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CONSUMER RESEARCH AND PRODUCT OPTIMIZATION
FOR GLUE STICK DEVELOPMENT IN THAILAND

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ABSTRACT

This study, on the development of a new glue stick product based on tapioca starch for Thai consumers, had a major emphasis on the use of consumer input in the product optimization. At the beginning of the development process consumers identified the problems of existing products and generated the important attributes of glue stick products. Then product prototypes were made using mixture experimental designs and quantitative relationships between the ingredients and the product attributes were determined. For evaluating the sensory attributes of prototypes, a trained panel was employed during the development of the first prototypes and then a consumer panel in the second prototype development. Consumers not only evaluated the product attributes of the prototype products using line scales but also indicated their ideal product attribute levels. Physical attributes of the products were also measured. Multiple regression was used to generate the empirical equations showing the relationships between the ingredients and the product attributes.

These linear relationships were then used to develop the constraints for a linear programming model. The consumer ideal product profile as well as the sensory profiles of the commercial products were employed to create upper and lower acceptable limits of the attributes' constraints. The raw materials and the physical properties were also included in the linear programming model. Acceptability maximization and cost minimization were used to generate the optimum formulations. The prototype products from these formulations were tested by a small consumer panel to select the one with highest acceptability. A pilot scale plant was designed and built and then a small quantity of the final formulation was produced.

The final product, from the successful pilot scale production, was tested in a home-use test by 108 students and 64 office workers in Bangkok. The consumers evaluated the performance of the developed product in comparison with their 'usual brand'. The results from the consumer testing showed that the developed glue stick was generally accepted by the target consumers. However, some improvements of the product in terms of colour, aroma and packaging are still necessary.

The product could be made commercially in Thailand in a simple plant using a closed stainless steel vessel with steam jacket, condenser and central anchor type mixer. Suitable packaging equipment is needed in order to maintain the high temperature of the mix while discharging the glue mixture into moulds. The product should be able to compete with the glue sticks already in the Thai market since it has the distinctive feature of adjustability and could be sold at a lower price.

PREFACE

Tapioca (cassava) has been regarded as one of the world's most important crops that can be used for human consumption, for animal feed and in various industries. Thailand is the largest exporter of tapioca products with the total export about 86 percent of the world's exports in 1989 (TTTA, 1990). The exports are made in two main forms, tapioca chips and pellets for use as animal feed and tapioca flour for human and industry consumption. The European Community is the dominant tapioca importer taking about 59 percent of the total export. Tapioca chips and pellets have been used extensively as one of the most important feed ingredients in the animal feed industry in Europe for over 20 years. Starch another important product from tapioca is used in both food and non-food industries. Tapioca flour is employed as a raw material by industries making such products as soup, candy, pudding, sausages, bread, ice-cream, noodles and vermicelli. It is used as a binder by the pharmaceutical industry in making pills. Moreover due to its saccharification property, tapioca flour is used for manufacturing food seasonings, glucose, fructose, soft drinks and canned food. Tapioca flour is also used in the production of adhesives, paper, textiles, plywood and alcohol.

In the adhesive industries, tapioca flour can also be used in the form of dextrin or modified starch. Adhesives from tapioca are mainly used in the corrugated board industry which manufactures vast amounts of board to be used for cartons, boxes and containers. Tapioca adhesive have also been used in laminated paper board, remoistening gums, wall paper and home use. Although tapioca starch has permanent use in some starch using industries, there is still the need to expand its use in various ways to be able to compete with other starches. Most research has been done on improving formulation and techniques in processing of adhesives used in paper and board industries. Nevertheless there is the demand for the development of an adhesive product for consumers' use particularly in Thailand.

Glue stick was considered to be a suitable product to be developed for Thai consumers. Glue stick is a consumer product which has become popular recently owing to its ease of use, convenience and good performance compared with other glue products. It was found that all the glue sticks commercially available in the Thai market are imported

from other countries: Germany, Japan, Korea and China. These glue sticks are based on synthetic polymers, mainly polyvinyl pyrrolidone which is one of the factors that contribute to the high cost of the product. It was decided that if tapioca starch could be used to replace polyvinyl pyrrolidone in glue stick formulation the cost of product could be reduced. This would also increase the use of tapioca starch in the non-food product area.

This project was done partly in New Zealand where the product was developed in the laboratory scale and partly in Thailand where the product prototypes were tested with Thai consumers, a pilot plant built and an optimum product was developed and tested with Thai consumers.

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CHAPTER 1

INTRODUCTION

The product development process involves the application of different techniques: consumer research, processing development, product formulation, engineering and marketing, to develop new products or to improve the existing products already in the market. The characteristics of the developed product depend on several factors: target consumers, the company policy and strategy, introduction of new raw materials, competitors, government regulations, culture of the society and availability of technology. Consumers' needs always change with time, products have to be improved to meet these new needs. The company may want to reduce the formulation cost or to introduce new raw materials. A new government regulation may specify the level of some ingredients in the formulation or ban ingredients currently used. All these factors have to be taken into account in order to obtain a successful improved or new product.

In general, the main steps of the systematic product development process as described by Earle (1989) are:

- * Development of project aim
- * Setting of project constraints
- * Product idea generation
- * Product idea screening
- * Development of the product concept and product design specification
- * Development of the prototype product
- * Development of a suitable process or manufacturing method
- * Testing of the product
- * Decision on and development of a market plan and type of product launch
- * Evaluation of the probable product success
- * Launching the product

However, this study did not involve the whole process of product development. It emphasized mainly the development of prototype products in order to obtain an optimum product prototype through product optimization.

1.1 PRODUCT OPTIMIZATION SYSTEM

The optimization of all aspects of a product is the goal in product development. In product optimization, the consumer study, the systematic experimentation, and the optimization technique are combined to generate an optimum product.

1.1.1 What is Product Optimization

Product optimization is defined as a comprehensive and efficient approach which can reduce the time used for developing the product and simultaneously develop a highly acceptable product for consumers while minimizing unit cost. The ultimate goal of consumer oriented product optimization is to maximize consumer acceptance of a product, given a fixed set of ingredients. The outcome of the process should support key decisions evolving from company policy and strategy (Gordon and Norback, 1985). Hence, a product optimization method considers all the constraints and objectives of the project, and will help the product developer to obtain an optimum formulation.

1.1.2 Product Optimization Procedures

Optimization requires a well-defined procedure. Several techniques have been developed for product optimization (Fishken, 1983; Sidel and Stone, 1983; Giovanni, 1983; Schutz, 1983; Moskowitz, 1983 and 1987). Although these methods differ, they all include the following steps (Lagrange and Norback, 1987):

- * An initial development study in which prototypes are developed and critical input and output variables are identified.
- * Product formulation development which includes the determination of the levels (or ranges) of the ingredients and processing variables for use in the subsequent optimization study. The evaluation of product attributes is conducted and the model showing relationships between inputs and output variables are generated at this stage.

* Formal optimization study, with or without constraints, that includes consumer testing, data analysis, reformulation and implementation.

* Final consumer testing of the product. In final product testing, the reaction of consumers toward the new product is measured. The product may be tested by itself or against the competitive products.

1.2 CONSUMER EVALUATION DURING PRODUCT OPTIMIZATION

Consumers can provide useful information to be used during product optimization. Consumers can be involved in selecting product ideas and product concepts. The information regarding the product to be developed and the reaction of consumers toward the existing products are used at the initial stage of product optimization to guide the direction of further study. Evaluation of the prototype products by consumers has been employed extensively in optimization of mainly food products. Moskowitz (1987) described product evaluation by a consumer panel during development of a cereal product. Consumer panels also took part in optimization of a fish cake product (Moskowitz and Rabino, 1983). However, the consumer panel has not been used in a great extent in optimization of non-food products.

1.2.1 Initial Development of Product

In the early stages of product optimization, product developers need some guidance on how to develop the product to gain consumers' acceptance. Strengths and weaknesses of competitors' products have to be identified by generating profiles of competing products and comparing them with an ideal product profile. Attributes that play an important role in consumers' acceptance and buying intentions have to be identified. Several techniques have been used to elicit importance of attributes from consumers (Alpert, 1971; Moskowitz and Chandler, 1978; Heeler et al., 1979; Jaccard et al., 1986).

Consumer panels have also taken part in generating profiles of existing products (Rabino and Moskowitz, 1980). Normally a number of products available in the market are purchased and tested with consumers. Products are usually tested on a blind basis

so there is no brand name effect on product rating. If prototypes have been developed from some basic formulations in the laboratory, they can be tested together with the products on the market. This will help the researcher to select the suitable basic formulation to be used in further study. Sometimes, consumers may be asked to indicate their ideal product on the same scale they evaluate each attribute of the samples, so the direction that the product should be improved can be obtained (Moskowitz, 1984 and Cooper et al., 1989).

Moskowitz and Jacob (1988) reported using a consumer panel to evaluate in-market products at the beginning of a Mexican entrée development. A consumer panel was also used to generate profiles of competitive products at the early stages of development of a hand lotion (Rabino and Moskowitz, 1980). In optimization of a rice bran oil based hand cream, Uaphithak (1990) also used consumers to develop an ideal product profile which could be used as a guidance to optimize the product.

1.2.2 Product Formulation Development

From the initial development stage, the direction in which the product should be developed is identified; in the development of product formulation, the product developer has to decide which basic formulation should be used to generate the product prototypes. Since consumers determine the success or failure of a product, it is logical to collect consumers' reactions to various formulation as early as possible in the product optimization process.

When new products are developed, another goal of the optimization procedure is to provide the product developer with information regarding the effect of input variables: ingredients, process conditions, and storage conditions, on various attributes of the prototypes: physical properties, acceptability, sensory attributes, liking of attributes, and shelf life. Sensory attributes of each prototype are measured by a sensory panel, either a trained panel or a consumer panel. Consumer panels have been used in evaluation of both food product and non-food product prototypes: a dry-powdered soft drink (Griffin and Stauffer, 1990), skin lotion (Moskowitz, 1982). Relationships between product attributes and input variables are investigated and empirical models are generated for further use in the optimization stage. Moskowitz (1982) generated model

relationships between purchase intent and sensory attributes of lotion which were later used to develop an optimum product.

1.2.3 Formal Optimization Study

In the product optimization stage, the researcher has to identify the appropriate levels of the important input variables which produce a product that achieves optimum acceptance from consumers. The relationships between input variables and consumer perceptions are applied with optimization techniques such as linear programming, multiple regression, response surface methodology, or gradient search, to generate an optimum product.

After the optimum formulation is obtained, the product has to be made on the pilot scale level in order to make sure that the product can be made on a larger production scale and that a suitable processing method and processing equipment are developed. Scaling up products from laboratory scale to pilot plant and from pilot plant to large-scale production will often result in product changes. Sensory panels can be used to detect and identify the differences between the desired product and the product from the large-scale production.

1.2.4 Final Consumer Testing of the Product

The product obtained from the optimization process is tested with consumers in order to measure product acceptance in terms of acceptability, purchase intention and price to buy. Penny et al. (1972) reported on the interrelationship between product rating on an intention-to-buy scale and the company's assessed product success or failure in the marketplace. They found that actual purchasing increased with scale position - there were higher percentage of consumers who subsequently bought the test product from the group who rated the product high on purchase intention compared with the group who rated the product low on purchase intention.

In final product testing, researchers may wish to compare their new product with a current formula or with the market leader. By comparison of the developed product with the commercial products it is possible to identify unique advertising points of view

about the product. Marketing information such as price, brand name and packaging can be included in product testing. Product acceptance and purchase intention is normally evaluated at this stage.

Even though consumer purchase intention is influenced by factors other than the product itself, product optimization is still necessary because if a product contains the attributes which satisfy consumers' needs it will have more chance of competing successfully with other products on the market.

Sensory testing has been applied to non-food products in particular personal care products, for example for more than 20 years in the form of deodorancy testing. Recently descriptive analysis techniques have been applied to lotion (Gibson, 1973; Moskowitz, 1982), soap, antiperspirants, shampoos and other personal care products. Dethmers and Boomsma (1989) described how traditional sensory methods had been modified and expanded to accommodate the multidimensional aspects of home care products such as: air care, floor care, furniture care, laundry care and insect control product. However, the science of sensory evaluation and the use of standard methods and procedures for conducting controlled sensory evaluations of products and materials are relatively new to the glue product industry especially to glue sticks.

This research was conducted in order to demonstrate the use of optimization techniques together with consumer panel evaluation in the optimization of a non-food product. Glue stick was selected as a product model to be studied.

1.3 DEVELOPMENT OF A GLUE STICK

Although the product optimization procedure has been used for optimization of food products and skin care products (Rabino and Moskowitz, 1980; and Uaphithak, 1990), there has been no evidence of using consumer evaluation in glue product optimization. This present research was conducted to ascertain if the consumer panel can be considered as an important tool in consumer-oriented product optimization, of glue sticks.

1.3.1 Why Glue Stick was Chosen as the Model Product

Product optimization techniques have been used mainly for food products (Norback and Evans, 1983; Lagrange and Norback, 1987; Moskowitz, 1987 and 1988). Linear programming one of the methods for optimization was used by Rust (1976) in formulating preblended meats, Dano (1972) in formulating ice cream. Bender et al. (1982) used this method in selecting a formulation for a least cost mayonnaise. Although Kavanagh (1978) used linear programming in paint and resin development, there is little evidence of the use of consumer data in the optimization of non-food products in the area other than skin care products. Glue stick is a product which is new to the Thai market. The price is high compared with other glue products with similar performance. The high cost of raw material is one of the factors which contributes to this high price. Replacing of some synthetic raw materials with natural raw materials not only could produce a cheaper product but also create an environmental friendly and a safe product.

No publications were found on using optimization techniques and consumer panels in development of a glue stick. Hence, a glue stick was considered suitable as a product model in this project.

1.3.2 Development of Glue Sticks in the Past

Glue stick was invented in the late 1950s. It was developed by adhesive companies. The first glue stick was made from hard resins: hydrogenated terpene, polymerized terpenes; soft rubbers: hydrocarbon polymers and butyl or natural latex; and soft waxes: Japan wax, stearic acid, paraffins and spermaceti (Brennan, 1966). Resins contribute largely to the 'adhesiveness' of the adhesive and control the softening point in combination with the waxes used. Rubbers give a spinning action when the adhesive is stroked rapidly across a sheet of paper and also add tack, especially in combination with the resin. The most important contribution of the soft wax is to maintain the applied film of adhesive in a softened and activated state for a period of time. They also plasticize and enhance the tack of the resins.

Glue stick was improved using a salt of an aliphatic carboxylic acid such as sodium

stearate as the gel forming agent to improve rub off attributes, and to reduce processing time and temperature (Muszik and Dierichs, 1971). Later, wax acid (Hoechst waxes) was used as the gel forming agent so that alkali-sensitive substances could be included in the formulation; acid-reacting active compounds may be added (Adhesive Tape Limited, 1974 and Werke H.u.M. Fischer, G.m.b.H., 1974). There were also further developments on removable bonding (Gollub et al., 1987) and temporary bonding glue sticks (Palm, 1989) for specific application using an alkali metal or ammonium salt of an aliphatic carboxylic acid as gel-forming agent and a mixture of carboxylated -alkyl ester of acrylic and polyethylene as adhesive.

1.3.3 Use of Starch in Glue Stick

Although the technology of making glue stick is not new as it was developed in the late 50s, this product is considered as 'new' by Thai consumers. The use of a glue stick instead of other glue products is increasing owing to its ease of use and cleanliness. Despite the fact that a glue stick has some advantages over other glue products, it is still not widely used because the price is higher than the prices of other glue products such as liquid glue, PVC glue and paste glue.

	Price (Bahts)*
Glue stick	15-20 (8 g)
Liquid Glue	10 (50 ml)
PVC glue	15 (60 ml)
Paste glue	5 (25 g)
* 1 N.Z. dollar	= 15 Bahts
1 U.S. dollar	= 25 Bahts

The price of glue stick in the Thai market is about 15 to 20 Bahts for a 8 g stick. In order to compete with other glue products available in the market, it is necessary to bring the price down either by using low price raw materials or by reducing the cost of production.

The adhesive component in glue stick is mainly synthetic polymers which makes the glue stick expensive. It was considered that if a natural polymer was used to replace

all or some part of synthetic polymers it would decrease the price of the final product. Apart from reducing the price of glue stick, the benefit from using natural polymers is that they are safe for consumers especially children because natural polymers are non-toxic and they are edible so it will be less harmful if children should eat them by accident. Natural polymers are a renewable resource so there will be no problem with regards to the continuity of supply of raw materials.

Natural polymers which can be used in glue sticks are starch, starch derivatives, cellulose derivatives, gum arabic. (Muszik and Dierichs, 1971; Werke H.u.M. Fischer, G.m.b.H., 1974 and Adhesive Tape Limited, 1974). Tapioca (cassava) starch was considered as a suitable replacement for an adhesive substance in glue stick formulation for the Thai market since it is produced in a large amount in Thailand. There was no evidence of the use of tapioca starch in glue stick formulation. Therefore, this study was conducted to explore the use of tapioca starch in the glue stick formulation.

1.4 AIM AND OBJECTIVES

It was found that only physical testing was employed for measuring the product attributes of adhesives (Ando, and Yamazaki, 1974; and Pletcher and Wong, 1978). There has been no evidence of using consumer testing in glue stick development nor report of the use of either experimental designs or optimization techniques for this kind of product.

Since glue stick is a consumer product, it is necessary that the product is accepted by the consumers. Although there are many reports on the use of consumer data in product development, no information was found on how the data generated from consumers can be used efficiently in product optimization, particularly in a non-food system.

Hence, the aim of this thesis was to study the use of consumer data as inputs in the optimization procedure for a non-food product, especially in development of a tapioca starch based glue stick product.

The objectives were to:

- * Study consumers' reactions toward glue product usage particularly glue sticks and generate a list of important attributes of glue sticks required by consumers.
- * Explore the use of tapioca starch as a raw material in glue sticks and select a suitable formulation for a starch based glue stick.
- * Develop product test measures and study the effect of glue stick components on physical and sensory attributes.
- * Generate an ideal product profile for glue sticks through a consumer panel.
- * Use linear programming to generate an optimum tapioca starch based glue stick which was highly acceptable by the Thai consumers and could compete with the products already in the market.
- * Confirm that the formulation and process developed in the laboratory could be transferred into industrial production.
- * Measure product acceptability in a home-use test.

CHAPTER 2

LITERATURE REVIEW

The goal of this project was to optimize a glue stick product for the Thai market. Since glue stick is a consumer oriented product, use of consumer input during the product optimization procedure is discussed in this chapter. The suitable product optimization techniques are investigated. Basic ingredients used in commercial glue stick formulations and their properties are reviewed. The use of starches in glue products specifically in glue stick will also be mentioned.

2.1 PRODUCT OPTIMIZATION TECHNIQUES

The major methods which have been used in optimization research are: linear programming, multiple regression, response surface methodology, and gradient search.

Linear programming is a mathematical technique used to determine the optimum allocation of a limited supply of resources, subject to certain constraints, to either maximise or minimise a specified objective (Nicklin, 1979). In product formulation problems, the resources are normally raw materials, the constraints are based on the functional properties of the final product and the objective is usually cost minimization or consumer acceptability maximization for a consumer oriented product.

Multiple regression involves the development of models that relate dependent and independent variables. The regression models obtained contribute significantly to the development of a data base concerning the relationships between the product characteristics, acceptance (output variables) and the raw material composition and also processing variables (input variables).

The response surface methodology systematically uses quantitative data from appropriate experimental designs to determine and simultaneously solve multivariate equations (Giovanni, 1983). The equations can be graphically represented as response

surfaces or contour diagrams. The information can be used to describe how the variables affect the response, determine the interrelationships between variables, and describe the combined effect of all variables on the response. This method has been used in the optimization of fragrances where both sensory and image properties were optimized (Williams et al., 1992).

The gradient search method is a procedure for moving toward a point on a continuous surface where all the partial derivatives of a function are at or very near zero. The gradient points in the direction where the size of the set of acceptors is increasing the fastest. The step size tells the technologist how far to move in the gradient direction (Lagrange and Norback, 1987).

2.1.1 Linear Programming in Product Optimization

Linear programming is often considered to be a limited tool because of its assumptions of linearity and infinite divisibility. However, the technique is much more flexible than is generally recognized (Bender et al., 1982). Linear programming has been successfully used in optimization of food products for more than 30 years. IBM (1966) reported use of linear programming in blended meat formulations. This method was also successfully used in formulation of ice-cream (Dano, 1972), mayonnaise (Bender et al., 1982), fresh turkey bratwurst (Beausire et al., 1988) and corn-based snack (Almeida-Dominguez et al., 1990). Linear programming has also been applied in non-food product formulation: paint and resin (Kavanagh, 1978), light duty liquid detergent formulation (Chan and Kavanagh, 1988) and hand cream (Uaphithak, 1990).

2.1.2 Use of Sensory Attribute Constraints in Linear Programming Models

In optimization of a consumer oriented product, sensory attributes of product have to be taken into account in order to obtain a product which is accepted by the target consumers. Use of sensory attributes in product optimization has been developed for many years, however, the applications were only widely used in food products. Although optimization of sensory attributes were conducted by using some optimization techniques: multiple regression (Moskowitz, 1985), and response surface methodology (Giovanni, 1983), the use of sensory attribute constraints in linear

programming model has only recently been introduced in food product development in the formulation of a fresh turkey bratwurst (Beausire et al., 1988). The method was later used in hand cream optimization (Uaphithak, 1990).

2.2 USE OF CONSUMER SURVEY AND CONSUMER TESTING IN PRODUCT OPTIMIZATION

In the product optimization process, information regarding the product has to be elicited from consumers as early as possible. Various methods have been used for getting information from the consumers. Consumer survey and testing of product with consumers are most commonly used.

2.2.1 Consumer Survey

Market research is classified into observation, experimentation and survey research. Survey research is the best known source of primary data collection, not only in marketing but the social sciences in general. Tull and Albaum (1973) stressed that surveys are concerned with understanding or predicting behaviour and offered as their definition: 'Survey research is the systematic gathering of information from (a sample of) respondents for the purpose of understanding and/or predicting some aspect of the behaviour of the population of interest'.

Consumer survey is a method developed to get consumer reactions towards both existing products on the market and also products which are new to the market. With the existing products, the consumer survey identifies for researchers the weaknesses and strengths of their own product and those of competitors - why consumers like or dislike the products and what improvements they want in the products. Consumer survey also helps the researchers to identify the important attributes of the product being studied. With the new product, the consumer survey can help the researcher screen the product ideas and obtain the product concept and also helps the researcher to foresee the consumer reactions toward the product to be developed.

