอแนะหรือข้อวิจารณ์ เพิ่มเติม เกี่ยวกับ ผลิตภัณฑ์นี้อีกหรือไม่ โปรดอธิบาย

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