The following are the tasks which the consumer survey can do:

- * Collect information about the product users
 - Percentage of population who use the product
 - Type of product users
- * Determine information about product usage
 - How often consumers use the product
 - How often consumers buy the product
- * Determine what are the alternative products
- * Identify the problems in product usage
- * Evaluate the importance of product attributes

Alreck and Settle (1985) stated that the main advantages of surveys are: comprehensive, customised, versatile, flexible and efficient. This means the survey is appropriate to almost all types of consumer research and suitable for all kinds of problems and budgets. In spite of these advantages, surveys also have their disadvantages (Hart, 1987):

- * The unwillingness of respondents to provide the desired data. The non-response error will invalidate research findings.
- * The ability of respondents to provide data. It is important to target individuals who have the knowledge and experience of the subject under survey.
- * The influence of the questioning process on the respondents. Respondents may give the answers they think the researcher will want to hear, thus distorting the accuracy of the data.

However, these disadvantages can be overcome by selecting a suitable survey method and the target consumers as well as the way the questions are presented to the consumers for a specific product. Alpert (1971) suggested that with a product involving more subjective buying motives, consumers should be asked indirect questions.

Lai (1987) used a consumer survey to obtain information from consumers in a bakery snack development process. The results indicated that a meat pie was the possible product to be developed. Devro Ltd. (Birch, 1990) conducted market research at the

beginning of sausage development. The information obtained from the survey suggested that consumers needed a pre-cooked, ready-to reheat sausage which provided a ready-to-eat breakfast. Moskowitz (1984) reported that the results from a market research study enabled the Riley Company to come up with an idea to develop a deep skin scrub made from natural products, which would both clean and enrich the skin.

Durgee (1990) recommended that in research on product sensory properties in groups or in one-on-one interviews, it is very important that respondents experience the product first-hand during the interviews. If it is a food product, they should taste it. If it is a perfume, they should smell it. Simply asking consumers to recall the taste or feel of a product lacks the immediacy of actually using the product. With a new product which is not available in the market, a product concept can be used to trigger consumers' opinion on the product and its attributes. However, consumers may have difficulty in visualize the product. In the development of the deep skin scrub, which was a new product, Moskowitz (1984) used with consumers a number of different stimuli representing both in-market products for facial cleansing, and also experimental prototypes of a deep skin scrub. The researcher realized that probably no single product tested actually would represent the final facial scrub.

In the consumer survey conducted in this study, permanent bonding glue stick was a product already available in the market so the commercial products could be used as reference. However, the temporary bonding glue stick was not on the market at that time so it was necessary to use a different product with similar temporary bonding, in this case a self-adhering note pad was used.

2.2.2 Consumer Testing

There are many reasons that make consumers a valuable measure in product testing. Those reasons are given below:

- * Consumers evaluate the product in a different way from the trained sensory panel. Consumers may use product dimensions different from those of a trained panel in evaluating product preference or product acceptance. Product acceptance should not be obtained from a trained sensory panel.

- * In determining product differences, consumers normally use product attribute preference to discriminate the products but this does not apply with the trained panel who merely use difference of attributes between products.
- * In the product optimization process, it is necessary for the product developer to identify the important product attributes which consumers use in product evaluation. These attributes can only be obtained effectively from consumers.
- * In measurement of purchase intention, the data should be collected from the target consumers in order to get effective results and give the correct prediction of product purchasing.
- * Trained sensory panels tend to have too much knowledge or experience about the product being tested which could cause bias in product evaluation.
- * By associating consumer data with sensory panel data and when possible with ingredients and processing variables, and/or with instrumental or chemical analyses of the product, the researcher can discover the relationships between the product formulation, product's attributes and consumer acceptance.

2.2.3 Identification of Important Product Attributes

Attributes represent the dimensions along which consumers rate products. The product optimization procedure depends critically on the correct selection of product attributes. If the researchers fail to select a true set of attributes, then this can invalidate the entire study because the panelists do not evaluate the product by the appropriate dimensions.

Attributes which are used to describe a product can be classified as use attributes, sensory attributes, liking attributes and image or appropriateness. These attributes possess various degrees of importance. The product developer usually has to limit attention to the primary and most important attributes during development of prototypes, otherwise there are great difficulties in analysing the data.

Moskowitz (1984) stated that attributes of a product are called 'important' if changes in those attributes markedly increase or decrease the acceptance of the product. Attributes are called unimportant if changes in these attributes do not affect final acceptance.

There are several methods which researchers use to measure importance of product attributes: direct rating (Alpert, 1971), rank order (Moskowitz and Chandler, 1978), conjoint measurement, open-ended elicitation approach, information search approach, indices based on Jaccard's subjective probability and paired comparison (Jaccard et al, 1986).

Alpert (1971) stated that, for products such as one-dollar pens, direct questioning methods - how important is each of these attributes in your own choice of a pen in the one-dollar category?, may be better than the indirect ones - with 'most people' substituted for 'you', but for other products involving more subjective buying motives, the indirect approach was more effective.

Moskowitz and Chandler (1978) used direct rating (via magnitude estimation) to determine important food attributes. They found that an acceptable flavour in foods appeared to be more important than the other product attributes surveyed. Heeler et al. (1979) found that 'self-reports', in which consumers rated the given attributes according to the attributes' importance to them, was the most reliable method to measure the importance of food blender product attributes compared with conjoint measurement and information display board.

Rabino and Moskowitz (1980) asked consumers to rank order attributes of skin lotion according to their relative importance, to identify the characteristics which consumers felt to be important as indications of an acceptable, efficacious hand lotion.

Jaccard et al. (1986) compared several methods to measure product attribute importance. Conjoint measurement technique, open-ended elicitation approach, information search approach, direct rating of importance, indices based on Jaccard's subjective probability approach and paired comparison approach were compared. The products they used in their studies were cars and birth control methods. They found that these measures have

relatively low levels of convergence. The results suggested that conclusions made about attribute importance may be quite different depending on the method used to assess importance.

It can be seen that some methods are suitable for some products. To decide which method to use, the type of products and consumers have to be taken into account. Open-ended elicitation method appears to be the method most suitable for a new product or a product whose list of attributes is not available.

After the researcher obtains a set of important attributes of the product being studied, they have to decide on which method they will use to measure these attributes during the optimization process.

2.2.4 Testing of Product Acceptability and Important Attributes of Product with Consumers

Since consumers determine the success or failure of a product, it is sensible that consumers' reactions to various formulations are collected early in the product optimization process. It can save product optimization resources a great deal if the direction toward successful product is discovered as early as possible. Acceptability as well as sensory attributes of the product should be measured. Acceptability itself is not enough for the product developer to make a decision on which attributes should be improved and in which direction. Acceptability is used in evaluating new product concepts, in selecting basic formulations during prototype development, in product optimization and in comparison between the developed product and the competitor's product in final product testing. Product acceptability can be measured in several ways, either by direct measurement or by relating to the purchase intention and the price the consumer is prepared to pay. Sensory attributes of the product are measured in order that the researcher knows the relationships between the ingredients and the sensory attributes. The models developed from these relationships can be used in the optimization stage.

There are several methods used for measuring product acceptability and the product sensory attributes. The type of measurement used in consumer testing depends on the

stage in the product optimization process at which the test is conducted. It also depends on the kind of information needed and how the results will be utilised. The number of attributes to be evaluated also has an effect on what method is to be used.

Usually consumer tests involve not less than 50 responses per product and larger panels are preferred rather than replicate responses (A.S.T.M., 1986). In the study conducted by Hovenden et al. (1979), it was found that the accuracy of an untrained panel is not different from the accuracy of trained sensory panels. This implies that the variance observed with consumers is similar to that observed with trained judges whereas the untrained panelists will provide information relevant for product developers as well as by marketing researchers (Sidel and Stone, 1985)

The methods generally used in sensory evaluation with consumers are product profile or line scaling, magnitude estimation, category scaling, ranking and paired comparison. Lawless and Malone (1986a) compared the ability to discriminate differences among products using four types of rating scales - nine-point category scales, line marking, magnitude estimation, and a hybrid of the category and line scale. In their study, visual, tactile and olfactory characteristics of products were assessed by consumers. Consumers judged that category scales were easy to understand and fast to complete but somewhat restrictive. Line scales were not restrictive, moderately fast, but a little harder to understand. Magnitude estimation appeared worst in all aspects. Category scales were found to have a sensitivity advantage as well as user-friendliness. All scales yielded high F-ratios for moderately clear sample differences and these number of subjects (34-55 panelists). Lawless and Malone (1986b) also found that magnitude estimation scaling was used less efficiently than category scales and linear scales by a heterogeneous sample of consumers.

Pangborn et al. (1989) compared using category, graphic and magnitude estimation scales. They found no difference between intensity estimates obtained with category scale and graphic scale. The results indicated that magnitude estimation was inappropriate for scaling of degree of liking.

As mentioned earlier, both the type of measurement scales and also how many categories should be in the scale depend on the stage in the product development

process at which the consumer test is conducted. It also depends on the kind of information desired and how the results will be used. The number of attributes to be evaluated also has an effect on what method is to be used. For the marketing point of view, the method used for consumer testing should give the measurement of consumer acceptance and also the purchase intention. These methods generate information about overall product preference not liking of individual product attributes so that the success of the product in the market can be estimated.

2.2.5 Consumer Research and Consumer Testing in Glue Stick Optimization

Although glue sticks have been marketed for a number of years, there are no reports about the consumer input during glue stick development or of the identification of product attributes by consumers. There appears to be no published consumer research on glue sticks. Glue stick is a consumer product, hence in development of this product, reaction of consumers towards the developed prototypes have to be taken into account.

2.3 PRODUCT PROFILE

Product profile or sensory profile is a quantitative descriptive test which represents the most sophisticated of available sensory methodologies compared with discrimination and acceptance testing methods. Product profiles include a complete sensory description of the test products and provide a basis for determining the sensory attributes that are important to product acceptance, as well as an aid in identifying the effects of underlying ingredients or process variables on specific changes in the sensory attributes of a product. This information cannot be obtained by conducting difference testing or preference testing.

Product profiling consists of three major procedures: Flavour Profile developed by the A.D. Little Co., Cambridge, Massachusetts in the late 1940s (Cairncross and Sjöström, 1950), Texture Profile developed at the General Foods Research Centre (Brandt et al., 1963; Szczesniak, 1963), and quantitative descriptive analysis (QDA) developed by Stone et al. (1974). These methods were developed originally for evaluation of food products. Later the method was expanded by Civille and Szczesniak (1973) and Civille and Liska

(1975) to include specific attribute descriptors including semisolid food, beverages, skin care products, fabric and paper goods.

Product profile is normally used with a trained sensory panel. However, this method has been successfully used with consumer panels (Szczesniak et al., 1975 and Uaphithak, 1990). Product profile is a useful tool for the researcher to get a picture of how consumers perceive the product or product prototypes. Profile of a product comprises a set of descriptive terms with the intensity of each attribute. Acceptability may be included to generate a more complete profile for the product (Moskowitz, 1984), but some researchers think that this should not be done as it influences the ratings on the attributes.

Szczesniak et al. (1975) stated that the consumer testing techniques used for measuring degrees of acceptance, preference or difference between samples did not give a thorough description of the product in terms of its sensory characteristics as they were perceived by an untrained group of persons. Although a texture profile panel was trained to do the job, it was criticized as being too 'artificial' and too removed from reality. Therefore they developed a consumer texture profile technique which could be administered in home use or in a central location type of a test. The developed method represents a combination of popular texture terminology, classified texture terms used by the panel, and a scaling technique on a semantic differential. One to six numbered scales were used where 1 indicated absence of a given characteristic and 6 indicated its presence to a very high degree. Texture terms were listed in a randomized order in the left hand side column. Alongside each word were six boxes for checking the intensity of the given textural characteristics. The end boxes were marked 'not at all' and 'very much so'.

They declared that this type of rating scale gave better results with consumers than a numerical scale in that it was more fully used to express intensities of discrimination. Their technique also permitted the description of an ideal texture for specific food items. An average of about 30 consumers per test had been used in the testing of breakfast cereals, puddings, dessert gels and whipped toppings. The results were presented in a typical 'profile' graph in which profiles for several related products, including an ideal was plotted on the same chart. Another way was to represent the ideal product as a

vertical straight line corresponding to a '0' rating and describing the test products in terms of their deviations (+ or -) from this line. This linear scale data could also be subject to factor analysis.

For glue stick testing in this study, anchor words at each end of the scale varied for each descriptive term instead of 'not at all' and 'very much so' in order that consumers could understand clearly what was the meaning on each part of the scale. The descriptive terms were presented in order of occurrence. In the sensory testing of skin care products Schwartz (1975) also suggested that the attributes were tested in sequence of occurrence.

2.3.1 Use of Line Scale in Product Profile

In the quantitative product profile or quantitative descriptive analysis, samples are evaluated independently by each panelist using a scaling technique, i.e., category scale, magnitude estimation scale or line scale. For the final report, data may be displayed in tabular or graphic form. Line scale is the most commonly used especially with consumer panels. This is owing to its simplicity to understand by consumers. Lawless and Malone (1986a and 1986b) and Lawless (1989) found that the line scale and the category scale were used more efficiently by a heterogeneous sample of consumers than magnitude estimation scale. Magnitude estimation was found to be somewhat less discriminative than category scaling or line scaling. Line scale was found a little harder to understand than category scale but it was not restrictive and could be used to provide continuity in quantitative data.

2.3.2 Ideal Product Profile

Ideal product profile is obtained by asking consumers to indicate their ideal product on a set of specified attributes (normally important attributes). The ideal product profile is compared with the profile of product prototypes in order to estimate how far the prototypes are from the consumer product ideal. Ideal product profile has been used in development of many products. Hoggan (1975) used ideal absolute scores with consumers to indicate their ideal beer on specific attributes. Szczesniak et al. (1975) described the use of ideal absolute scores in a consumer texture profile method.

Sinthavalai (1986) stated that ideal absolute scores had to be shown in either graphical or numerical form alongside the test sample scores so that the differences between sample and ideal, in both magnitude and direction, could be understood.

Since it was found that the ideal absolute score itself was not useful in quantitatively measuring how the different product prototypes were nearing the optimal product, the ideal ratio score was introduced to the product testing system (Cooper et al., 1989). Ideal ratio scores, the ratio of the product score to the ideal score, were used to decide the size and direction of product changes required to reach the consumers' ideal product. Ideal ratio score has been used successfully at Massey University for many years (Sinthavalai, 1986; Lai, 1987; and Wiriyacharee, 1990). Beausire and Earle (1986) stated that mean ratio scores could be used in factorial experimental designs to give empirical equations which could be used to predict the levels of ingredients or processing conditions necessary to give optimum sensory characteristics. Use of logarithms of ideal ratios was introduced later in order that ratio scores could be symmetrized, which reduced the skewness of the data considerably.

2.3.3 Use of Product Profile in Product Optimization

There have been reports on use of the product profile in many food product development projects. However, in the area of non-food products, the use of the product profile was reported only in the development of skin care products (Szczesniak et al., 1975; Uaphithak, 1990).

Schwartz (1975) showed how the principles of sensory texture profiling were applied to the evaluation of skin care products and how the basic methodology was modified to accommodate problems unique to this type of product. Schwartz suggested that the perception of texture comprised the following phases, which occur in sequence:

- * Pick-Up - the removal of the product from the container;
- * Rub-Out - the application of the product to the skin, and;
- * After-Feel - the evaluation of the effect of the product on the skin.

In her study, a wide variety of ingredients were screened and selected for use in finished products. Prototypes were evaluated in comparison with commercial products and results used successfully in predicting consumer response.

For glue stick testing, although there is no set pattern of how panelists evaluate the product, this pattern of Schwartz can be applied. The pattern of testing can be as shown below:

- | | |
|-----------------------------|--|
| * Appearance | - the evaluation of appearance of the stick; |
| * Rub-out | - the application of product to the surface of substrate; |
| * Glue residue on substrate | - the evaluation of amount of glue coated on substrate; |
| * Effect on substrate | - the evaluation of change occurring to the substrate (paper, wood etc.) after applying glue, and; |
| * Stickability | - the evaluation of bond strength of glue after 2 surfaces of substrate were placed to contact each other. |

Development of the sequence and the descriptive terms for glue stick testing is described in Section 3.2.2.

From the sensory profiles of prototypes and competitors including the level of product characteristics desired by the target consumers, it is possible to determine which attributes of each prototype come closest to the ideal, and which attributes need modification and to what degree. Such a profiling method helps the researcher to determine what to do next in a product development project. Empirical equations showing relationships between ingredients and product sensory attributes can be obtained and used in the optimization stage.

2.4 DEVELOPMENT OF MODEL USING PRODUCT PROFILE

Product profile is a useful tool in that it can produce quantitative data for model development. Empirical equations showing relationships between ingredients and product attributes are necessary for optimization of the product. These equations can be generated using multiple regression. Moskowitz (1984) stated that the model plays

a key role in optimizing because the model summarizes the data in a tractable form, allowed the researcher to express empirical relations in a simple form rather than having to lay out the data in extended tables. The model also allowed the researcher to interpolate between levels to estimate the likely sensory attributes' ratings of the untested points.

Moskowitz (1984) showed the use of the relationships between formulation ingredients and sensory attributes in lotion optimization. A consumer panel evaluated the product in a home-use test using magnitude estimation scaling. Model relationships between ingredients and product sensory attributes were developed by using multiple regression and were used further for product optimization. Beausire et al. (1988) used an in-house panel to test the textural attributes of fresh turkey bratwurst. Then the quantitative relationships between the sensory attribute and the ingredients were developed for product optimization.

2.5 FINAL PRODUCT TESTING

After the product had been made successfully in the pilot plant scale production, it should be tested with consumers. In final product testing, researchers may want to compare their new product with a current formula or with the market leader. Marketing information such as price, brand name and packaging can be included in product testing. Product acceptance and purchase intention is normally evaluated at this stage. Aldridge et al. (1983) reported the case history of Knorr seasoning cubes in Nigeria. In final product testing, the researcher used Maggi product, which was in a strong monopoly position at that time, to be compared with the developed product. Monadic test was used in the product testing. Five-point scales were employed to measure consumers' perception on each product.

The product testing can be carried out in a central location or in a home use test. Central location tests usually differ from in-home use tests in terms of testing environment, as well as in the nature and length of exposure to the product. Penny et al. (1972) suggested the use of 'in-home test' for:

* Products whose assessment must be made over a period of time.

- * Products for which a heavy fatigue element may be involved (e.g. highly spiced foods, strong toothpaste, flavours, etc).
- * Products for which in-home factors (e.g. preparation of foods) may be crucial in the overall assessment.
- * Products where usage instructions are followed with varying consistency.

After the consumers have used the product(s) for a period of time, the reaction of consumers toward the tested product may be obtained by a self-completed questionnaire or by an interview. Penny et al. (1972) reported on one experiment designed to compare the results from consumer testing by self-completed postal questionnaire and a face-to-face interview with 2 types of products: washing powder and margarine. They concluded that the results did not differ between these tests.

2.6 GLUE STICK FORMULATION AND PROCESSING METHOD

Adhesive sticks can be divided by their performance into 3 categories: permanent bonding, removable bonding and temporary bonding.

- * Permanent Bonding (Brennan, 1966; Muszik and Dierichs, 1971; and Ando and Yamazaki, 1974)

The adhesive is usually intended to give a permanent bond, i.e. when one surface has been bonded to a receiving surface and the adhesive has dried the two surfaces cannot be separated without tearing the material into pieces. It can be used to stick paper with paper or other materials such as textiles, aluminium foil and porous wood.

- * Removable Bonding (Gollub et al., 1987)

This kind of adhesive can be used for temporary bonding purposes, such as attaching pieces of paper bearing messages to a notice board, desk window or other substrate, the paper being removable without difficulty and without leaving a film of adhesive on the substrate.

* Temporary bonding (Palm, 1989)

For temporary bonded adhesive, the adhesive coated surface can be adhered to a receiving surface and removed from this without leaving traces of adhesive on the receiving surface, and this process can be repeated a number of times.

2.6.1 Raw Materials in Glue Stick Formulation

Adhesive sticks can be produced from rubber, resins and waxes (Brennan, 1966). These components are combined in the form of a pressure sensitive, thermoplastic adhesive which is shaped into an elongated or crayon like body. Muszik and Dierichs (1971) found that with crayons made from rubber, resin and waxes the surface layer must be rubbed off these adhesive applicator crayons under relatively high pressures in order to carry out the spreading of the adhesive. This can cause the crayon itself to break and the paper is damaged during the rubbing of adhesive from the crayon. So they showed that self-supporting adhesive sticks can be formed from alkali metal salts of aliphatic carboxylic acids, water or water-miscible organic solvents and water-soluble or water-dispersible adhesive materials.

Ando and Yamazaki (1974) used the reaction product of sorbitol and benzaldehyde as the gel-forming agent. By using this as gel-forming agent, an adhesive which could maintain a constant hardness and adhesiveness in a wide temperature and humidity range was obtained. It could be readily spread by rubbing it on a surface to be bonded to form a thin and uniform film.

However, it was found that using alkali-metal salts of aliphatic carboxylic acids as gel-forming agents had some disadvantages: no alkali-sensitive substances may be employed and no acid-reacting active components may be added because this would destroy the gel-like supporting structure of the stick. It was recommended that free long chain aliphatic carboxylic acids be used. Particularly preferred were wax acids obtained by oxidation of mineral or petroleum waxes, such as peat wax, montan wax or from ozokerite (Werke H.u.M. Fisher, G.m.b.H., 1974). Hence, adhesives which are active in the acid range, e.g. resin acids or esters of resin acids can be employed.

In general the raw materials used in adhesive sticks can be classified as follows:

- * Adhesive
- * Gel forming substance
- * Solvent

The following raw materials may also be added in the formulation in order to improve some properties of the adhesive stick.

- * Plasticizers
- * Emulsifiers
- * Filler
- * Antifoam
- * Colouring
- * Perfume

2.6.2 Adhesive

Adhesive or film forming substance is the primary component and has the function of holding the substrates, particularly paper, together. The adhesive can be hard resins such as hydrogenated terpenes, polymerized terpenes, phenolic terpenes, polymerized rosin esters, and hydrogenated rosins with melting points of approximately 65 °c. Rubber ingredients which are used as adhesive are hydrocarbon polymers with molecular weights of from about 1,000 to 25,000 (Brennan, 1966).

Adhesive can also be any water- or alcohol-soluble adhesive either natural or synthetic, e.g. polyvinyl alcohol, polymethacrylic acid, polyacrylamide, copolymers of acrylamide, salts of polyacrylic acids, polyvinyl pyrrolidone, ethylene maleic anhydride copolymer, methyl vinyl ether copolymers, carboxylated polyvinyl acetate. The preference of many manufacturers is polyvinyl pyrrolidone (Adhesive Tapes Limited, 1974). Natural carbohydrate polymers or modified carbohydrate polymers, such as starch, dextrin, gum arabic, cellulose, methylcellulose, cellulose esters or carboxymethyl cellulose may also be employed. Mixtures of adhesives may be used. It is particularly preferred to employ polyvinyl pyrrolidone especially in conjunction with 2-6% by weight of a carbohydrate

or modified carbohydrate polymer (Werke H.u.M. Fischer, G.m.b.H., 1974). Adhesive Tapes Limited (1974) reported the use of 10 percent dextrin solution with polyvinyl alcohol as the adhesive substance in glue stick formulation.

2.6.3 Gel Forming or Shape-Giving Substance

Gel forming substances are blended with the binder in an adhesive stick to give a stick which is easy to apply without deformation. It also gives a uniform coating, free from lumps of adhesive on the substrate. However the gel forming agent reduces the tack of the adhesive so the type and the amount of this ingredient must be chosen carefully (Palm, 1989). The following are gel forming agents commonly used:

- * alkali or ammonium salts of aliphatic carboxylic acids with 8 to 36 carbon atoms such as: sodium stearate (Muszik and Dierichs, 1971; Gollub et al., 1987 and Palm, 1989)
- * reaction products of sorbitol and benzaldehyde (Ando and Yamazaki, 1974)
- * wax which can be one or more partly saponified or fully saponified esters of 10 to 30 carbon atom acids with various alcohols, both natural and synthetic, oxidised polyethylene wax, paraffin wax, chlorinated paraffin wax, glycerides of fatty acids, hydrogenated oils and fatty alcohols. The preference is for ester waxes (Adhesive Tapes Limited, 1974).

2.6.4 Solvent

Solvent can be water or water miscible organic solvent or both. Water miscible organic solvents used are one or more mono or multivalent alcohols, e.g. methanol, ethanol, isopropanol, glycerol, ethylene glycol and may include water as in water/organic solvent mixtures, e.g. water/acetone, ester/ethanol (Adhesive Tapes Limited, 1974). Some water is used in most formulations to dissolve the adhesives and other water soluble ingredients

2.6.5 Plasticizers and Emulsifiers

Plasticizers or softening or moisture retaining agents can be used to tackify the adhesive and to control drying out on the substrate to which the adhesive is applied. These substances are also conducive to an easy, soft rubbing. Tri- and tetra-ethylene glycol, sorbitol, mannitol, glucose, glycerol, propylene glycol, polyethylene glycols and polypropylene glycols of molecular weight 400 to 1500 can be used. The preference is for glycerol - up to 25% by weight (Werke H.u.M. Fischer, G.m.b.H., 1974).

The emulsifier can be non-ionic, cationic, anionic or mixtures of these emulsifiers provided that, in combination with the other ingredients, it produces a water in oil emulsion. The preference is for non-ionic emulsifiers, particularly the polyethylene oxide esters of phenols and fatty esters. The emulsifier can also act as a lubricant in the adhesive stick. These substances may be used to increase transparency of the product.

The following are examples of the types of emulsifiers which can be used (Adhesive Tapes Limited, 1974):

Nonionics: polyoxyethylene esters of a phenol, polyoxyethylene esters of a fatty acid, polyoxypropylene esters of phenols and fatty acids, polyoxyethylene esters of phenols and fatty acids, glycerides of fatty acids, sorbitan fatty acid esters, fatty acid amides, natural occurring emulsifiers - lanolin and cholesterol derivatives.

Cationics: ethoxylated amines, quaternary ammonium compounds.

Anionics: soaps, sulphonates, phosphates.

2.6.6 Fillers, Antifoaming Agents, Colours, Perfumes

Fillers are nonadhesive substances added to the adhesive to improve its working properties, strength, permanence, or other qualities. Fillers are also used to reduce materials costs. Considerable changes can be made in the properties of the adhesive by selective use of fillers such as clay, chalk (Pletcher and Wong, 1978).

Antifoam Nopco 8034, an antifoam agent containing silica, mineral oil and a methacrylate copolymer can be added (Palm, 1989). Dye-stuffs, e.g. phthalocyanine blue, may be used to add colour to glue stick (Pletcher and Wong, 1978). Odour improving compounds such as, pine-needle oil, eucalyptus oil, aniseed oil, benzaldehyde, may be used (Muszik and Dierichs, 1971).

2.6.7 Formulation, Processing and Packaging

The composition of the adhesive sticks must be so chosen, that a not too soft mass is formed which may be readily rubbed off. This is usually achieved when the content of the gel forming substance is between 3 and 60% preferably from 10 to 40%. The volatile liquid components of the adhesive sticks normally amount to about 20-80%, particularly 30 to 65% and the proportion of adhesive components normally lies somewhere between 5 and 50%, usually between 20 and 40% (Werke H.u.M. Fischer, G.m.b.H., 1974).

The tougher and more cohesive the formulation, the more difficult it is to separate a film of the material from the crayon body. It has been found that the higher the initial strength of a formulation tested, the more difficult the film of adhesive will be to separate from the crayon (Brennan, 1966). Brennan also added that the formulation with the lower softening temperature will apply a film with less physical effort than the formulation with the higher softening point. For this reason the softening point should be generally kept as low as practical.

Processing methods vary according to the raw materials used in glue stick. The adhesive sticks are usually prepared by mixing the individual components while heating them to 60-95 °C until homogeneous under reflux conditions, the process taking about 7 hours. Then the mixture is allowed to cool in a mould or after extrusion in the desired shape form (Muszik and Dierichs, 1971).

The stick may be conveniently mounted in an applicator of the lip stick holder type. In such a holder it may be readily carried among personal possessions or kept in an office desk for use in light gluing applications such as the sticking together of sheets of paper or cardboard or thin layers of flexible plastic materials. The stick can also be placed in a pencil-shaped holder so that it can readily be carried in a person's pocket.

2.7 USE OF STARCHES IN GLUE STICK

Starch adhesives are suitable for labelling and sealing by high-speed, automatic machinery for manufacturing corrugated boxwood, plywood, envelopes, stamps and gummed tapes. They possess the advantages of low price and can be applied cold or at moderately low temperatures, being reasonably lacking in odour and taste. The latter point makes them especially useful in the food packaging industry or for any use where the adhesive may make contact with the tongue, e.g. envelopes and stamps. The adhesive properties of starch are developed when the starch is gelatinised and then cooled to a gel. The starch gelatinization involves firstly hydration of the starch granules which swell to several times their original size, followed by a change from opaque to clear solution, with a rapid increase in viscosity. Finally the linear molecules of amylose dissolve and diffuse from the ruptured granules. Tapioca starch has a gelatinization temperature higher than potato starch but lower than maize starch, and develops a moderate viscosity during cooking.

Upon cooling the uniformly dispersed matrix forms a gel or a paste-like mass. This three-dimensional gel network is a mixture of swollen granules, microgels of amylopectin and a soluble fraction of macromolecules and amylose. The strength of this network determines the strength and rigidity of the gel. The elasticity of the starch gels is due to the ability of the gel to be stretched to a certain extent without breaking. The gel stability of tapioca starch is much higher compared to cereal starches and hence is preferred for adhesive products. In addition, the higher paste clarity is a desirable property of tapioca starch. For adhesive purposes, the starch gel should retain its water solubility for considerable periods of time. Starch gel obtained from corn starch shows an excessive loss of adhesive properties on aging. This appears to be due to retrogradation of starch molecules. Tuber, root and waxy starch products give starch gels that retain their adhesiveness for long periods of time because of slower rates of retrogradation (Swinkles, 1985).

2.7.1 Uses of Starch and its Derivatives in Adhesive

The physical nature of the native unmodified starches limit the usefulness of starch in many commercial applications. These shortcomings may include the lack of free-flowing properties; insolubility or failure of the granules to swell and develop viscosity in cold water; excess or uncontrolled viscosity after cooking; and the sensitivity of the cooked

starch to break down during extended cooking, when exposed to shear, to low pHs or high pHs (Wurzburg, 1986). There are many effective ways to overcome these shortcomings and thus expand the usefulness of starch for a number of industrial applications. Starch can be modified by depolymerization reactions, cross-linking reactions and stabilization (Fleche, 1985).

Depolymerizing a starch reduces its viscosity and consequently, allows its use at a higher level of dry solids. This can be done by dextrinification, acid conversion, alkaline conversion or oxidation, thermochemical liquefaction, and enzyme-produced liquefaction.

Cross-linking or bridging the molecular chains, leads to a more rigid macromolecular network inside the granule. This reaction, while limiting granule retention capacity, sets the viscosity level to the desired value, provides greater resistance to thermomechanical shearing, improves stability in acid media (Fleche, 1985). In industry, those starches with gels resistant to mechanical shearing and to various media (acid, basic, or salts) can be used in corrugated cardboard, in textile printing pastes, in adhesives and in other applications.

The stabilization of starch reduces the hydroxyl number and decreases the reassociation of the molecules. Consequently, retrogradation is slowed down and starch stability increases, particularly at low temperatures. Esterification or etherification provides stabilization, although most of the commercially modified starches are cross-linked and stabilized.

Apart from modification, starch can be made into dextrin. The term dextrin covers products produced in a variety of ways. In its broader sense it refers to all degradation products of starch without reference to the manner in which they are produced. Thus, dextrin may refer to the degradation product produced by enzymatic, as well as acidic catalyzed, hydrolysis run in aqueous medium on granular or peptide starch or by pyrolysis of starch in the dry granular form. They may range from slightly degraded starch polymers to highly degraded polymers of anhydroglucose units. Three primary groups of dextrans are now known: British gums, white dextrans and yellow dextrans. All are made by heating powdered starch. They differ in the manner in which the starch

is treated prior to the heat treatment, the manner and extent of heating, and the properties of the resulting products (Wurzburg, 1986).

These modified starch and dextrins are used in numerous adhesive applications. Cross-linked starches are used in corrugating adhesives to provide high viscosity under strongly alkaline conditions (Rutenberg, and Solarek, 1984). Dextrins are used in Tube winding, laminating, case and carton sealing, bottle labelling, flat gumming, envelope sealing, and gummed tape manufacture.

2.7.2 Use of Tapioca Starch in Thailand

Tapioca starch has the same general properties as other kinds of starch and so it makes a good substitute. It does have one feature which is of interest. Tapioca starch contains very little protein, thus it is a fine material to start with in industrial processes which transform starch into other substances. Fewer steps are required and this means lower production costs.

Tapioca starch can be converted into sugars - glucose and fructose and because of this, it is widely used in the preparation of a variety of foods. It is also used as a raw material in producing monosodium glutamate. In addition, thanks to its qualities as a thickener, a hardener, and adhesive, and a moisture stabilizer, tapioca starch finds applications in the manufacture of many different materials. including glues, plywood, textiles, paper and medicines.

Tapioca starch has been used in making many kinds of tasty Thai sweets and other foods and nowadays tapioca starch is also widely used in many of the commercially prepared foods and confectionary products sold in shops and department stores. Tapioca starch is an ingredient in, for example, bakery products, sausages, bean vermicelli, rice noodles, tonic food beverages, ice cream, and many types of candies (TTTA, 1990).

One of the important end use of tapioca starch is adhesive application. It can be simply gelatinized in hot water or with the help of chemicals. Tapioca is considered more suitable for the manufacture of adhesive in that it gives adhesives which are more

viscous, smoother in working and more easily prepared, whilst the joints made from these adhesives give a higher tensile strength than those made from potato or maize starches (Radley, 1976).

2.7.3 Use of Starches in Glue Stick Formulation

Adhesives which are now commonly used in glue stick can be either water- or alcohol-soluble. Although polyvinyl pyrrolidone (Adhesive Tapes Limited, 1974) is more commonly used, mixtures of adhesives may be used. It is preferable to employ polyvinyl pyrrolidone in conjunction with 2-6% by weight of a carbohydrate or modified carbohydrate polymer (Werke H.u.M. Fischer, G.m.b.H., 1974).

Although it was mentioned that starch and starch derivative could be used in glue stick formulation (Werke H.u.M. Fischer, G.m.b.H., 1974), there was no report on which type or form of starch was suitable and at what level. Tapioca starch was chosen as a substitute for synthetic adhesive in glue stick formulation, firstly because tapioca is a raw material produced largely in Thailand, secondly, tapioca starch has low retrogradation tendency, and good sol stability. Tapioca starch products give starch films that retain their adhesiveness for longer periods of time compared with starch films from other starch such as corn and wheat starch which show an excessive loss of adhesive properties on aging due to retrogradation of starch molecules (Swinkels, 1985). Therefore, tapioca starch or a derivative of tapioca starch was considered suitable for using as an adhesive substance in glue stick. There was no mention found in the literature on the use of tapioca starch in glue stick. Hence, the suitable level of the tapioca starch as well as other starch compatible basic ingredients in glue stick formulation had to be investigated.

2.8 TESTING OF GLUE STICK PROPERTIES

No standard method for glue stick testing was found in the literature. There were reports showed that researchers had used physical testing to determine the performance of the products during the development of glue sticks (Ando and Yamazaki, 1974; and Pletcher and Wong, 1978). Although the usage properties perceived by the consumers

had been mentioned (Muszik and Dierichs, 1971; and Palm, 1989), no sensory evaluation had been involved in the development of this product.

The important physical properties of glue stick which are normally tested can be grouped into 4 main categories: characteristics of the stick itself, amount of glue applied on paper, initial adhesion, and adhesion after drying. The physical properties which have been tested are as follows:

2.8.1 Stick characteristics

The softening temperature was determined using a Fisher-Johns melting point apparatus set to rise in temperature at a rate of 2 °C per minute. The temperature at which the material softens and starts to turn translucent. The softening temperature of at least about 40 °C was recommended so that the stick will not become too tacky or fluid to hand hold or store. Although no mention was found on maximum softening temperature, an unduly high softening temperature will render the adhesive difficult or impossible to friction activate and will detract from other properties (Pletcher and Wong, 1978).

Hardness was measured according to Japanese Industrial Standard (JIS) K 2530 by using a penetrometer as used for asphalt and was shown by a depth of penetration for 3 seconds of a needle loaded up to 46.3 g in total weight (Ando and Yamazaki, 1974).

The shape-stability was shown by the number of cycles of putting an adhesive crayon out and in repeatedly, which was packed in a cylindrical container of 15 mm in diameter, made of polyethylene and provided with a screw used for putting out and in a content, by operating the screw until it became impossible to set the crayon in the container (Ando and Yamazaki, 1974).

2.8.2 Amount of glue applied on paper

The write-on factor relates to the quantity of adhesive which is deposited on the substrate while rubbing. The physical effort required in rubbing should be neither too

high nor too low. If the effort required to transfer a given amount of adhesive is too small, it is likely that too much adhesive will be applied (which is wasteful and can be messy). On the other hand, if the effort required to transfer a given quantity of adhesive is too great, inadequate adhesive will be transferred to the surface to be adhered to allow a firm bond to be achieved.

The write on factor is measured utilizing an apparatus with an oscillating base and in which an adhesive stick can be mounted vertically above and resting on the base. An adhesive stick approximately 1 cm by 1 cm in cross section and about 5 to 8 cm long is mounted in the apparatus and the bottom is flattened by running it against a piece of paper clamped to the oscillating base. The adhesive stick is then weighed and replaced in the apparatus. A sample of 100% rag paper with a 20 lb basis weight and a cockle finish is then clamped to the base and the base is set into motion at about 220 cycles per minute, the total distance travelled by the base being 6.9 cm per cycle. The preflattened end of the adhesive stick to be tested is lowered onto the oscillating base, the stick being pressed against the base with a force of about 2,720 g. After 18 cycles the adhesive stick is lifted from the paper and reweighed. Its loss of weight in grams during the 18 cycles is the write on factor. The recommended write-on factor was at least 0.06 g per 18 cycle (Pletcher and Wong, 1978).

2.8.3 Initial adhesion

The open-time is the interval during which the adhesive remains bondable after being cooled below the softening temperature i.e. after rubbing finished. This should be sufficiently long to allow the pieces which are to be adhered to be positioned in contact but not so long that there is an undue wait for the firm bond to develop. An open time of from about 20 seconds to 10 minutes was recommended. Preferably the open time of the glue stick is at least about one minute.

The open time is determined utilizing the same apparatus and sample preparation as in the procedure for determining the write on factor. The adhesive stick is run against the rag paper for 18 cycles to heat the adhesive on the end of the stick above its softening temperature and to transfer it to the rag paper sample on the base. As soon as the rubbing is stopped the adhesive on the rag paper sample cools to a temperature

below its softening temperature. Thus, the open time for a particular adhesive stick is the elapsed time between the end of the rubbing cycles and the point at which the adhesive on the rag paper reverts to its non-bondable state. Whether the adhesive is still bondable after a particular interval is determined by placing a strip of 80 lb basis weight construction paper in contact with the adhesive on the rag paper sample and pressing it down with four passes (twice in each direction) of a two kilogram roller. The composite sample is allowed to stand for thirty minutes and the two pieces of paper are then pulled apart. If delamination occurs, the adhesive was in the open state when the construction paper was applied. The open time for an adhesive stick is the maximum interval between the end of the rubbing cycle and the application of the construction paper to the adhesive on the rag paper which results in bonding. To determine this, several composite samples must be prepared and tested for delamination. The open time is ordinarily determined to an accuracy of at least about 10% (Pletcher and Wong, 1978).

The initial adhesion was measured by observing the breaking state of paper layer, which is occurred by peeling rapidly a sheet of craft paper of 25 mm x 100 mm in size, 0.13 mm in thickness and 68.5 g/m² in weight, bonded to another sheet of the same craft paper by applying an adhesive and fixing the both sheets and then pressing for a certain period by means of a rubber roll loaded up to 30 kg in total weight (Ando and Yamazaki, 1974).

The peel adhesion or peel strength in the open state is desirably great enough to hold the two pieces to be adhered (e.g. paper) together against their own weight, but low enough to allow repositioning of the pieces without damaging them by delamination.

The 180° peel adhesion is tested on an apparatus of the type described in 'Test Methods for Pressure Sensitive Tapes' by the Pressure Sensitive Tape Council, Illinois, and using a sample prepared as follows:

An 0.13 mm (5 mil) thick film of the adhesive to be tested is knife coated onto a silicone release liner, the coating knife and the (molten) adhesive being at about 120 °C. After cooling, the coated material is cut into 2.54 cm strips approximately 20 cm long. A composite test sample is prepared by placing the following on a 10 cm by 20 cm tin plated steel panel in the listed order: a 2.5 cm by 20 cm 100% rag paper as described

above, the 2.54 cm by 20 cm adhesive strip (with silicone liner removed), a 2.5 cm by 20 cm by 0.05 mm thick strip of aluminum foil (the dull side of the foil against the adhesive strip) and a 10 cm by 20 cm glass plate. The assembled test sample is placed in an oven at about 80 °C for eight minutes. Thereafter the steel panel and the glass plate are removed and the sample is placed in a 21 °C, 50% relative humidity atmosphere for testing. The open state peel adhesion is run 5 minutes after removal of the sample from the oven. The carriage of the adhesion machine is set to move at a rate of about 229 cm (90 inches) per minute. The strip of 100% rag paper is attached to the carriage with double coated tape. The adapter ring leading from the meter on the machine is attached to the aluminum foil. The carriage is started and the value observed from the gauge is recorded as the adhesion value in grams per centimetre. The peel adhesion in the open state should not less than about 50 g/cm. (Pletcher and Wong, 1978).

2.8.4 Adhesion after drying

The peel adhesion in the closed state is desirably great enough to hold the pieces together strongly but not so great that the adhesive cannot be removed from desk tops and the like.

The closed state peel adhesion is run 24 hours after removal of the sample from the oven using the same procedure as the open state peel adhesion. The peel adhesion in the closed state should not less than about 100 g/cm. (Pletcher and Wong, 1978).

Ando and Yamazaki (1974) measured the peeling strength by using an Instron in the manner of peeling an aluminum foil of 0.06 mm in thickness, which was bonded to another same foil of 25 mm X 100 mm by applying an adhesive on the surface of either foil within an area of 25 mm x 25 mm at 20 °C and 65% relative humidity and fixing two foils and then pressing at a pressure of 50 kg/ 25 mm x 25 mm, under the conditions of tensile rate of 200 mm/mm and peeling angle of 180°.

The shearing strength was measured on the sample, prepared in the same manner as the sample used in the test of peeling strength, under the conditions of a tensile rate of 10 mm/mm and a shearing angle of 0° (Ando and Yamazaki, 1974).

2.9 CONCLUSIONS

Although tapioca starch is widely used in the adhesive industry, no mention was found on the use of tapioca starch in glue stick formulation. According to the literature, natural carbohydrate polymers such as starch and starch derivatives could be used upto 6% in combination with polyvinyl pyrrolidone. Therefore, it was decided to explore the use of tapioca starch as substitute of polyvinyl pyrrolidone which was the most commonly used adhesive substance in glue stick.

In the development of glue stick using tapioca starch as adhesive substance, it was necessary to select the suitable basic raw materials at the right levels using proper processing method. The effects of ingredients on glue stick attributes had to be identified. The suitable testing methods for glue stick attributes, both the physical and sensory attributes, had to be established.

In this project, consumer acceptance of the product was the vital key to its success. Although consumers have been employed in optimization of various products, there has been no investigation into the stages where consumer input is useful in developing adhesive products especially glue stick products. The important attributes of this product also had to be identified so it was possible to assess the consumer acceptability of the product.

Linear programming was selected as optimization technique because it provided a means of determining optimum formulation relatively quickly and efficiently and sensory constraints including acceptability constraint obtained from consumer panel can be included.

CHAPTER 3

PROJECT METHODS

In this chapter, the optimization procedure used in the research is outlined and details of some of the stages in the project shown in Figure 3.1 will be described. Since the methods used in this project were different in nature, this chapter discusses the project methods in general, while specific methods and techniques for certain stages are discussed in the chapters associated with them.

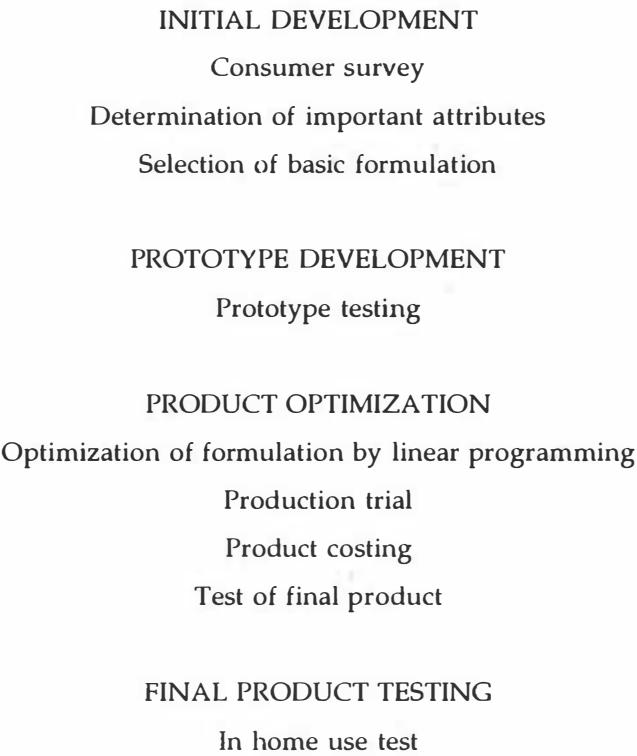


Figure 3.1 Stages of glue stick optimization

3.1 CONSUMER STUDY

Two major types of consumer study methods were used in the project: consumer survey and consumer panel testing.

3.1.1 Consumer Survey

Consumer survey was used at the beginning of the glue stick optimization process in order to gain information on how consumers perceived glue sticks already on the market and what were the important attributes of this product according to the consumers.

The consumer survey was done in two sections: preliminary survey in New Zealand with Thai consumers and New Zealand consumers and the survey with the target consumers in Thailand. Details are given in Section 4.2.

3.1.2 Consumer Testing

The consumer testing was conducted in Bangkok with the target consumers - students (school and university students) and office workers. The consumer testing was divided into laboratory testing and home-use testing. Ninety consumers were used in laboratory testing and 172 consumers were used in home-use testing. In laboratory testing, the sensory product profile technique was used. In home-use testing, a self-administered questionnaire with multiple-choice questions as well as open-ended questions was employed. Details are given in Section 6.4.

3.2 SENSORY TESTING OF GLUE STICKS BY TRAINED SENSORY PANEL

A trained sensory panel was used during selection of the basic formulation. This enable the author to be able to identify the suitable basic formulation for starch based glue stick before the prototypes were tested by the consumer panel. The sensory panel training comprised 3 parts: selection of panelists, development of descriptive terms, and training of panelists.

3.2.1 Panel Selection

The questionnaire used for panel selection was adapted from a prescreening questionnaire for a tactile panel (Meilgaard et al., 1987b) and a scaling questionnaire was used to test the candidate's potential to learn scaling (see Appendix 3.1).

In order to be qualified at this stage the candidates had to:

- * Be available for the training sessions.
- * Answer 80% of the verbal questions correctly and clearly.
- * Assign scalar ratings which were within 10% of the correct value for all figures.

Candidates, 15 students in the Consumer Technology Department, Massey University, New Zealand, were invited to attend the panelist selection session. These candidates were those who were interested in participating in the sensory project and were available for sensory testing when needed. They had never been trained as a sensory trained panelist, but most of them had done sensory testing and knew how to use the line scale which was employed in this study. They were informed that 7 dollars per hour would be paid for those who attended the panel training. Fifteen panelists were screened at this stage and only one candidate was not qualified.

The triangle test was used to select panelists who had ability to discriminate products. Sequential triangle tests as described by Meilgaard et al. (1987a) were used in order to economize in the number of evaluations required. These tests are very practical and efficient because they take into consideration the possibility that the evidence derived from the first few evaluations may be quite sufficient to draw a conclusion. Four commercial glue sticks and four glue stick prototypes prepared in the laboratory were used in the test. Four subjects were rejected from this testing. The other subjects were asked to attend the training session for glue stick sensory testing and test prototype products during the development of the basic formulation for starch based glue stick.

3.2.2 Development of Descriptive Terms

Ten selected panelists, 6 men and 4 women, were asked to attend the descriptive term development which comprised two one-hour sessions. The objective of this part of the training was to develop descriptive terms and their definitions for the sensory attributes of glue stick.

During the first session, panelists were presented with 6 commercial glue sticks and were asked to use the products in the same manner as they normally did, then they wrote down the sensory attributes of the products for the following categories: - appearance, sensory attributes while applying glue, glue residue on paper, stickability, effect on paper. Odour and packaging attributes were not included in the study. Fifty three terms were developed. Panelists then discussed the terms developed, deleted the terms which had the same meaning and changed some terms to make them easier to understand both for the trained panelists and for consumers in the future work. There were 25 terms altogether at the end of the session (see Appendix 3.2).

In the second session, panelists developed the definitions for the descriptive terms. It was necessary that the definition of each term was developed so that every panelist agreed on the definition, and used these terms in the same way during the sensory testing of the product. In the first place, some panelists did not agree with the developed definition, they had to discuss it and modify the definition until everyone agreed with it.

In this session, panelists also developed the adjective terms describing the intensity of the sensory attributes. They had to make decisions on which terms should be on each end of the scale in order that everyone understood the scale and did not mark on the wrong part of the scale.

3.2.3 Training of the Panel

Panelists were invited to the training sessions, each session lasted about one hour. The panel was divided into two groups with 5 panelists in each group to make it easy for the panel leader to manage and so that the panelists could chose to join the session

when they were available. Panelists were circulated between groups so they had a chance to work with different panel members.

A 15 cm semi-structured line scale anchored at both ends was used. For descriptive terms whose intensity could be varied from none to all, the line scale was anchored at both ends. For the terms whose intensity varied from very weak to very strong, the scale was anchored at 1.5 cm from both ends.

The descriptive terms for product attributes developed in Section 3.2.2 were used during the panel training. Only those terms describing sensory attributes perceived while applying, glue residue on paper, effect on paper, and stickability were used. There were 18 terms used in the training.

Samples used in the training were commercial glue sticks. They varied in many sensory attributes so that the panelists could experience what constituted the extreme intensities for many of the attributes. Each sample was coded with 3 digit random number.

The testing procedure started with a panelist orientation on the sensory testing method. Each panelist was asked to read the instructions and the questionnaire before performing the test. The definition of each sensory attribute term in the questionnaire was explained by the panel leader to make sure that everyone understand it clearly. If any panelist did not fully understand any sensory attribute term, it was explained until the term was clearly perceived.

In general, sensory testing should be conducted in a room which is partitioned into separate booths, in order to avoid subject-to-subject influences. However, in this study, no such room was available and also during the training an overhead projector was needed so a seminar room was used. Lighting for the testing area was uniformed and provided by daylight fluorescent lamps so that panelists could perceived the glue residue on paper and the effect of glue on paper. The panelists were seated separately during sample evaluation to avoid any distraction.

A set of samples was presented to the panelists, they were told to wash their hands before the testing so that there was no dirty mark on the paper during testing. Every

subject was instructed to evaluate the product in the same manner. Firstly wind up the stick so that the end of the stick comes out about 0.3-0.5 cm, and hold the stick 90 degree to the paper surface then rub the stick along the surface of paper and spread adhesive to cover the area to be bonded using back and forth strokes. After finishing one set of rubbing, panelists were asked to clean the tip of the stick every time in order to get rid of the part that might disintegrate from the stick.

For the effect on paper and stickability attributes, the panelists were asked to apply glue on a piece of paper then place this coated paper on top of another piece of paper and rub repeatedly with fingers, then evaluated the attributes.

Bond strength was evaluated both before drying (as soon as the rubbing finished) and after drying (30 minutes after rubbing). In order to allow 30 minutes drying time for bond strength after drying, panelists were asked to use the sample to stick the given papers together at the beginning of the test then evaluate the bond strength after drying at the end of the test.

In the training method, the panelists were trained in four sessions. Each session lasted about one hour. At the end of each session, the panelists compared their scores by transferring their scores onto the overhead projector. If their score was different from the others they were asked to test the sample again and explain how they tested and evaluated the sensory attributes. If their testing method was different from the other panelists they had to change their method. After that they could change their score if they wanted.

In the first three sessions, 3 samples were presented to the panel. For the first training, the panelists evaluated the samples in an open session so they could compare their scores with other members in the group, discuss the testing method and the terms which were used to describe glue stick sensory attributes. The panel leader also motivated the panelists to use the whole scale, if from the results, they used only some part of the scale.

At the end of the third training, one of the three samples was selected to be a reference. The average scores obtained from the panel for that sample were used as reference

attribute scores. Panelists were asked to test the reference sample again. Then they were asked whether they agreed with the given scores. The scores were adjusted until everyone agreed.

In order to reduce the number of sensory attributes to be tested, some attributes were dropped at this stage. Those attributes were spreadability, stickiness, evenness, wetness, and visibility of glue residue trail the paper.

In the fourth training session, only 13 sensory attributes were used. These terms and their definitions are shown in Figure 3.2. Reference attribute scores were marked on the line scale in the questionnaire beforehand. The questionnaire is shown in Appendix 3.3. Panelists were asked to test the reference sample and they were asked to mark the scores for the reference if they did not agree with the specified scores. They were then asked to test 4 samples, 2 samples were previously used in the first three sessions, the other two samples the panel had not tested before.

The reference was used in order that panelists had something to refer to during testing the samples. The results from different testing could be compared; if scores of the reference were much different in different tests, the scores had to be analyzed carefully.

3.2.4 Use of Trained Panel

The trained panel was used to test the product prototypes developed in New Zealand, during the selection of the basic formulation for starch based glue stick.

SENSORY ATTRIBUTES WHILE APPLYING GLUE STICK

*** Ease of applying** Rub the stick along the surface of paper and spread adhesive to cover the area to be bonded.

Slipperiness - The feeling of force between working surface of the stick and paper while rubbing the stick along the paper. Rated as 'drags - slips'.

*** Perceive attribute of the stick while applying**
While using the stick the following attributes are evaluated:

Hardness - Perceive hardness of the stick. Rated as 'very soft - very hard'.

Deformation - Tendency to deform when apply with hard force. Rated as 'low - high'.

Disintegration - The tendency to disintegrate when apply with hard force. Rated as 'low - high'.

GLUE RESIDUE ON PAPER The following attributes are evaluated by visual inspection

Degree of coverage - Degree of adhesive cover the area of paper after applying one coat. Rated as 'none - total'.

Thickness - Amount of adhesive left on paper after applying one coat. Rated as 'very thin - very thick'.

Visibility of glue trail - Ease of seeing the glue trail. Rated as 'invisible - very visible'.

EFFECT ON PAPER Place another piece of paper on top of the coated paper and rub repeatedly with fingers then evaluate effect on paper by feeling the surface of the papers with fingers and using visual inspection.

Smoothness - Unevenness of paper surface may cause by moisture or lump of adhesive. Rated as 'very wrinkly - very smooth'.

Cleanliness of work - Adhesive residue left on top surface of (degree of stain) paper which makes paper dirty and sticky. Rated as 'very dirty - very clean'.

STICKABILITY

Adjustability - Ease of repositioning the paper. Rated as 'very difficult - very easy'.

Bond strength - Strength of adhesive bond between two surfaces. Rated as 'very weak - very strong'.

 Before drying - Evaluate by peeling bonded paper immediately after two surfaces are placed to contact each other.

 After drying - Evaluate by peeling after adhesive dried out (30 minutes after placing two surfaces to contact each other).

Delamination of paper - Degree of delamination of paper after peeling the bonded papers. Rated as 'none - all'.

Figure 3.2 Descriptives and their definitions used by trained panel

3.3 PHYSICAL TESTING

The test methods used during development of glue stick products were chosen from the existing methods such as American Standard Testing Method (ASTM, 1991), standard test methods from 3M, a reliable organization (Pletcher and Wong, 1978), test methods developed by researchers or companies for similar products (Ando and Yamazaki, 1974). However, in some cases the new methods were developed for the product testing in order to cover all the tests necessary for the product.

3.3.1 Choosing the Physical Testing Methods for the Product

Several factors were recognised in choosing the physical test methods for glue sticks - correlation of physical tests and consumer reactions, need for simple tests for routine quality control, reliability and precision. As glue stick is a consumer product, the physical test should allow the researcher to estimate the reaction of consumers toward the use of product. The substrate used in product testing should be the substrate which represents the one that will be used with finished product, in this case paper. The testing methods should also be appropriate for routine testing since they are used as performance quality control tests. The number of test methods should be as small as possible but covered all the necessary product characteristics. Reliability and precision of the methods were important factors to be considered as well.

The physical testing methods used in this project were:

- | | |
|-----------------------------------|---------------------|
| * Properties of the stick | - hardness |
| | - melting point |
| | - moisture content |
| | - water activity |
| * Amount of glue applied per area | - wet glue per area |
| | - dry glue per area |
| * Stickability | - open time |
| | - peel strength |

3.3.2 Hardness

Hardness of glue stick had an impact on ease of applying. If the stick was too hard, high pressure was required for application, the stick itself could break or the parts to be glued together, such as thin paper might be damaged during a rubbing. If the product was too soft, there would be too much glue left on the paper.

The Instron Universal Testing Instrument Model 4502 (Instron Corporation, Massachusetts) was used to measure hardness of glue stick. Compression force measurement was conducted, see diagram in Figure 3.3. A 3 mm diameter probe was driven onto the sample (1.5 cm diameter and 3 cm length) at crosshead speed 10 mm/min. The depth of penetration was preset so that each test had the same mechanical parameters. The maximum load was measured. Three replications were conducted for each sample and the average data was used.

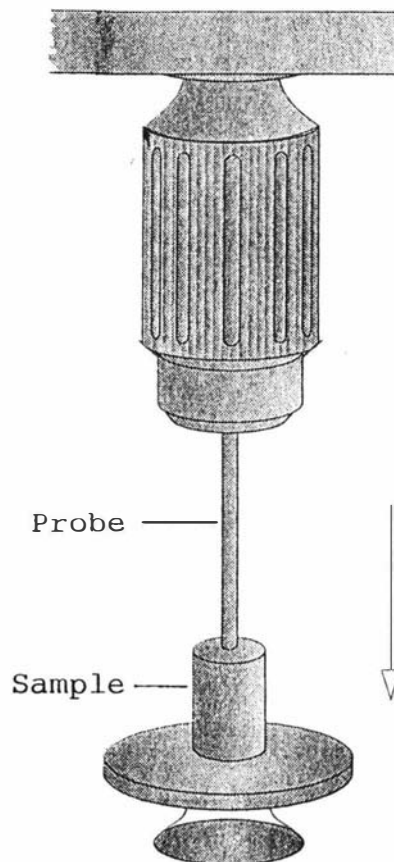


Figure 3.3 Hardness testing diagram

3.3.3 Melting Point

Melting point was measured to determine the temperature at which the stick began to change from solid phase to liquid phase. This indicated the temperature at which the stick became soft and might lose its shape if applied with a hard force.

Melting point was measured using Sofi 6920 hot stage melting point measurement (Leitz Wetzlar, Germany). A small sample was mounted on a slide and covered with a coverglass. This sample was then gradually heated at the rate of 2 °C per minute. The temperature at which glue became transparent was measured. Two replications was conducted for each sample.

3.3.4 Moisture content

Moisture content measured in this study included moisture and other volatile substances in glue stick. The moisture content was determined by weighing approximately 2 g of the glue stick sample into an aluminium moisture dish, which had been dried in the drying oven at 100 ± 2 °C for three hours and cooled for one hour in a desiccator beforehand. The moisture dish and the sample was weighed, with the lid in place, to the accuracy of 0.0001 g. Then the moisture dish which contained the sample was dried in the oven at 100 ± 2 °C for 24 hours with the lid opened. After cooling in a desiccator for one hour, the lid was replaced and the moisture dish with the dried sample was weighed. The weight loss was calculated as the moisture content in percentage. Two replications were conducted and the average data was used.

3.3.5 Water activity

Water activity of the sample was measured using CX-1 water activity meter (Decagon Device, Inc., Pulman, Washington, D.C.). The sample was placed in a disposable sample cup until it filled half the cup (about 3-4 grams of sample was used.) Then the sample cup was put in the sample drawer. When the sample reached equilibrium, the water activity was read from the display.

3.3.6 Amount of Glue Applied per Area

This method was adapted from the ASTM standard testing method D898-90 ‘Applied weight per unit area of dried adhesive solids’ (ASTM, 1991a). The amount of glue applied per area indicated how much glue was deposited on the paper while applying. The amount of glue should be neither too high nor too low. If too much glue was left on the paper, it was wasteful, messy and caused wrinkling of the paper, if too small an amount of glue was left on the paper there was inadequate glue to make a strong bond between surfaces and the consumer had to rub the glue onto the paper many times which could cause damage to the paper.

The paper used for this test was the 80 g/m² white paper normally used for report writing or photocopying. The surface area of each test paper (6 cm x 6 cm) was calculated to an accuracy of 1%. Then the paper was conditioned at 23±1 °C and 50±5% relative humidity for 48 hour. The weight of the test paper was determined to the accuracy of 0.0001 g.

Thirty six strokes of adhesive were applied on the conditioned paper. The paper was reweighed immediately. Then the coated paper was dried in the drying oven at 100±1 °C for 14 hours. At the end of the heating period, the paper was removed to a desiccator and cooled to room temperature. Then the paper was weighed immediately upon removal from the desiccator. Three replications were tested for each sample and the average data was used.

The weight of adhesive applied was calculated as follows:

$$S = [(W_1 - W_0) / A]$$

where

S = weight of wet adhesive applied, expressed in g/m² of surface area

W₀ = original uncoated weight of the paper (g)

W₁ = weight of paper (g) immediately after application of the adhesive

A = area of test paper, m²

This measurement gave the amount of glue applied per surface area (wet glue per area). From this data, it was possible to know how much glue residue was left on the paper after a number of applications.

The weight of dry adhesive applied was calculated as follows:

$$D = [W_2 - W_0(1 - k)/A]$$

where

D = weight of dry adhesive applied, expressed in g/m^2 of surface area

W_2 = weight of paper (g) after application of the adhesive and elimination of solvents,

k = a factor applied to correct for changes in paper weight that occur during the solvent elimination process. It was obtained by weighing an uncoated paper and then exposing it simultaneously with the coated paper to the solvent evaporation procedure. The average k was obtained from five replication.

k was calculated as follows:

$$k = (M_0 - M_1)/M_0$$

where

M_0 = original weight of duplicate paper, and M_1 = weight after exposure to solvent elimination.

This measurement gave the amount of dry glue applied per surface area (dry glue per area). This indicated how much glue residue was left on the paper after drying.

3.3.7 Open time

The open time was the interval during which the adhesive remained bondable after being applied onto the paper. The open time had to be sufficiently long to allow the pieces which were to be adhered to be positioned in contact but not so long that there was an undue wait for the firm bond to develop. Preferably the open time of the glue stick was at least about one minute, with a maximum of 10 minutes (Pletcher and

Wong, 1978).

The paper used for testing of open time was 5 cm x 5 cm of 80 g/m² paper. To determine open time, 18 strokes of the glue stick sample were applied on 3 cm x 3 cm area of the test paper. The open time for an adhesive stick was the elapsed time between the end of the rubbing and the point at which the adhesive on the paper reverted to its non-bondable state. Whether the adhesive was still bondable after a particular interval was determined by placing a piece of 3 cm x 3 cm 80 g/m² paper in contact with the adhesive on the first piece of paper and pressing it down with four passes (twice in each direction) of a 2 kg roller. The composite sample was allowed to stand for 30 minutes and the two pieces of paper are then pulled apart by hands. If delamination occurred, the adhesive was in open state when the other piece of paper was applied. If delamination did not occur, the adhesive had already reverted to the closed, nonbondable state before the other piece of paper was applied. The open time for an adhesive stick was the maximum interval between the end of the rubbing cycle and the application of the paper to the coated paper which resulted in bonding - the adhesive was still in bondable stage. To determine this, several composite samples had to be prepared at different intervals and tested for delamination.

3.3.8 Peel Strength of the Adhesive Bond

Stickability is one of the most important attributes of glue products. This attribute was tested to make sure that the glue did its job properly i.e. stuck two pieces of substrates together. The substrate used in the test depends on the purpose of glue usage. Since the glue stick developed in this research was to stick paper together, paper was used as test substrate.

The test method was from the ASTM standard testing method D903-49 (ASTM, 1991b). The test sample consisted of one piece of paper, 1 in. x 12 in. (25 mm x 304.8 mm), coated with 10 strokes of adhesive for 6 in. (152.4 mm) at one end and bonded to another piece of paper, 1 in. x 8 in. (25 mm x 203.2 mm), with the unbonded portions of each member being face to face. Samples were conditioned for 7 days by exposure to a relative humidity of, 50±2 % at 23±1 °C.

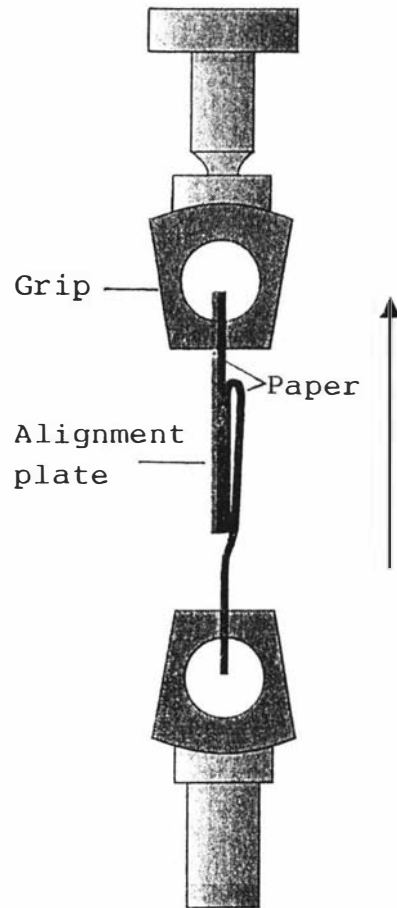


Figure 3.4 Peel strength testing diagram

The sample was placed in the Instron Universal Testing Instrument Model 4502 (Instron Corporation, Massachusetts) by clamping the free end of the 8 in.-long paper in one grip, the free end of the 12 in.-long paper was turned back and clamped in the other grip (see Figure 3.4). The test paper was maintained approximately in the plane of the clamps during the test. This was done by holding the paper against an alignment plate attached to the stationary clamp.

The separating members of the sample were stripped approximately at an angle of 180 degree. The rate of travel of the power actuated grip was 12 in. (305 mm)/min. This rate which provided a separation of 6 in. (152.4 mm)/min had to be uniform throughout the test. The sample was peeled at least one half of the bonded area, even though a peel strength value had been indicated before this point. The maximum peel strength was recorded. This measurement indicated the strength of bond after drying.

3.4 INGREDIENTS AND THEIR PROPERTIES

3.4.1 Starches

The raw starch used in this study was obtained from First Victor Co., Ltd., Bangkok, Thailand. The modified tapioca starch used in this study was 'National Frigex' which was cross-linked and stabilized starch. This type of starch could withstand the high temperature in an alkaline system without changing in colour. The modified tapioca was obtained from National and Chemical Starch Ltd., Auckland, New Zealand for the laboratory scale experimentation and from National and Chemical Starch Ltd., Bangkok, Thailand for the pilot scale production.

3.4.2 Polyvinyl Pyrrolidone

Polyvinyl pyrrolidone (PVP) is prepared by the polymerization of N-vinyl-2-pyrrolidone, a colourless liquid. It is manufactured in four viscosity grades identified by their K-value, which are approximately K-15, K-30, K-60, and K-90. The number average of the molecular weights for these grades are about 10,000, 40,000, 160,000, and 360,000, respectively.

The PVP used in this study was GAF PVP K-90 with average molecular weight 360,000. The sample was obtained from ISP (Australasia) Pty. Ltd. and ISP (Hongkong) Ltd., Bangkok representative office.

3.4.3 Glycerol

Glycerol is used as plasticizer in adhesives to impart the finished film characteristics to adhesives. It makes the film dry slowly without becoming brittle. The quality of the plasticizer and its level of use must be such that it gives the desired bond flexibility without excessive stickiness or blocking. Glycerol is a better plasticizer than are sugars and does not cause darkening of the bond with age. The glycerol used in this study was Glycerine BP (GLY 510) from Bronson and Jacobs Limited, Auckland, New Zealand.

3.4.4 Stearic Acid

Stearic acid was used in the glue stick in order to react with sodium hydroxide in the system to give sodium stearate which acted as a gel forming agent in glue stick. Stearic acid is reported to increase starch gelatinization temperature. The stearic acid used in this study was stearic acid STE 922 obtained from Bronson and Jacobs Limited, Auckland, New Zealand.

3.4.5 Sodium Hydroxide

In the glue stick formulation, sodium hydroxide reacted with stearic acid and gave sodium stearate which performed as the gel forming agent in the system. The sodium hydroxide used in the laboratory scale experimentation was laboratory grade sodium hydroxide from BDH Limited, England. The sodium hydroxide used in the pilot scale was industrial grade obtained from Arsrom Co., Ltd., Bangkok.

3.4.6 Glyceryl Monostearate

Glyceryl monostearate was used as an emulsifying agent in the system. The glyceryl monostearate was Lexemul 561 (LEX 657) obtained from Bronson and Jacobs Limited, Auckland, New Zealand.

3.4.7 Brij 35

Brij 35, polyoxyethylene lauryl, was used as an emulsifying agent. It was a non-ionic

surfactant stable in acid and alkaline solution. The Brij 35 used in this study was obtained from BDH Limited, England.

3.4.8 Dextrin

Dextrin sample was Dextrin MW obtained from N.Z. Starch Products, Ltd., Auckland, New Zealand. It was white dextrin with 10% moisture content. Its viscosity at 17% solid, 40°C, was 25.0-40.0 cp.

3.4.9 Casein

Sulfuric acid casein was obtained from New Zealand Dairy Research Institute. Its molecular weight was 20,000. The casein sample contained 10% moisture content. Its viscosity at 15% solid, 25 °C was 30 poise.

3.5 PROCESSING OF GLUE STICK

The processing method described here is the method used in the laboratory experimentation. The method which was used in the production trial is described in Chapter 8.

3.5.1 Equipment

Equipment used in the laboratory scale production of glue stick was as follows:

- * A 500 ml round bottom flask with a 5-neck lid
- * Motor driven stirrer
- * Thermometer
- * Condenser
- * Water bath

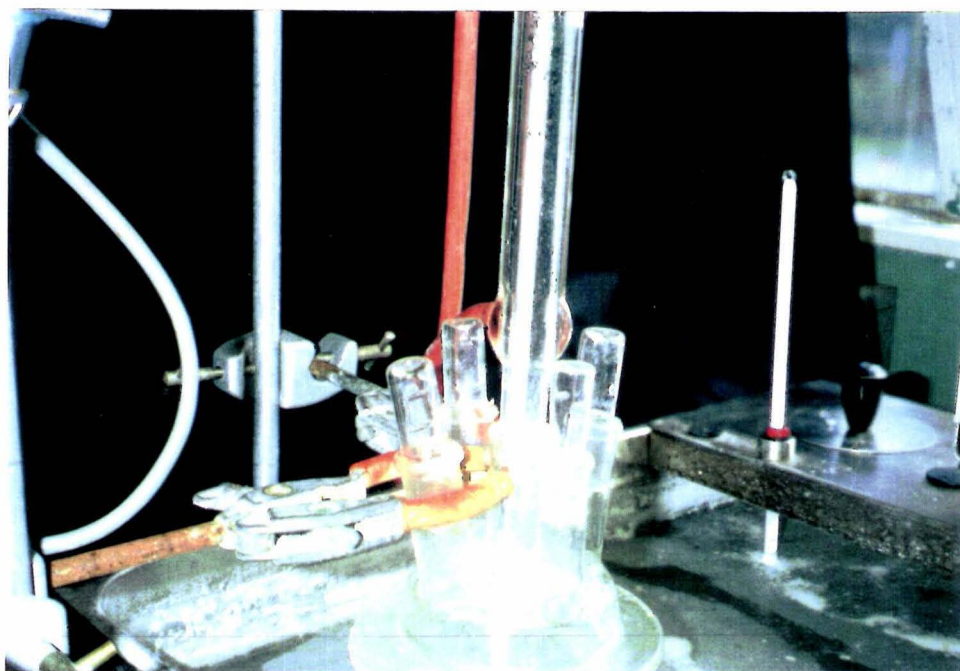
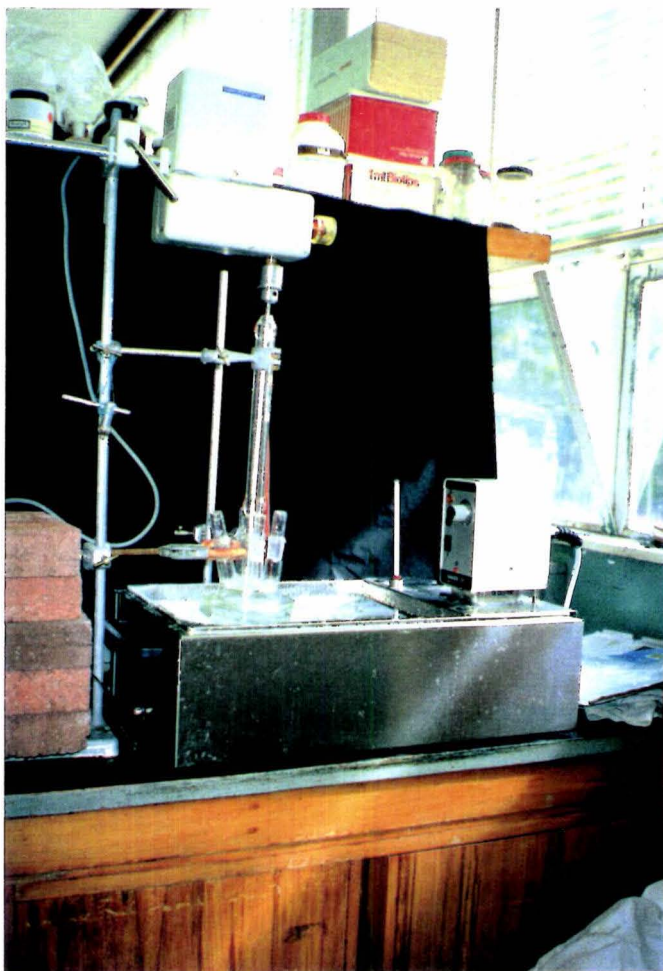


Figure 3.5 Laboratory scale equipment

The mixing equipment comprised of the 500 ml round bottom flask with 5-neck lid which was connected to a reflux system, see Figure 3.5. The reflux system included a spiral glass condenser fitted with two rubber tubes, one connected to cold water tap and the other one to let the water out from the system. A blade motor-driven stirrer was inserted through the neck of the lid. The water-bath comprised an aluminium bath, thermostat, pump for water-circulation, thermometer, and aluminium foil lid.

3.5.2 Method of Processing

At the beginning of the process, starch was mixed with cold water in the flask to form a starch slurry. Then the other ingredients were added. The mixture was stirred manually so that the ingredients were thoroughly mixed together before being exposed to the heat. The flask containing the mixture was then put in the water-bath, held at temperature 90 ± 1 °C and the stirrer was connected. Condenser was fitted and cold water was turned on. The glue mixture was heated under reflux. The water in the water bath was then gradually heated up to 99 ± 1 °C. The mixture was stirred using high speed (30 rpm) for the first 10 minutes then low speed (15 rpm) until the process was finished. About every 10 minutes, the stirrer was stopped in order to let the mixture be stirred by hand using a glass-rod stirrer. This had to be done regularly because some part of the mixture at the bottom was not mixed by the stirrer.

Speed of the stirrer was important for emulsification of the ingredients, too low a speed would not give good emulsification but too high a speed might break the emulsion system.

The reason that the mixture was heated at a low temperature at the beginning was to allow the starch to slowly gelatinize and at the same time stearic acid, glyceryl monostearate, sodium hydroxide and PVP dissolved into the mixture. If the starch was heated up rapidly, it tended to give lumps of gelatinized starch and this could not be easily mixed with other ingredients.

At the end of the process, the viscous hot mass was poured into a 10 ml plastic beaker. The finished product was allowed to cool down at room temperature for an hour. Then it was cut into sticks using a 1.5 cm diameter plastic tube and mounted in the

containers normally used for 8 g commercial glue sticks. Glue stick was aged at least 5 days before testing.

3.6 EXPERIMENTAL PLANS

Constrained mixture designs were used as the experimental plan, since in the experiments changing the proportion of one component affected the proportion of other components in the system. Snee and Marquardt (1974) recommended that the extreme vertices for the mixture design containing 'q' components can be computed using the XVERT algorithm described below.

- (i) Rank the components in order of increasing ranges (upper limit - lower limit) or $(b_i - a_i)$. X_1 has the smallest range, and X_q has the largest range.
- (ii) Form a two-level design from the upper and lower bounds of the $q-1$ components with the smallest ranges.
- (iii) Compute the level of the q^{th} component

$$X_q = 1.0 - \sum X_i$$

- (vi) A given point is an extreme vertex if $a_q \leq X_q \leq b_q$. For those points which are outside of the constraint limits, set X_q equal to the upper or the lower limit, whichever is closest to the computed value.
- (v) From each point originally outside of the limits, generate additional points ($\text{max} = q-1$) by adjusting the level of one component by an amount equal to the difference between the computed value for x_q and the substituted upper or lower limit. Additional points are generated only from those components whose adjusted level remain within the limits of the components.

Table 3.1 Six components extreme vertices

RUN	Starch	PVP	Water	Glycerin	Stearic	NaOH
Min	10	10	38	8	9	3
Max	16	16	45	14	12	4
Range	6	6	17	6	9	1
CORE MATRIX						
1	10	16	45	14	12	3
2	10	16	44	14	12	4
3	16	10	45	14	12	3
4	16	10	44	14	12	4
5	16	16	42	14	9	3
6	16	16	41	14	9	4
7	16	16	45	8	12	3
8	16	16	39	14	12	3
9	16	16	44	8	12	4
10	16	16	38	14	12	4
C.P.1	14.8	14.8	42.7	12.8	11.4	3.5
C.P.2	14.8	14.8	42.7	12.8	11.4	3.5
ADDITIONAL POINTS						
11	15	10	45	14	12	4
12	10	15	45	14	12	4
13	13	16	45	14	9	3
14	10	16	45	14	11	4
15	12	16	45	14	9	4
16	10	16	45	13	12	4
17	15	16	45	8	12	4
18	16	13	45	14	9	3
19	16	10	45	14	11	4
20	16	12	45	14	9	4
21	16	10	45	13	12	4
22	16	15	45	8	12	4
23	16	16	45	11	9	3
24	16	16	45	8	11	4
25	16	16	45	10	9	4

The results shown in Table 3.1 were obtained from the experimental plan used for prototype development in Section 5.2.2. Only core points and 2 centre points were chosen for conducting the experiment. Centre points were calculated by averaging the coordinates of the 10 vertices.

Twelve runs (core matrix and 2 runs from the centre point) were used to develop prototype products. Other constrained mixture designs used in this project were calculated in the same manner and are shown in Sections 5.2.3 and 5.2.4.

3.7 DATA PROCESSING METHOD

There were 5 main computer programmes used in the processing of data obtained during the optimization process:

- * VP Planner Plus (Paper Software International, California)
- * Minitab 8.2 (Minitab Inc., Pennsylvania)
- * Stat-Packets (Walonick Associates, Inc., Minneapolis, MN)
- * LP88 (Eastern Software Products, Inc., Alexandria, Virginia)
- * SPSS/PC+™ version 4.0 (SPSS Inc., Chicago, IL)

Data were put into VP Planner before being analyzed by the other programmes. VP Planner was used to calculate means and standard deviations of the data. It was also used for transformation of data into ideal ratios and logs of ideal ratios.

Minitab 8.2 was used for correlation, stepwise multiple regression and analysis of variance of the data obtained from physical testing and sensory testing of the product prototypes.

Stat-Packets was used for determination of significance using the t-test. LP88, the linear programming package, was used to generate optimum glue stick formulation in the optimization stage. SPSS/PC+™ was used for cross-tabulation of the data obtained from the final consumer testing in Chapter 9.

CHAPTER 4

CONSUMER STUDY

The consumer study was conducted in order to study the consumers' perspective towards glue products especially glue sticks. The primary consumer study was carried out with Thai and New Zealand consumers in New Zealand so as to identify the important attributes of the glue sticks. The problems of using glue products were also identified. Then a consumer survey was conducted with Thai consumers in Thailand in order to find information on glue product usage, and the importance of glue product attributes particularly of glue sticks and the possibility of introducing the developed product to the market.

4.1 AIM AND OBJECTIVES

The aim of this study was to develop the product concept with consumers. The objectives were to:

- * Obtain information regarding glue product usage.
- * Identify important attributes of glue products.
- * Identify the differences between the two cultures as regards glue usage.
- * Generate direction for improvement of glue products.
- * Generate a product concept.

4.2 METHOD OF CONSUMER STUDY

4.2.1 Products of Interest

This study was focused on the direction of improvement of glue stick. As mentioned before, glue stick could be in the form of permanent bonding or temporary bonding so the decision on which type of glue stick to be developed had to be made. The permanent bonding glue stick is a solid adhesive in lipstick-type container. The adhesive is usually intended to give a permanent bond when applied to paper or cardboard. The advantages of this product when compared to other glue products used for paper work are: easy to apply, does not seem to soak through paper, less messy, short drying time, easy to carry in pocket. For the temporary bonding glue stick, the glue coated surface can be adhered to a receiving surface such as paper, notice board, desk-top and can be removed from this without leaving traces of adhesive on the receiving surface, and this can be repeated a number of times. This product has advantage over the self-adhering note pad in that the latter has a limited field of utilization, although it in itself functions very well.

As permanent bonding glue stick products were already on the market, the commercial products were given to consumers as a reference for generating their opinions towards the product. However, temporary bonding glue stick was not available on the market at the time, so the self-adhering note pad precoated with glue, which had similar properties as that from temporary bonding glue stick, was used.

Although the study was focused on glue stick, other glue products such as: liquid glue, paste glue, PVA glue, cello tape and 2-sided tape were also included in the study in order to get general information on pattern of glue usage from consumers.

4.2.2 Stages of Survey in New Zealand and Thailand

The first consumer study was conducted in New Zealand with Thai and New Zealand consumers. They were 21 Thai students in various Faculties at Massey University and 21 New Zealand students in the Technology Faculty, Massey University. This survey was done in order to preliminary explore the general glue product usage by consumers

and to identify any problems consumers had when using glue products. Important attributes of glue stick and self-adhering note pad were generated by the consumers.

The second consumer study was conducted in Thailand with Thai consumers. They were 17 undergraduate students, 17 post-graduate students (both groups were studying at Kasetsart University, Bangkok, Thailand) and 17 government office staff. In this study, the importance of the product attributes elicited from the former study were measured to confirm that they were important according to the consumers in Thailand. Buying intention, price and size of the glue stick product to be developed were also obtained. This was further used to develop the concept of the product.

4.2.3 Method Used in Generation of Important Attributes

Normally the important attributes of products can be obtained from the literature in the same area or from the company reports. However, if there is no such information available the list of the important attributes has to be developed for that specific product. It is widely known that the important attributes perceived by consumers are different from those perceived by researchers. In order that the important attributes to be used in further study were the same as the ones consumers used in making decisions of glue selection, consumers were employed in establishing the list of important attributes. In this study, the consumers in New Zealand were asked to think about any problems they had with using glue products and write it down in the questionnaire (see Section 4.2.5). Samples of a commercial glue stick, 'UHU' (GmbH, Germany), and self-adhering note pads, 'Post-it' (3M), were also given to consumers as references. After that they were told to give a list of attributes they considered important for the products. With this method, the consumers were reminded to think of the problems and they described them in the first part of the questionnaire, so they could identify the attributes they thought were important in the following part of the questionnaire.

4.2.4 Method of Measuring Importance of Attributes

There were two methods used in this study: open-ended elicitation measure and direct-rating method. Both methods were used in the survey conducted in New Zealand. Only the direct-rating method was used with consumers in Thailand.

In the elicitation measure, consumers were asked to give lists of product attributes that were important to them in evaluating a glue stick and a self-adhering note pad. Responses were analyzed to determine what attributes were mentioned and in what order. An importance index for a given attribute was defined for each individual to incorporate order of elicitation. This involved dividing the rank order of elicitation of the attribute (where 1 = last elicited attribute through n = first elicited attribute) by the number of attributes elicited by the subject. If an attribute was not mentioned, the index number for that attribute was set to zero (Jaccard et al., 1986).

In the direct-rating method conducted in New Zealand, consumers were asked to evaluate the importance of the given attributes of products using the linear scale containing scores from 0 to 10; 0 = not important, 10 = very important. Product attributes used were obtained from a literature survey and the researcher's opinion. In the study conducted in Thailand, scores 1 (not important) to 5 (very important) were used and the list of attributes were obtained from the results of the consumer study in New Zealand.

4.2.5 Questionnaires for Consumer Survey in New Zealand and Thailand

The questionnaire for the consumer survey in New Zealand comprised questions related to glue product usage especially glue stick, the problems consumers had with product usage, improvement of glue products, important attributes of glue products. The questionnaire used with Thai consumers was translated into Thai. Questionnaire testing was conducted before the survey with 3 Thai students and 3 New Zealand students. Alteration of the questionnaire was made where necessary. The questionnaire used in the survey is shown in Appendix 4.1.

The questionnaire for the consumer survey in Thailand was written in Thai. It comprised questions related to glue product usage, rating of glue attributes' importance, buying intention, size and recommended price of product to be developed. The questionnaire was pre-tested with 6 Thai students at Massey University. The questionnaire including the English translation are shown in Appendix 4.2.

4.2.6 Survey Method

A self-administered survey was used in both surveys. In the survey conducted in New Zealand, as the number of respondents was small a 'drop and collect' survey was used. The questionnaires as well as the product samples were handed out to the respondents. They were allow enough time to fill out the questionnaire, approximately 3-4 days then return it back.

In the survey conducted in Thailand, the questionnaires and the product samples were given to the representatives of each group of consumers who handed them to the consumers. After the questionnaires were finished the consumers returned them back to their representatives.

4.3 DATA PROCESSING

The data from the consumer study were coded and input in the VP Planner then analyzed using SPSS/PC+™ computer programme. For the answers from open-ended questions, the coding frames for all the open-ended questions were developed, each response was read and a judgement made as to which code frame category it matched. The appropriate code was then given to that response ready to be input. This method was described by Hague and Jackson (1990).

4.4 PATTERN OF GLUE USAGE

The percentages of users of each glue product are shown Table 4.1. The pattern of glue usage of the students and the office workers in Thailand were not significantly different so the data were grouped and presented as the total. Of the 93 respondents, 98 % used cellotape and 95 % used glue stick and only 56 % used self-adhering note pad. There were differences in the pattern of usage of self-adhering note pad between Thais in Thailand and Thais in New Zealand, only 25 % used them in Thailand but 100 % used them in New Zealand.

Table 4.1 Users of each glue product

Products	Total	Thais (in Thailand)	Thais (in New Zealand)	New Zealanders
Cellotape	91 (98%)	49 (96%)	21 (100%)	21 (100%)
Glue stick	88 (95%)	50 (98%)	20 (95%)	18 (86%)
PVA glue	75 (81%)	39 (76%)	19 (90%)	17 (81%)
2-sided tape	74 (80%)	37 (73%)	18 (86%)	19 (90%)
Liquid glue	70 (75%)	31 (61%)	21 (100%)	18 (86%)
Paste glue	54 (58%)	21 (41%)	17 (81%)	16 (79%)
Self-adhering note pad	52 (56%)	13 (25%)	21 (100%)	18 (86%)

Note: Percentage is given out of the total number of respondents, i.e. 51 Thais (in Thailand), 21 Thais (in New Zealand), 21 New Zealanders and 93 total.

The frequency of using the different glue products also varied as shown in Table 4.2. Consumers used cellotape most often, only 9 percent of the respondents used it less than once a month. Glue stick was used more often than the other glue products (64% used it more than once a month) and paste glue was used least often only 11 percent used it once a month or more. The frequency of using self-adhering note pad, PVA glue, liquid glue and 2-sided tape were not very different - 34-41% of the respondents used them more than once a month.

Table 4.2 Frequency of glue product usage

Products	Consumers	3 times a week or more	Once a month to 2 times a week	Less than once a month and not used
Cellotape	Thais in Thailand	23 (45%)	22 (43%)	6 (12%)
	Thais in N.Z.	6 (29%)	13 (62%)	2 (10%)
	New Zealanders	8 (38%)	13 (62%)	-
	TOTAL	37 (40%)	48 (52%)	8 (9%)
Glue stick	Thais in Thailand	14 (28%)	32 (63%)	5 (10%)
	Thais in N.Z.	3 (14%)	7 (33%)	11 (52%)
	New Zealanders	2 (10%)	2 (10%)	17 (81%)
	TOTAL	19 (20%)	41 (44%)	33 (35%)
PVA glue	Thais in Thailand	3 (6%)	25 (49%)	23 (45%)
	Thais in N.Z.	2 (10%)	1 (5%)	18 (86%)
	New Zealanders	2 (10%)	-	19 (90%)
	TOTAL	7 (8%)	26 (28%)	60 (65%)
2-sided tape	Thais in Thailand	-	25 (49%)	26 (51%)
	Thais in N.Z.	4 (19%)	-	17 (81%)
	New Zealanders	7 (33%)	2 (10%)	12 (57%)
	TOTAL	11 (12%)	27 (29%)	55 (59%)
Liquid glue	Thais in Thailand	2 (4%)	17 (33%)	32 (63%)
	Thais in N.Z.	5 (24%)	2 (10%)	14 (67%)
	New Zealanders	4 (19%)	2 (10%)	15 (71%)
	TOTAL	11 (12%)	21 (23%)	61 (66%)
Paste glue	Thais in Thailand	1 (2%)	8 (6%)	42 (82%)
	Thais in N.Z.	-	-	21 (100%)
	New Zealanders	1 (5%)	-	20 (95%)
	TOTAL	2 (2%)	8 (9%)	83 (89%)
Self-adhering note pad	Thais in Thailand	-	13 (25%)	38 (75%)
	Thais in N.Z.	5 (24%)	6 (29%)	10 (48%)
	New Zealanders	3 (14%)	5 (24%)	13 (62%)
	TOTAL	8 (9%)	24 (26%)	61 (66%)

The purposes of glue product usage obtained from the survey in New Zealand are shown in Table 4.3.

Table 4.3 Purposes of glue product usage

Purposes	Cellotape	Glue stick	Liquid glue	PVA glue	Paste glue	2-sided tape	Note pad
Reports (photos, graph, diagram)	10 (26%)	15 (75%)	4 (27%)	3 (38%)		8 (67%)	
Seal envelope flap	11 (29%)	7 (35%)	2 (13%)				
Wrapping presents	5 (13%)						
Other purpose for sticking paper together	19 (50%)	9 (45%)	10 (67%)	3 (38%)	1 (100%)	4 (33%)	
Put up notice on board	11 (29%)			3 (38%)		2 (17%)	
Stick paper to nonpaper	3 (8%)						
Stick non paper to non paper	6 (56%)		1 (7%)	3 (38%)		1 (8%)	
Writing message or note							19 (100%)
Total	38	20	15	8	1	12	19

Note: The percentage is given out of the total number of respondents who used the product as one of the three products they used most often.

The purposes of glue usage were grouped into categories that had a similar meaning. Most of the products were used for sticking paper together. However, some products were also used with non-paper materials as well. It was found that cellotape seemed to have more applications than other products followed by glue stick, 2-sided tape, PVA glue and liquid glue. Self-adhering note pad was used for writing messages or as a reminder.

4.5 ATTRIBUTES OF GLUE STICKS WHICH SHOULD BE IMPROVED

Consumers were asked to define the attributes of glue stick that should be improved. The responses were grouped into categories and the results are shown in Table 4.4.

Table 4.4 Attributes of glue stick product needing improvement

Attributes	Total	Thais (in Thailand)	Thais (in N.Z.)	New Zealanders
Ease of use	38 (52%)	23 (45%)	13 (72%)	2 (50%)
Stickability	16 (22%)	10 (20%)	5 (28%)	1 (25%)
Aesthetic	15 (21%)	10 (20%)	5 (28%)	
Uniformity of coating	13 (18%)	6 (12%)	6 (33%)	1 (25%)
Price	11 (15%)	11 (22%)		
Cleanliness	10 (14%)	8 (16%)	1 (6%)	1 (25%)
Size	10 (14%)	5 (10%)	5 (28%)	
Effect on paper	6 (8%)	5 (10%)	1 (6%)	
Drying time	4 (5%)	3 (6%)	1 (6%)	
Versatility	3 (4%)	2 (4%)		1 (25%)
Refill	2 (3%)	2 (4%)		
Keeping quality	2 (3%)	2 (4%)		
Heat/water resistance	1 (1%)		1 (6%)	

Note: The percentage is given out of the total number of respondents who answered the question, i.e. 51 Thais (in Thailand), 18 Thais (in New Zealand), 4 New Zealanders, and 73 total.

Ease of use was the attribute that the most consumers recommended should be improved followed by stickability, aesthetic and uniformity of coating.

The attributes of self-adhering note pad which should be improved according to the results obtained from consumer study in New Zealand are shown in Table 4.5.

Table 4.5 Attributes of self-adhering note pad needing improvement (Panel in New Zealand only)

Attributes	Total	Thais (in N.Z.)	New Zealanders
Stickability	12 (63%)	8 (67%)	4 (57%)
Size	7 (37%)	5 (42%)	2 (29%)
Aesthetic	5 (26%)	5 (42%)	
Price	2 (11%)	1 (8%)	1 (14%)
Ease of use	1 (5%)		1 (14%)
Removability	1 (5%)	1 (8%)	

Stickability was the attribute that 63% of the New Zealand panel wanted to be improved, they wanted the product to have a stronger bond.

4.6 IMPORTANT ATTRIBUTES OF GLUE STICK AND SELF-ADHERING NOTE PAD

As no information was found on the important attributes of glue products, it was necessary that the list of important attributes was generated at the beginning of the product optimization process. The New Zealand panel including Thais and New Zealanders were employed to generate the list of important attributes of glue stick and self-adhering note pad products. In the consumer study in New Zealand, consumers were asked to describe the attributes they considered important for a glue stick and a self-adhering note pad. There were 48 important attributes identified by New Zealanders and 28 attributes identified by Thais for glue stick. There were 32 and 17 attributes respectively identified as important for self-adhering note pads. The list of important attributes of a glue stick and a self-adhering note pad given by consumers are shown in Table 4.6 and Table 4.7 respectively.

Table 4.6 The attributes of a glue stick product

Attributes	Description
* Appearance	
Colour	- Colour of glue
Size	- Volume and quantity
	- Nice shape
* Smell	- Nice perfume
	- No awful smell
* Ease of use	
Lid	- Ease of getting lid on and off / Using a screw off or flip-top cap
	- Not get 'glued up'
Screw bottom	- Ease of wind up and down
The stick	- Hardness, does not go out of shape when applied
	- Can be used to the very end
Dispensation	- Dispensing technique
	- Ease of spreading
	- Smooth roll up
	- Uniformity of coating
Shape	- Easy to carry
	- Handsize for accuracy
Adjustability	- Ability to slip the paper around to position it
Ease of applying on paper	- Slipperiness / ease of spreading
	- Uniformity of coating
* Effect on paper	- Not soak through the paper
	- Must not colour or discolour the paper
	- Must not affect the print on the paper
	- Cannot be seen through the paper
	- Does not wrinkle the paper
* Stickability	- Strength of bond
	- Long lasting
* Cleanliness	- Cleanliness of work
	- Cleanliness of container after use
	- Ease of cleansing from hands.
* Other attributes	- Heat resistant
	- Water solubility
	- Keeping quality / storage life
	- Multipurpose
	- Amount of glue needed to stick paper together
	- Drying time / Ability to dry evenly
* Image	- Price/Value for money
	- Non toxic/environmental friendly
	- Manufacturer/Brand name
	- Country of manufacture

Table 4.7 Important attributes of self-adhering note pads given by the consumers

Attributes	Descriptions
* Appearance	
Colour	- Bright colour / easy to see - Variety of colour
Size	- Decent size / variety of size - Number of pages per pack
Shape	- Rectangle or square
* Ease of use	- Ease of pulling from the pads - Easy to write on - A good quality paper - Ease of pulling away from the receiving surface
* Performance	- Stickiness - Reattachability - Versatility / ability to stick on fabric - Ability to stick well on surface without curling of edge
* Damage of substrate	- No damage on the receiving surface - Clean removal - No discolouring of surface
* Image	- Price/value for money - Environmental friendly - Manufacturer/Brand name - Country of manufacture
* Others	- Quality of paper - Ability to be used on both sides / gum on both sides

4.7 IMPORTANCE MEASURE OF GLUE PRODUCT ATTRIBUTES

The New Zealand panel were employed to evaluate the importance of attributes of glue stick and self-adhering note pad products by open-ended elicitation and direct rating methods. In the consumer survey in Thailand, the consumers evaluated the importance of the attributes of glue products in general and of the glue stick products to be developed in this study by direct rating method.

4.7.1 Importance of Attributes Measured by Open-ended Elicitation Method with Panel in New Zealand

In this method, it was assumed that order of elicitation was sensitive to attribute importance. An index number was given to the attribute according to the order of elicitation (see Section 4.2.4). Sum of index numbers of each glue stick attributes and self adhering note pad are shown in Table 4.8 and 4.9 respectively. The higher the index number, the more important the attribute was to the consumers.

Table 4.8 Importance of glue stick attributes from open-ended elicitation method

Attributes	Total (42)	Thais (21)	New Zealanders (21)
Ease of use	18.91	5.92	12.99
Stickability	17.48	7.26	10.22
Cleanliness	16.33	5.80	10.53
Price	14.49	6.76	7.73
Size	10.16	4.42	5.74
Uniformity of glue coating	7.75	5.95	1.80
Hardness of the stick	5.57	3.35	2.22
Drying time	3.64	0.25	3.39
Effect on paper	3.02	1.92	1.10
No awful smell	3.01	1.58	1.43
Nice perfume	2.27	0.67	1.60
Colour of the stick	2.26	0.83	1.43
Versatility	1.94	0.50	1.44
Keeping quality	1.32	0.99	0.33
Brand name	1.57	1.57	0.00
Amount of glue needed	1.20	0.00	1.20
Thickness of adhesive film	0.33	0.33	0.00

The results show that ease of use, stickability, cleanliness, and price were the important attributes of glue stick according to both groups of consumers.

Table 4.9 Importance of self-adhering note pad attributes from open-ended elicitation method

Attribute	Total (42)	Thais (21)	New Zealanders (21)
Size of paper	22.46	11.05	11.41
Stickability	18.20	4.50	13.70
Ease of use	11.78	8.88	2.90
Price	10.17	4.89	5.28
Damage of receiving surface	8.21	4.76	3.45
Colour of paper	7.84	3.30	4.54
Force needed to pull paper	4.91	1.33	3.58
Versatility	3.53	2.53	1.00
Brand name	0.88	0.50	0.38
Uniformity of glue coating	0.50	0.50	0.00
Keeping quality	0.44	0.31	0.13

The results show that size of paper had a high index number so it was a very important attribute for most consumers. However stickability seemed to be very important according to New Zealand consumers. Ease of use was also considered important by Thai consumers. Brand name, uniformity of coating and keeping quality were not very important as they gained very low index numbers.

4.7.2 Importance of Attributes Measured by Direct-rating Method with Panels in New Zealand and Thailand

The results of importance measure using direct-rating method obtained from the survey conducted in New Zealand are shown in Tables 4.10 and 4.11.

Effect on paper, ease of use, drying time, uniformity of coating, keeping quality and amount of glue needed to stick paper together were considered as important attributes for glue stick by the consumers (see Table 4.10). However hardness and no awful smell were regarded as important by Thai consumers and price was also considered important by New Zealand consumers.

Table 4.10 Importance of glue stick product attributes from panel in New Zealand (scores varied from 0 - not important to 10 - very important)

Attributes	Total (42)	Thais (21)	New Zealanders (21)
Stickability	8.8 ^a	9.3 ^a	8.4 ^a
Effect on paper	8.8 ^a	9.3 ^a	8.3 ^{ab}
Ease of use	8.7 ^{ab}	8.7 ^{ab}	8.7 ^{ab}
Drying time	8.2 ^{abc}	8.6 ^{ab}	7.8 ^{abc}
Uniformity of glue coating	8.1 ^{abc}	8.6 ^{ab}	7.6 ^{abcd}
Keeping quality	8.0 ^{abcd}	8.6 ^{ab}	7.3 ^{bcd}
Amount of glue needed	7.8 ^{bcd}	8.1 ^{abc}	7.5 ^{abcd}
Price	7.6 ^{cd}	7.5 ^{bc}	7.8 ^{ab}
Hardness of the stick	7.5 ^{cde}	8.1 ^{abc}	6.8 ^{cd}
Versatility	7.4 ^{cde}	8.0 ^{bc}	6.9 ^{cd}
No awful smell	7.4 ^{cde}	8.1 ^{bc}	6.8 ^{cd}
Thickness of adhesive film	7.1 ^{de}	7.6 ^{bc}	6.7 ^{cd}
Size	6.7 ^e	6.9 ^c	6.5 ^d
Nice perfume	3.1 ^f	3.7 ^d	2.6 ^e
Colour of the stick	3.7 ^f	4.0 ^d	3.3 ^e
Brand name	3.7 ^f	3.7 ^d	3.0 ^e

Note: Mean Scores followed by a different letter are significantly different at $p < 0.05$

Table 4.11 Importance of self-adhering note pads attributes from panel in New Zealand (scores varied from 0 - not important to 10 - very important)

Attribute	Total (42)	Thais (21)	New Zealanders (21)
Damage of receiving surface	9.1 ^a	9.1 ^a	9.1 ^a
Ease of use	8.1 ^b	8.4 ^{ab}	7.9 ^{ab}
Stickability	8.1 ^b	8.2 ^{ab}	8.0 ^{ab}
Keeping quality	8.0 ^b	8.7 ^{ab}	7.2 ^b
Price	7.5 ^{bc}	7.5 ^b	7.5 ^b
Versatility	7.4 ^{bc}	7.6 ^b	7.2 ^{bcd}
Force needed to pull paper	7.0 ^{bcd}	7.5 ^b	6.5 ^{bcd}
Uniformity of glue coating	7.0 ^{bcd}	7.9 ^{ab}	6.0 ^{cd}
Colour of paper	6.4 ^{cd}	7.0 ^c	5.8 ^{cd}
Brand name	3.2 ^e	3.7 ^e	2.8 ^e

Note: Mean scores followed by a different letter are significantly different at $p < 0.05$

It can be seen that damage of the receiving surface is the most important attributes for self-adhering note pad followed by ease of use, keeping quality, price, versatility, force needed to pull paper away from receiving surface and uniformity of glue coating.

4.7.3 Importance of Attributes of Glue Products with Panel in Thailand

The consumers in Thailand were asked to rate the importance of attributes of the glue products they normally used to stick paper together. The results from the consumer study (see Table 4.12) indicated that effect on paper and stickability were the most important attributes of glue products followed by uniformity of coating, cleanliness and ease of use.

Table 4.12 Importance of glue product attributes from Thailand panel (scores varied from 0 - not important to 5 - very important)

Attributes	Mean scores
Effect on paper	4.82 ^a
Stickability	4.78 ^{ab}
Uniformity of coating	4.45 ^{bc}
Cleanliness	4.37 ^{cd}
Ease of use	4.10 ^{de}
Drying time	4.00 ^{ef}
Amount of glue needed	3.78 ^{efg}
Keeping quality	3.71 ^{fg}
Versatility	3.49 ^{fgh}
Price	3.41 ^{gh}
Odour	2.51 ^h

Note: Mean score followed by a different letter are significantly different at $p < 0.05$, using t-test.

They were also asked to rate the importance of permanent bonding and temporary bonding glue sticks. The results are given in Tables 4.13 and 4.14 and compared with the results obtained from the New Zealand panel.

Table 4.13 Importance of permanent bonding glue stick attributes

Attribute	Thais in Thailand (51)	Thais in N.Z. (21)	New Zealanders (21)
Effect on paper	4.8 ^a	9.3 ^a	8.3 ^{ab}
Cleanliness of work	4.8 ^{ab}		
Ease of use	4.7 ^{ab}	8.7 ^{ab}	8.7 ^a
Stickability	4.7 ^{ab}	9.3 ^a	8.4 ^a
Uniformity of glue coating	4.5 ^b	8.6 ^{ab}	7.6 ^{abcd}
Thickness of adhesive film	4.2 ^c	7.6 ^{bc}	6.7 ^{cd}
Price	4.1 ^c	7.5 ^{bc}	7.8 ^{ab}
Drying time	4.2 ^c	8.6 ^{ab}	7.8 ^{abc}
Amount of glue needed	4.0 ^c	8.1 ^{abc}	7.5 ^{abcd}
Cleanliness of container	4.0 ^c		
Hardness of the stick	3.5 ^d	8.1 ^{abc}	6.8 ^{cd}

Note: The numbers in the parentheses are number of consumers

Table 4.14 Importance of temporary bonding glue stick attributes

Attribute	Thai in Thailand (51)	Thai in N.Z. (21)	New Zealanders (21)
Damage on surface	4.8 ^a	9.1 ^a	9.1 ^a
Ease of use	4.3 ^b	8.4 ^{ab}	7.9 ^{ab}
Stickability	4.2 ^b	8.2 ^{ab}	8.0 ^{ab}
Reattachability	4.2 ^b		
Versatility	4.1 ^{bc}	7.6 ^b	7.2 ^{ab}
Force needed to pull paper	3.8 ^c	7.5 ^b	6.5 ^{bcd}

Note: The numbers in the parentheses are numbers of consumers

4.8 ACCEPTABILITY OF ATTRIBUTES OF GLUE PRODUCTS BY PANEL IN THAILAND

Thai consumers in Thailand were asked to rate their acceptability towards the attributes of the existing glue products which included glue stick, liquid glue, PVA glue and cellotape. The acceptability of each attribute of the glue products was measured using a 5 point category scaling: 1 = not acceptable to 5 = very acceptable.

From Table 4.15, it can be seen that the average acceptability of glue stick was close to that of cellotape. Glue stick obtained higher acceptability in terms of ease of use and effect on paper but had lower acceptability in terms of drying time, versatility, price and odour. Price of glue stick had lowest acceptability compared with other products.

Table 4.15 Acceptability of glue products by panel in Thailand

Attributes	Glue stick	Liquid glue	PVA glue	Cellotape
Ease of use	4.5	2.3	2.5	4.1
Cleanliness	4.3	2.0	2.1	4.1
Effect on paper	4.2	1.8	1.9	3.7
Drying time	4.0	2.0	2.2	4.7
Odour	3.7	3.0	2.4	4.1
Uniformity of glue coating	3.7	2.2	2.6	3.9
Keeping quality	3.7	3.1	3.2	3.6
Amount of glue needed	3.7	2.5	2.9	3.4
Stickability	3.6	3.1	3.6	3.8
Price	2.9	3.9	3.1	3.3
Versatility	2.7	2.5	3.4	3.3
MEAN	3.7	2.6	2.7	3.8

Note: The number of respondents was 51

4.9 BUYING INTENTION, SIZE AND PRICE FROM PANEL IN THAILAND

The Thai consumers in Thailand were asked to indicate their buying intention for the glue stick to be developed. Size of glue stick as well as the price which consumers were prepared to pay were also asked.

Table 4.16 Buying intention of consumers towards the new product

Buying intention	Permanent bonding	Temporary bonding
Definitely buy	27 (54%)	21 (42%)
Probably buy	23 (46%)	22 (44%)
Not sure		6 (12%)
Probably not		
Definitely not		1 (2%)

Note: The number of respondent was 50 because one consumer did not answer this question

Fifty four percent of the consumers said that they would definitely buy the improved permanent bonding glue stick and 46 % of the consumers said that they would probably buy the product. This indicates that if the product is improved according to what consumers recommended it is possible that the product will get a high market share. The number of consumers who said they were going to buy (definitely and probably buy) temporary bonding glue stick were a little lower (86 %) than those of permanent bonding.

Consumers were asked to estimate how long it took them to use up one 8 g glue stick. The results are shown in Table 4.17.

Table 4.17 Usage time for one stick of glue

Usage time	Permanent bonding (49)	Temporary bonding (50)
less than one month	3 (6%)	
1 month	21 (42%)	14 (28%)
2 month	10 (20%)	17 (34%)
3-4 month	11 (22%)	12 (24%)
6 month	4 (8%)	6 (12%)
more than 6 month	1 (2%)	1 (2%)

Note: The number of respondents for permanent bonding and temporary bonding were 49 and 50 respectively because some consumers did not answer the questions

Most consumers (48 %) stated that one permanent bonding glue stick would last them for about one month or less. Consumers seemed to think that they would use temporary bonding glue stick less often than permanent glue stick only 28 % would use

one stick up within one month or less.

The price consumers were prepared to pay for the new products are shown in Table 4.18.

Table 4.18 Price of glue stick consumer prepared to pay

Price	Permanent bonding (51)	Temporary bonding (49)
less than 10 Bahts	27 (53%)	17 (35%)
10-12 Bahts	16 (31%)	14 (28%)
12-15 Bahts	8 (16%)	15 (31%)
16-18 Bahts		2 (4%)
more than 18 Bahts		1 (2%)

Note: The number of respondents for temporary bonding was 49 because some consumers did not answer the question

Fifty three percent would buy the permanent bonding glue stick at a price less than 10 Bahts, no one would buy the product at a price higher than the average price of commercial products (15 Bahts). The study indicated that consumers were prepared to pay more for temporary bonding glue stick 37 % would buy the product at the same price or higher than the commercial permanent bonding glue stick.

The results from the consumer study indicated that most consumers in Thailand (61 %) preferred small size glue stick - 1.9 cm diameter X 8 cm high containing 8 g of glue rather than a large stick.

4.10 DISCUSSION

4.10.1 Pattern of Glue Usage

Cellotape seemed to be the glue product most consumers used (98 %). There were 95 % of the consumers who used glue sticks. Most consumers in Thailand in this study used glue sticks (98 %), hence there is no trouble of introducing an improved glue stick to the Thai consumers since the consumer needs for this kind of product already exists

product already exists and the consumers are familiar with the product.

Self-adhering note pads were widely used by the New Zealand panel, both Thais (100%) and New Zealanders (86%), but only 26% of the consumers in Thailand used this product.

The frequency of usage of cellotape by consumers in Thailand was similar to that of glue stick. PVA glue and liquid glue were used less often.

4.10.2 Importance of Attributes

It was found that ease of use, stickability, cleanliness and uniformity of coating came up as very important attributes for permanent bonding glue stick in both methods. Effect on paper was judged as very important by direct rating but not by elicitation measure. Price and size were considered important by elicitation measure. As price of glue stick obtained very low acceptability by the consumers in Thailand, it should be included in the important attribute list as well.

Damage of receiving surface, ease of use, stickability and price were shown as important attributes for self-adhering note pad by both methods. However, size of paper came out as important in elicitation measure. Keeping quality, versatility, force needed to pull paper and uniformity of glue coating on paper were judged as important by direct rating but were not noted as important attributes by elicitation measure.

It can be seen that for most of the attributes which were more important than the others they came out as important in both methods. This indicated that both methods can be used to measure importance of attributes. However, elicitation measure is useful in the case that there are other important attributes of the product being studied which are not included in the list suggested by the researcher. With some attributes such as price, elicitation measure is considered more suitable for measuring of importance.

The results from the study showed that New Zealand consumers were able to generate more important attributes than Thai consumers. This might have resulted from the difference in tendency to express their opinion. Nevertheless, it was found that there

were no significant differences between Thai and New Zealand consumers in importance rating using elicitation measure both for glue stick ($p=0.18$) and self-adhering note pad ($p=0.76$). With direct rating, there were highly significant differences between the two groups for glue stick ($p=0.00$) and self-adhering note pad ($p=0.00$). Price was judged as important for both products by New Zealand consumers but not by Thai consumers. Keeping quality for glue stick and uniformity of glue coating on self-adhering note pad were judged as important by Thai consumers not by New Zealand consumers.

There were no difference in rating of importance of attributes by Thai consumers from both group: in New Zealand and in Thailand.

4.10.3 Differences between Cultures in Glue Usage

When comparing the results obtained from the Thais in New Zealand and the New Zealanders, only slightly differences were found between cultures in glue usage in terms of type of glues, frequency, and purposes of usage. However, there were differences between the usage patterns of the consumers in Thailand and New Zealand. A slightly higher percentage of the consumers in Thailand used glue sticks and used them a lot more often than the consumers in New Zealand. It was found that the consumers in Thailand used self-adhering note pads less than the consumers in New Zealand.

4.10.4 Comparison between Glue Products

Although there were some problems in terms of ease of use according to the consumers, cellotape was the most popular amongst the products used for sticking paper together. This might have occurred because cellotape has a wider application than the other glues. It can be used very effectively with non-paper materials. To develop a product which can overcome these defects it might be possible to gain some market share from this product. Other glue products (liquid glue, PVA glue and paste glue) had some disadvantages compared to glue stick in terms of drying time, effect on paper, ease of use, uniformity of coating and cleanliness. However, consumers found that glue stick was expensive compared with those products. In order to increase market share of the

glue stick product, the price factor should be considered.

4.10.5 Consumers Intention of Buying between the Two Products - Permanent and Temporary Bonding Glue Sticks

Consumers in Thailand indicated that they wanted to buy the developed permanent bonding glue stick at a lower price than the commercial products. Most of them wanted to buy at the price lower than 10 Baht. This implied that consumers considered that glue sticks in the market were too expensive. Although price did not seem to be a very important attribute according to the panel in Thailand, the existing glue stick's price obtained lowest acceptability by the consumers. This indicated that if the glue stick could be developed and sold at a lower price, there is high opportunity to compete with competitors.

For temporary bonding glue stick, 86 percent of consumers said that they might buy the product. Moreover, some of them (36 percent) would buy the product at a price equal to or higher than the commercial glue sticks. This might have happened because the self-adhering note pad is an expensive product and if consumers could use this glue instead of the note pad, they would be prepared to pay more for it even though this product had a narrower range of usage.

4.10.6 Development of Product Concept

The results of the consumer study revealed that both permanent bonding glue stick and temporary bonding glue stick had similar opportunity to be further developed. More consumers were willing to buy permanent bonding glue stick and would use it more often.

Since the consumer study showed that there was the need for a permanent bonding glue stick especially a glue stick which would be sold at a cheaper price than glue stick already on the market, it was decided that in further study, emphasize would be given to permanent bonding glue stick. Most consumers were willing to buy the developed product if it could overcome some defects which the present commercial glue sticks possess. Therefore, the concept of the product to be developed was:

'A glue stick which can be applied smoothly and easily onto paper and give a uniform coating. The paper can be repositioned within a few minutes of applying, then it would form a firm bond between the substrates to be bonded together. The finished work would be free from wrinkle or curling. The product should be water soluble, easy to clean off hands or other materials. The 8 g glue stick would be sold for 10 to 12 Bahts.'

4.10.7 Using the Consumer Study for Development of Glue Stick Products

The consumer study was used successfully in obtaining information regarding glue usage from consumers. Although consumers were not especially trained to describe the important attributes of glue products, the evidence from the results showed that consumers could be used for generating important attributes of glue products.

J. Walter Thompson Company Ltd. used a 'sensitivity' panel which comprised 8 housewives, aged 25-45 with at least one child at home in development of adhesive products. These panelists were given some training in perception and responsiveness in a research situation. The respondents were asked to make notes on the perceived advantages and disadvantages of glue products, which members of the family used adhesives, for what purposes, and so on. It was found that packaging and systems of application turned out to be as important as the products themselves, and many suggestions were made for improvement (Fuller, 1984).

However, in the area of glue products or any consumer products, the information regarding product usage should be elicited from the users themselves rather than the non-users. This could lead the research to the wrong direction and end up with a product failure.

4.11 CONCLUSIONS

Permanent bonding glue stick was finally chosen as the suitable glue product to be developed for the Thai market. With the use of tapioca starch in the formulation, the price of the final product could be reduced. This would persuade more consumers to buy the product and the government offices as well as the private companies who did not buy glue stick to use in their offices owing to the high price could take the new price into account.

From the consumer study, it can be summarised that the important attributes of permanent bonding glue sticks are as follows:

- * Effect on paper
- * Cleanliness of work
- * Ease of use
- * Stickability
- * Uniformity of coating
- * Price

Since there were no differences between cultures in the pattern of glue usage, if the product was developed and was found successful in Thai market, there was opportunity that the product should be able to be exported to other countries such as New Zealand.

At this stage of the research project, a final decision was made to choose the glue stick product to be developed. The following chapter discusses the selection of the basic formulation for tapioca based glue stick and the development of testing procedures for glue stick attributes.

CHAPTER 5

INITIAL DEVELOPMENT STUDY ON GLUE STICK FORMULATION

This preliminary study on starch based glue stick formulation was conducted in order to explore the appropriate ratio of ingredients in the formulation to be used in the development of prototypes. Glue stick comprises three major parts: adhesive substance, solvent and gel-forming agent, and the suitable ratios of these components were investigated. Since starch was to be used as adhesive in the formulation, the ingredients which were compatible with starch were focused.

5.1 AIM AND OBJECTIVES

The aim of this study was to explore the use of tapioca starch in glue stick and to select a suitable basic formulation for a starch based glue stick. The objectives were to:

- * Explore the suitable levels of basic ingredients for starch based glue stick.
- * Investigate the relationships between ingredients and attributes of glue stick.
- * Study the relationships between physical attributes and sensory attributes.
- * Select a set of attributes for product testing by consumers.
- * Select physical attribute measures.

5.2 SELECTION OF PRELIMINARY FORMULATION

Although glue stick was developed many years ago, the knowledge on formulation and method of glue stick processing are not widely known. Therefore, the main purpose of this formulation selection was to obtain a simple glue stick formulation which could be made with simple laboratory equipment and did not require a complicated processing method. This formulation would be used as a basic formulation for further development.

5.2.1 Criteria for Selection of Preliminary Formulation

The decision on glue stick formulation was made based on the following:

- * Availability of ingredients
 - Some companies in New Zealand did not sell ingredients in small amounts and did not have a small sample of ingredients for experimentation. Therefore this limited the choice of ingredients which could be used in the formulation
 - Only the ingredients which were available in New Zealand where the experiments took place were used
- * Properties of ingredients
 - Non-toxic
 - Price
 - Compatibility with starch
- * Processing method
 - Availability of processing equipment in the laboratory
 - Time and temperature used in the process
- * Basic properties of finished glue stick
 - Colour
 - Stickability
 - Structure / maintain shape when rubbing on paper
 - Homogeneity of the stick

From the conditions mentioned above, the following initial formulation was chosen (Muszik and Dierichs, 1971):

	%
Polyvinyl pyrrolidone	32
Sodium stearate	7
Water	47
Glycerine	14

This formulation was chosen because it had simple ingredients and contained polyvinyl pyrrolidone as adhesive substance which could be used with carbohydrate or modified carbohydrate (Werke H.u.M. Fischer, G.m.b.H., 1974). The finished product was water

soluble so it could be easily cleaned off hands or other materials.

5.2.2 Preliminary Experimentation

In the preliminary experiment, tapioca starch (raw starch and modified starch) was used to replace some part of the polyvinyl pyrrolidone in the preliminary formulation. Glue stick samples from the formulations shown in Table 5.1 were made in the laboratory using the method described in Section 3.5.2.

Table 5.1 Formulations used in preliminary experimentation

Ingredients	F1	F2	F3	F4	F5	F6
ADHESIVE						
Raw starch	16.0	22.0	20.0			
Modified starch				16.0	10.0	10.0
Polyvinyl pyrrolidone	4.0	6.0	5.0	4.0	20.0	20.0
SOLVENT						
Water	56.0	48.5	45.5	50.5	46.5	46.5
Glycerin	14.0	10.0	10.0	14.0	8.0	8.0
GEL-FORMING AGENT						
Sodium stearate	10.0	10.0				
Stearic acid			12.0	9.0	9.0	9.0
Sodium hydroxide			4.0	3.0	3.0	3.0
EMULSIFYING AGENT						
Brij 35		3.5	3.5	3.5	3.5	
Glyceryl monostearate						3.5

The purpose of the study at this stage was to obtain the suitable formulation for starch based glue stick and the samples generated from the formulations in Table 5.1 were very much different in their properties, so they could be easily judged by the author. Hardness of the sample was judged by pressing fingers on sample. The sample was rated as soft, medium hard and hard. Stickability was assessed by the ability to stick paper together after drying and was rated as poor, fair and good. Homogeneity and colour were judged by eye according to appearance of the finished product. The results are shown in Table 5.2.

Table 5.2 Properties of glue stick samples from preliminary experimentation

Formulation	Hardness	Stickability	Homogeneity	Colour
F1	Soft	Poor	Poor	Pale brown
F2	Soft	Poor	Fair	Pale brown
F3	Soft	Good	Fair	Pale brown
F4	Medium hard	Poor	Fair	Off white
F5	Hard	Fair	Fair	White
F6	Hard	Fair	Good	White

It was found that sodium stearate did not give a product which could be made into a stick in the starch based system (F1 and F2) therefore stearic acid and sodium hydroxide were used to form the gel-forming agent. When modified tapioca starch was used (F4, F5 and F6) instead of raw starch, the colour of the stick was improved and it also gave a harder stick. In the formulations which used higher amounts of polyvinyl pyrrolidone, the stickability was improved. The emulsifying agent increased homogeneity of the stick, glyceryl monostearate (F6) gave better homogeneity than Brij 35.

From the results of the preliminary experimentation, formulation F6 was chosen for further study. Since this formulation gave only fair stickability, in order to improve this property, it was decided to try adding other natural adhesives in the formulation to increase stickability. Dextrin and casein were considered.

5.2.3 Dextrin Experimentation

In the system using stearic acid and sodium hydroxide to form the gel-forming agent, the alkalinity of the system was very high. This caused dextrin to change to very dark brown colour when heated. It was decided that the amount of sodium hydroxide used in the formulation should be decreased and amount of stearic acid should be increased.

Based on the formulation F6, a constrained mixture design with 3 variables: modified tapioca starch (14-16%), polyvinyl pyrrolidone (14-16%) and dextrin (4-8%) was developed and samples were made in the laboratory using the method described in Section 3.5.2. The other ingredients were fixed as follows:

	%
Stearic acid	10.0
Sodium hydroxide	1.5
Water	43.0
Glycerin	8.0
Glyceryl monostearate	3.5

The experimentation plan is shown in Table 5.3.

Table 5.3 Experimentation plan for dextrin experiment

Run	Starch	Polyvinyl pyrrolidone	Dextrin	Others
D1	16.0	14.0	4.0	66.0
D2	10.0	16.0	8.0	66.0
D3	16.0	10.0	8.0	66.0
D4	14.0	16.0	4.0	66.0
D5 (centre point)	14.0	14.0	6.0	66.0
D6 (centre point)	14.0	14.0	6.0	66.0

The hardness and peel strength of the glue stick samples from this experimentation were measured using the method described in Section 3.3. The homogeneity and colour of glue stick was judged subjectively by eye. The results are shown in Table 5.4

Table 5.4 Physical attributes of dextrin glue sticks

Samples	Hardness	Peel strength	Homogeneity	Colour
D1	1.62	4.93	Fair	Pale brown
D2	1.98	3.26	Fair	Brown
D3	2.89	3.28	Fair	Brown
D4	2.48	4.40	Fair	Pale brown
D5	2.41	4.20	Fair	Brown
D6	2.43	4.53	Fair	Brown

The correlations between ingredients and physical attributes are shown in Appendix 5.1. The empirical equations relating physical attributes to the ingredients are shown in Table 5.5.

Table 5.5 Empirical equations showing relationships between ingredients and attributes of glue sticks from dextrin experiment

Attributes	Equations	t-ratio	R ²
Hardness	0.162*Starch	11.21 ^{***}	0.95
Peel strength	0.197*Starch	4.53 [*]	0.99
	+ 0.167*PVP	3.85 [*]	
	- 0.167*Dextrin	-2.25	

Note: * - Significant at $0.05 \geq p \geq 0.01$
 ** - Significant at $0.01 \geq p \geq 0.001$
 *** - Significant at $p < 0.001$

The empirical equations showing the relationships between ingredients and glue stick attributes showed that starch increased hardness of glue stick. Starch and polyvinyl pyrrolidone increased peel strength. From the equation, dextrin decreased peel strength of glue stick and also showed negative correlation with peel strength ($p=0.01$), see Appendix 5.1.

Since it was found that dextrin did not increase stickability of glue stick and the finished product was brown in colour, it was decided that dextrin was not to be included in the glue stick formulation.

5.2.4 Casein Experimentation

Casein was considered to be used as adhesive substance in the tapioca based glue stick. The experiment was conducted to investigate the effect of casein on glue stick properties. Effects of using sorbitol instead of glycerin in the formulation were also studied. The mixture experimentation plan of the casein experiment is shown in Table 5.6.

Table 5.6 Experimentation plan for casein experiment

Runs	PVP	Casein	Glycerin	Sorbitol	others
C1	14.0	0.0	13.0	0.0	73
C2	8.0	6.0	13.0	0.0	73
C3	14.0	0.0	0.0	13.0	73
C4	8.0	6.0	0.0	13.0	73
C5 (centre point)	11.0	3.0	6.5	6.5	73
C6 (centre point)	11.0	3.0	6.5	6.5	73

Other ingredients in the formulation were fixed as follows:

	%
Modified tapioca starch	18.0
Stearic acid	12.0
Sodium hydroxide	3.0
Water	41.0

Glyceryl monostearate, 3.5 g, was added to 100 g of the complete formulation. The casein solution used in the experiment was obtained from adding 20 g of casein into the mixture of 80 grams of water and 0.6 grams of sodium hydroxide. The solution which gave the amount of casein required was weighed then more water and sodium hydroxide was added later to make up the percentage required in the formulation. The samples were made in the laboratory using the method as described in Section 3.5.2

The samples were tested by physical testing, see Section 3.3 and sensory testing by trained sensory panel as described in Section 3.2.3. The results are shown in Appendix 5.2. The correlations between ingredients and glue stick attributes are shown in Appendix 5.3. The empirical equations relating ingredients to physical attributes and sensory attributes are presented in Table 5.7 and 5.8 respectively.

Table 5.7 Empirical equations showing relationships between ingredients and physical attributes from casein experiment

Physical attributes	Ingredients	t-ratio	R ²
Dry glue/Area	1.333*PVP	12.72***	0.99
	1.754*Casein	5.75**	
%Moisture	3.362*PVP	40.27***	0.99
	3.034*Casein	15.27**	
	-0.260*Glycerin	-2.36	
Peel strength	0.254*PVP	15.72***	0.99
	0.216*Casein	4.60**	
Physical hardness	0.412*PVP	10.93***	0.98
	0.432*Casein	3.94*	
Wet glue/ Area	2.418*PVP	10.15***	0.98
	3.256*Casein	4.70**	
Open time	0.384*PVP	8.73***	0.93

Note: * - Significant at $0.05 \geq p \geq 0.01$
 ** - Significant at $0.01 \geq p \geq 0.001$
 *** - Significant at $p < 0.001$

From the empirical equations, it can be concluded that polyvinyl pyrrolidone and casein increased physical hardness, wet glue and dry glue per area, moisture content and peel strength of the samples. Polyvinyl pyrrolidone also had significant effect on open time. It was found that neither glycerin nor sorbitol showed significant effect on physical attributes of the samples.

From the empirical equations in Table 5.8, it could be seen that casein increased thickness, smoothness, cleanliness, perceived hardness, and bond strength before drying. Use of casein increased deformation and disintegration of glue stick samples and it was found that casein did not dramatically increase stickability therefore casein was not included in the formulation in further study.

Table 5.8 Empirical equations showing relationships between ingredients and sensory attributes of glue stick from casein experiment

Sensory Attributes	Ingredients	t-ratio	R ²
Thickness	0.621*PVP + 0.771*Casein	13.30*** 5.68**	0.99
Smoothness	0.775*PVP + 0.708*Casein	72.50*** 22.77***	0.99
Cleanliness	0.815*PVP + 0.757*Casein + 0.027*Sorbitol	83.89*** 32.72*** 2.10	0.99
Slipperiness	0.283*PVP + 0.107*Sorbitol	14.63*** 4.12*	0.99
Hardness	0.549*PVP + 0.465*Casein + 0.154*Sorbitol	13.29*** 4.74* 2.83	0.99
Deformation	0.676*PVP + 0.784*Casein	12.8*** 5.10**	0.99
Visibility	0.660*PVP + 0.735*Casein	11.80*** 4.52*	0.98
Adjustability	0.635*Glycerin + 0.470*Sorbitol	12.98*** 9.60***	0.98
Disintegration	0.635*PVP + 0.868*Casein	9.91*** 4.66**	0.98
Coverage	0.969*PVP	11.44***	0.96
Bond strength 1	0.405*PVP + 0.564*Casein	7.17** 3.43*	0.96
Bond strength 2	0.435*PVP + 0.368*Casein	8.41*** 2.45	0.96
Delamination	0.221*PVP + 0.112*Glycerin	6.05** 2.29	0.96

Note: * - Significant at $0.05 \geq p \geq 0.01$
 ** - Significant at $0.01 \geq p \geq 0.001$
 *** - Significant at $p < 0.001$

Sorbitol was positively correlated ($p < 0.05$) with perceived hardness and glycerin was negatively correlated ($p < 0.05$) with perceived hardness. Hence, it can be said that sorbitol increased hardness while glycerin decreased hardness of glue stick. It was found that use of sorbitol in the formulation resulted in decreasing of delamination and adjustability so it was decided to continue using glycerin in the formulation not the sorbitol.

5.3 ATTRIBUTES OF COMMERCIAL GLUE STICKS

Since there was no consumers’ ideal product profile or the standard on glue stick attributes which could be used as guidance in the development of glue stick prototypes at this stage, it was necessary that the attributes of commercial glue sticks were investigated. Six of the commercial glue sticks available in the market (see Appendix 5.4) were bought and tested using the physical methods described in Section 3.3 and sensory attributes were evaluated by the trained panel (see Section 3.2.3). The physical attributes and sensory attributes of the commercial glue sticks are shown in Tables 5.9 and 5.10 respectively.

Table 5.9 Physical attributes of the commercial glue sticks

Samples	Wet glue/area (g/m ²)	Dry glue/area (g/m ²)	Moisture (%)	Hardness (Newton)	Open time (minute)	Mp (°c)	Peel strength (Newton)
PRITT	32.6	11.6	57.0	3.52	12.25	64.3	3.65
UHU	36.2	13.2	59.8	3.55	21.75	52.5	4.99
AMOS	45.8	14.9	67.2	2.86	24.00	68.0	4.46
BOSTIK	31.9	10.3	67.3	2.93	12.75	64.0	4.71
PELIFIX	36.6	14.8	47.9	2.67	99.00	68.0	6.30
ESSELTE	35.0	11.6	65.5	2.42	16.75	56.3	4.86

Some of the physical attributes of the commercial glue sticks varied in a wide range such as open time, moisture content and peel strength. Most of the physical attributes of UHU, the glue stick which most Thai consumers used, were in the middle of the ranges except that the hardness was the highest and melting point was the lowest.

Table 5.10 Sensory attributes of the commercial glue sticks (mean scores varied from 0-15)

Samples	Slip	Hardness	Deform	Disintegr.	Cover	Thick	Visible	Smooth	Clean	Adjust	Bond strength1	Bond strength2	Delaminate
PRIT	9.6	9.1	6.6	7.0	10.2	6.6	8.3	12.0	12.6	8.5	6.7	10.7	10.5
UHU	5.9	9.2	10.2	8.1	11.0	6.2	9.4	11.8	12.0	9.6	7.6	9.9	9.1
AMOS	9.5	7.0	8.9	6.4	11.4	8.0	9.7	10.5	12.4	10.3	8.2	10.2	9.6
PELIFIX	6.8	7.3	8.8	5.2	10.5	8.1	12.9	12.1	12.2	10.4	6.7	9.4	10.3
ESSELTE	6.5	8.1	5.8	3.8	10.8	7.8	6.1	12.2	12.4	9.3	6.3	9.7	9.5

Although, the sensory attributes of commercial glue sticks varied in a wide range. These attributes could be used as guidance at this stage. Then the ideal product profile which was developed later by the target consumers would be used to guide the direction in which the prototypes should be improved in the optimization stage.

5.4 DEVELOPMENT OF GLUE STICK PROTOTYPES

In order to make the decision on the suitable levels of the ingredients in the starch based glue stick, the attributes of the prototypes developed at this stage would be compared with the attributes of commercial glue sticks. The formulation providing sample with the attributes in the ranges of commercial glue sticks would be chosen as a basic formulation. This basic formulation was to be used later to developed prototypes for consumer testing.

At this stage it was decided that the formulation F6 from Section 5.2.2 should be used as the basic formulation to develop product prototypes. This formulation contained modified tapioca starch and polyvinyl pyrrolidone as adhesive substances, water and glycerin as solvents, stearic acid and sodium hydroxide as gel forming agent. The suitable lower and upper level of each ingredients were specified in order that the effect of each ingredient on product attributes could be assessed. The ranges of each ingredient used in the experimentation are shown below:

	%	
	Low level	High level
Modified tapioca starch	10.0	16.0
Polyvinyl pyrrolidone	10.0	16.0
Water	35.0	45.0
Glycerin	8.0	14.0
Stearic acid	9.0	12.0
Sodium hydroxide	3.0	4.0

Amount of glyceryl monostearate was fixed at 3.5 grams per 100 grams of glue mixture.

The experimentation plan as described in Section 3.6 is shown in Table 5.11.

Table 5.11 Experimental plan for prototype development

Run	Starch	PVP	Water	Glycerin	Stearic	NaOH	Total		
							Adhesive	Solvent	Gel forming agent
1	16.0	16.0	42.0	14.0	9.0	3.0	32.0	56.0	12.0
2	16.0	16.0	45.0	8.0	12.0	3.0	32.0	53.0	15.0
3	10.0	16.0	45.0	14.0	12.0	3.0	26.0	59.0	15.0
4	16.0	10.0	45.0	14.0	12.0	3.0	26.0	59.0	15.0
5	16.0	16.0	39.0	14.0	12.0	3.0	32.0	53.0	15.0
6	16.0	16.0	41.0	14.0	9.0	4.0	32.0	55.0	13.0
7	16.0	16.0	44.0	8.0	12.0	4.0	32.0	52.0	16.0
8	10.0	16.0	44.0	14.0	12.0	4.0	26.0	58.0	16.0
9	16.0	10.0	44.0	14.0	12.0	4.0	26.0	58.0	16.0
10	16.0	16.0	38.0	14.0	12.0	4.0	32.0	52.0	16.0
11	14.8	14.8	42.7	12.8	11.4	3.5	29.6	55.5	14.9
12	14.8	14.8	42.7	12.8	11.4	3.5	29.6	55.5	14.9

Note: Runs 11 and 12 are centre points

Glue sticks from each run were made in the laboratory using the method as described in Section 3.5.2. The sticks were mounted in the containers and kept at room temperature before testing. The samples were aged at least 5 days before being evaluated.

5.5 PROPERTIES OF GLUE STICK PROTOTYPES

The glue stick samples from each experimental run were subjected to physical testing as described in Section 3.3, the results are shown in Table 5.12.

Table 5.12 Physical attributes of the glue stick samples from constrained mixture design experiment

Samples	Wet glue/area (g/m ²)	Dry glue/area (g/m ²)	Moisture (%)	Hardness (Newton)	Open time (minute)	Mp (°c)	Peel strength (Newton)
Run 1	48.3	21.3	54.1	4.53	10.25	80.5	3.70
Run 2	23.9	12.5	50.5	6.67	1.50	71.0	4.24
Run 3	20.2	9.0	53.5	5.95	0.00	71.5	4.21
Run 4	29.5	12.5	53.3	5.63	0.00	73.0	4.55
Run 5	30.9	14.3	50.3	6.39	2.50	75.3	3.96
Run 6	64.2	28.4	51.3	1.85	36.00	79.3	4.64
Run 7	42.6	19.3	54.5	5.11	1.25	78.3	4.58
Run 8	34.1	13.7	57.3	4.01	0.00	79.3	3.49
Run 9	45.5	18.1	57.4	4.29	3.25	73.0	4.38
Run 10	43.3	19.8	51.6	4.89	4.50	80.5	5.66
Run 11	46.7	21.8	47.7	4.43	5.5	78.3	3.48
Run 12	37.8	18.5	47.9	4.92	5.0	78.0	3.14

A trained sensory panel of 10 panelists was used for sensory testing. The panelists evaluated the samples as they did in the panel training (see Section 3.2.3). Samples were randomly presented to the panelists. Each panelist attended 2 sessions with 6 samples in each session. The mean of sensory scores obtained from the trained sensory panel are tabulated in Table 5.13.

Table 5.13 Sensory attributes of the glue stick samples from mixture design experiment (mean scores on a scale from 0-15)

Samples	Slip	Hardness	Deform	Disintegr.	Cover	Thick	Visible strength1	Smooth	Clean	Adjust	Bond	Bond strength2	Delaminate
Run 1	5.1 (1.7)	9.1 (1.6)	11.6 (1.8)	11.9 (1.3)	10.9 (2.1)	9.0 (1.0)	5.7 (2.2)	11.0 (1.3)	11.7 (0.9)	8.6 (1.9)	6.3 (1.7)	7.4 (1.7)	4.9 (2.5)
Run 2	3.7 (1.5)	10.6 (1.9)	8.2 (2.1)	7.3 (2.4)	7.4 (2.3)	7.8 (1.9)	4.8 (1.7)	11.8 (1.5)	12.2 (0.7)	9.7 (1.7)	6.0 (2.2)	4.9 (1.6)	2.1 (1.4)
Run 3	6.1 (1.0)	9.6 (1.7)	9.1 (2.3)	9.2 (2.3)	8.1 (2.4)	5.8 (1.4)	7.0 (1.9)	12.0 (0.5)	11.9 (0.8)	10.8 (2.1)	4.4 (1.8)	3.5 (1.5)	1.2 (0.9)
Run 4	6.3 (2.2)	9.2 (2.0)	9.8 (2.4)	9.9 (2.6)	9.6 (1.4)	6.5 (2.3)	5.9 (2.3)	11.7 (1.5)	12.2 (0.4)	10.0 (2.1)	3.3 (1.4)	3.2 (1.1)	0.4 (0.5)
Run 5	4.8 (1.8)	8.9 (2.0)	10.0 (2.3)	9.3 (2.8)	8.0 (1.9)	7.7 (1.3)	5.8 (2.4)	11.8 (0.4)	11.8 (0.8)	8.4 (2.2)	5.4 (1.9)	4.7 (1.3)	2.2 (1.8)
Run 6	4.9 (1.7)	5.6 (1.8)	11.1 (2.5)	12.8 (1.8)	12.6 (1.4)	11.8 (1.8)	10.5 (2.1)	9.8 (2.0)	11.0 (1.1)	8.8 (2.0)	8.1 (2.7)	10.5 (1.5)	8.7 (1.7)
Run 7	4.0 (1.4)	9.2 (2.9)	10.2 (2.2)	9.5 (1.2)	8.3 (2.3)	7.5 (2.1)	8.8 (0.9)	11.3 (1.4)	12.1 (0.6)	6.9 (2.0)	6.7 (1.9)	5.3 (2.0)	3.7 (2.4)
Run 8	7.4 (2.0)	8.3 (1.9)	8.6 (2.1)	9.3 (1.7)	9.7 (2.5)	6.0 (1.7)	7.4 (2.4)	11.3 (1.1)	12.1 (0.3)	9.8 (1.7)	5.3 (1.9)	3.3 (1.3)	1.0 (1.2)
Run 9	7.3 (1.3)	9.0 (1.6)	9.9 (2.3)	10.6 (1.2)	9.6 (1.5)	8.2 (1.7)	8.2 (2.2)	11.7 (1.0)	12.2 (0.3)	8.2 (2.1)	5.3 (1.7)	4.4 (2.1)	1.1 (1.0)
Run 10	4.7 (1.5)	8.4 (2.4)	8.8 (1.6)	9.5 (1.5)	9.0 (2.2)	9.1 (2.0)	8.1 (2.4)	11.4 (0.8)	12.0 (0.3)	8.7 (1.9)	6.2 (2.1)	6.0 (2.0)	4.9 (2.7)
Run 11	5.3 (1.5)	8.0 (2.4)	10.6 (1.6)	9.1 (1.5)	8.9 (2.3)	8.2 (1.2)	10.2 (1.4)	11.4 (1.1)	11.8 (0.7)	8.3 (2.2)	6.9 (1.6)	7.7 (2.0)	7.0 (2.7)
Run 12	5.1 (1.9)	8.7 (1.5)	7.6 (2.3)	8.6 (1.6)	8.9 (2.3)	8.3 (1.9)	10.0 (1.1)	11.3 (1.2)	11.8 (0.6)	8.3 (1.7)	6.6 (1.5)	6.9 (2.1)	6.0 (2.4)

Note: The numbers in parentheses are standard deviations

5.6 COMPARISON BETWEEN PROTOTYPE PRODUCTS AND COMMERCIAL PRODUCTS

Comparison of physical measurement and sensory attribute results of prototype products and commercial products are shown in Table 5.14 and 5.15 respectively. Since the sample from Run 6 gave a very soft stick and a high amount of glue applied onto

paper, it was decided that the results from experimental Run 6 not be included in the comparison.

Table 5.14 Comparison between physical attributes of prototype products and commercial products

Physical Attributes	Commercial	Prototype
Wet glue per area	31.9-45.8	20.2-48.3
Dry glue per area	10.3-14.9	9.0-21.8
%Moisture content	57.0-67.3	47.7-57.4
Hardness	2.42-3.55	4.01-6.67
Open time	12.3-99.0	0.0-10.3
Melting point	52.5-68.0	71.0-80.5
Peel strength	3.65-6.30	3.14-5.66

Some physical attributes of the prototypes: wet glue per area, dry glue per area and hardness were in the ranges of the commercial products' attributes. Melting point of the prototypes (71-81 °C) were much higher than those of the commercial products (53-68 °C). The high melting points indicated that the prototypes would not melt in hand during usage or during storage at room temperature but also gave a harder glue sticks. Open time of the prototypes were between 0 to 10 minutes while those of the commercial ones were between 12 to 99 minutes. The prototypes had slightly lower peel strength.

Table 5.15 Comparison of sensory attributes of prototype products and commercial products

Sensory Attributes	Commercial	Prototype
Coverage	10.2-11.4	7.4-10.9
Thickness	6.2-8.1	5.8-9.1
Visibility	6.1-12.9	4.8-10.2
Smoothness	10.5-12.2	11.0-12.0
Cleanliness	12.0-12.6	11.7-12.2
Adjustability	8.5-10.4	6.9-10.8
Bond strength 1	6.3-8.2	3.3-6.9
Slipperiness	5.9-9.6	3.7-7.4
Hardness	7.0-9.2	5.6-10.6
Deformation	5.8-10.2	7.6-11.6
Disintegration	3.8-8.1	7.3-11.9
Bond strength 2	9.4-10.7	3.2-7.7
Delamination	9.1-10.5	0.4-7.0

Note: The mean scores were on line scales from 0-15

Most sensory attributes of the prototypes were in the ranges that covered the ranges of the commercial products except bond strength before drying, disintegration, bond strength after drying and delamination. Bond strength before drying, bond strength after drying and delamination were lower than those of the commercial ones. Disintegration was higher than those of the commercial products. The profiles of samples from centre point (average mean scores from Runs 11 and 12) and Run 10 which possessed the attributes closest to those of the commercial ones are shown in Figure 5.1.

From the comparison between the prototypes and the commercial products, the glue stick had to be improved in terms of disintegration, bond strength before and after drying and delamination. Although melting point was high, this was not the main problem as long as there was no problem in applying glue onto paper. The recommended open time of a glue stick was at least one minute since prolonged open time was unnecessary (Pletcher and Wong, 1978). Therefore with the right levels of ingredients, it was possible to obtain the required open time from this basic formulation.

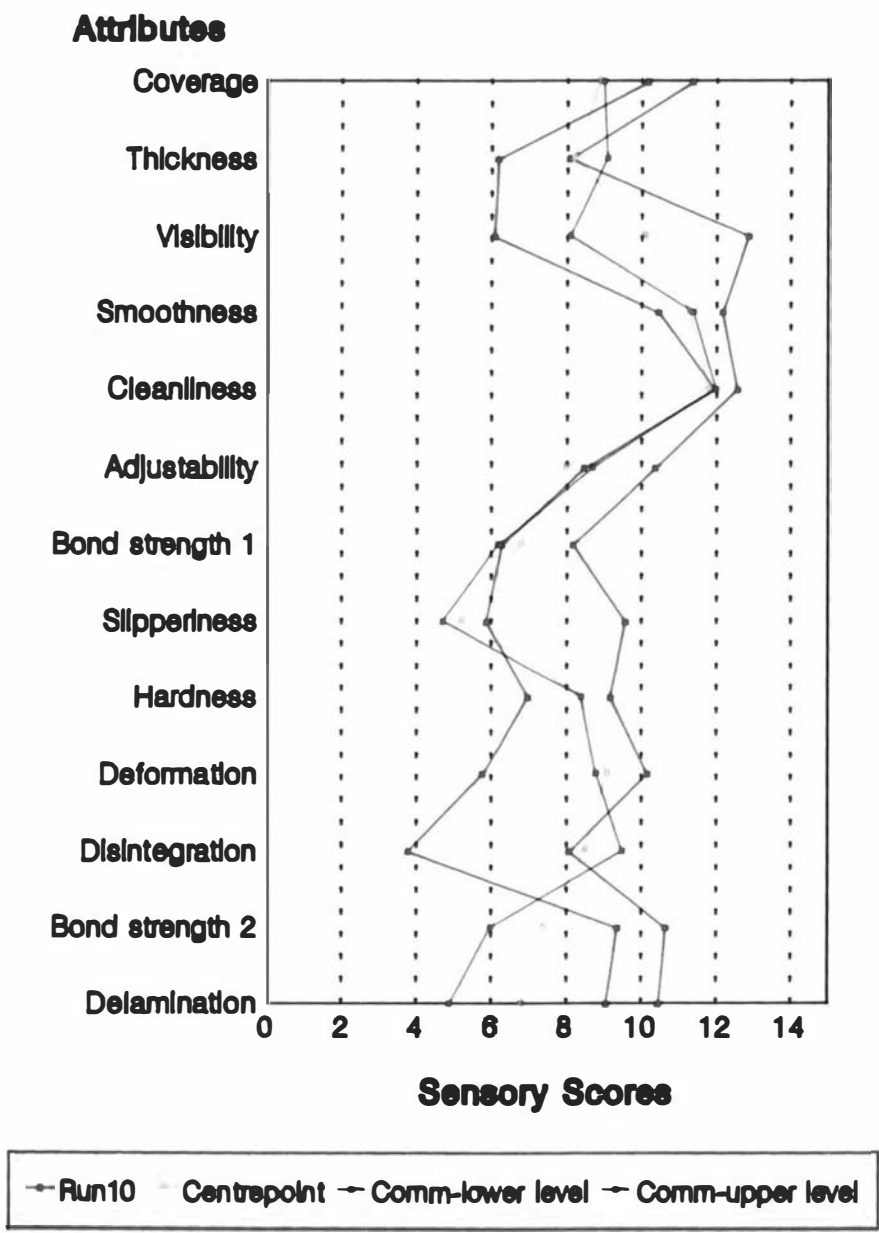


Figure 5.1 Product profiles of glue stick prototypes compared with commercial product attributes

5.7 RELATIONSHIPS BETWEEN GLUE STICK ATTRIBUTES

5.7.1 Correlations between Glue Stick Physical Attributes

The correlations between physical attributes were determined and are shown in Table 5.16. The relationships between the physical attributes can be shown as the diagram in Figure 5.2.

Table 5.16 Correlations between physical attributes of glue stick samples from mixture design experiment

	Wet glue/area	Dry glue/area	%Moisture	Hardness	Open time	Melting point
Dry glue/area	0.977***					
%Moisture	-0.034	-0.226				
Hardness	-0.872***	-0.802**	-0.153			
Open time	0.787**	0.798**	-0.193	-0.793**		
Mp	0.694*	0.708*	-0.085	-0.609*	0.405	
Peel st	0.136	0.111	0.199	-0.029	0.144	-0.036

Note: * - Significant at $0.05 \geq p \geq 0.01$
 ** - Significant at $0.01 \geq p \geq 0.001$
 *** - Significant at $p < 0.001$

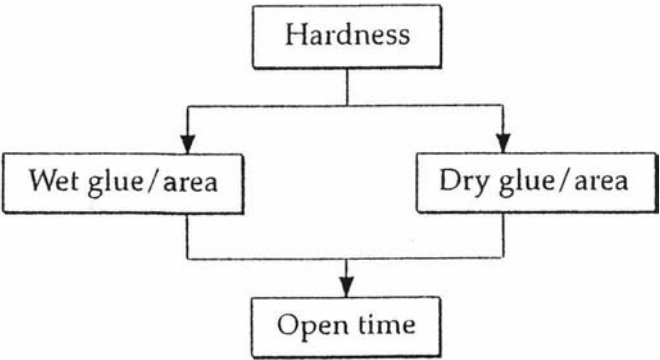


Figure 5.2 Diagram Showing Relationships between Physical Attributes

Hardness of glue stick affected the amount of glue applied per area (wet glue and dry glue per area). The harder the stick, the less amount of glue was applied onto the surface. The amount of glue applied per area affected the open time. In consequence, hardness also affected open time.

It was found that the melting point of the sample was negatively correlated with hardness of the stick ($p < 0.05$). Generally, it was expected that increasing melting point should be related to increasing hardness. However, it has been mentioned that there was often no relation between melting point of mixtures and hardness (Bennett, 1963). Therefore the melting point could not be used to indicate hardness of glue stick.

5.7.2 Correlations between Glue Stick Sensory Attributes

The correlations between sensory attributes are shown in Table 5.17. The diagram in Figure 5.3 shows relationships between the sensory attributes.

Table 5.17 Correlations between sensory attributes of glue stick samples from mixture design experiment

	Cover	Thick	Visible	Smooth	Clean	Adjust	Bond strength1	Slip	Hardness	Deform	Disintegr.	Bond strength2
Thick	0.656 [*]											
Visible	0.375	0.465										
Smooth	-0.862 ^{***}	-0.810 ^{**}	-0.554									
Clean	-0.695 [*]	-0.756 ^{**}	-0.488	0.828 ^{***}								
Adjust	-0.059	-0.436	-0.461	0.279	0.115							
Bondst1	0.380	0.794 ^{**}	0.632 [*]	-0.736 ^{**}	-0.658 [*]	-0.597 [*]						
Slip	0.245	-0.406	0.030	0.167	0.229	0.378	-0.526					
Hard	-0.790 ^{**}	-0.687 [*]	-0.712 ^{**}	0.857 ^{***}	0.811 ^{**}	0.205	-0.583 [*]	-0.097				
Deform	0.576	0.433	0.086	-0.465	-0.480	-0.318	0.259	-0.038	-0.412			
Disintegr.	0.911 ^{***}	0.616 [*]	0.267	-0.737 ^{**}	-0.661 [*]	-0.177	0.301	0.196	-0.679 [*]	0.775 ^{**}		
Bondst2	0.621 [*]	0.910 ^{***}	0.605 [*]	-0.834 ^{***}	-0.847 ^{***}	-0.424	0.880 ^{***}	-0.438	-0.714 ^{**}	0.458	0.544	
Delamin.	0.499	0.819 ^{**}	0.705 [*]	-0.765 ^{**}	-0.785 ^{**}	-0.455	0.885 ^{***}	-0.466	-0.698 [*]	0.333	0.399	0.965 ^{***}

Note:

- ^{*} - Significant at $0.05 \geq p \geq 0.01$
- ^{**} - Significant at $0.01 \geq p \geq 0.001$
- ^{***} - Significant at $p < 0.001$

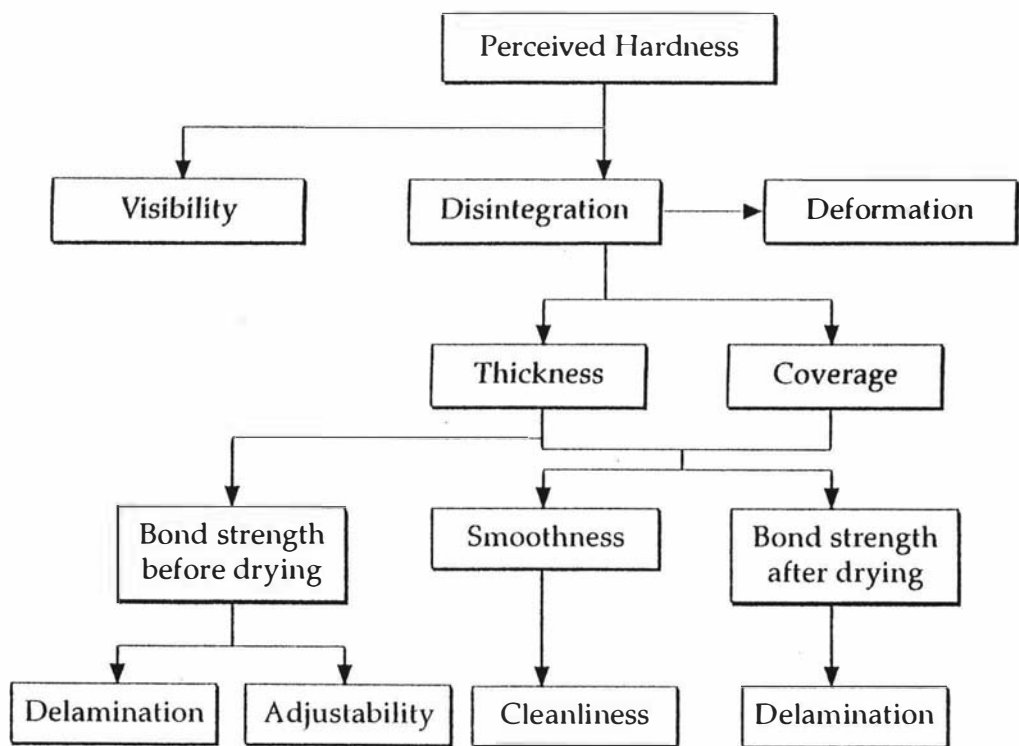


Figure 5.3 Diagram Showing Relationships between Sensory Attributes

From the diagram, it can be seen that perceived hardness of a glue stick affected disintegration and deformation of the glue stick. Disintegration affected thickness and degree of glue coverage on the paper. Glue stick with high disintegration gave high thickness and high degree of coverage. As a result, these also increased bond strength before drying, adjustability, delamination and decreased smoothness and cleanliness of finished work.

5.7.3 Relationships between Physical Attributes and Sensory Attributes

Normally only physical testing methods are used to assess consumer response in the quality control of product manufacturing because sensory evaluations involve substantial time and money expenditures, and often exhibit poor reproducibility (Szczesniak, 1987). Since there were no standard methods set for glue stick testing, therefore the relationships between physical attributes and sensory attributes were investigated. The correlations between physical attributes and sensory attributes are shown in Table 5.18. Amount of glue applied per area (wet glue and dry glue per area) were correlated with most of the sensory attributes of glue stick samples, except slipperiness. Therefore, it can be said that amount of glue applied per area could be used to assess sensory attributes of glue stick in terms of glue residue on paper, stickability and effect on paper. Physical hardness was correlated with most of the sensory attributes except adjustability, slipperiness and deformation. Hence, hardness can be used to predict some sensory attributes of glue stick. A hard glue stick would give low degree of glue cover on paper, low stickability, but smooth and clean finished work. Moisture content was correlated with slipperiness and delamination. A glue which had a high moisture content was easy to apply with high slipperiness but gave low delamination.

Although open time was expected to correlate with adjustability, the results showed that they were not correlated. Hence, the adjustability judged by the sensory panel was not related to open time. As it was found that adjustability was negatively correlated with bond strength before drying this meant that adjustability only depended on the tack of the glue before the drying occurred. Peel strength was not correlated with any sensory attributes.

Table 5.18 Correlations between physical and sensory attributes of glue stick samples from mixture design experiment

	Wet glue/area	Dry glue/area	Moisture	Hardness	Open time	Mp	Peel strength
Coverage	0.793 ^{**}	0.711 ^{**}	0.198	-0.888 ^{**}	0.820 ^{***}	0.516	0.059
Thickness	0.848 ^{***}	0.897 ^{***}	-0.328	-0.655 [*]	0.877 ^{**}	0.487	0.259
Visibility	0.654 [*]	0.677 [*]	-0.275	-0.694 [*]	0.479	0.491	-0.069
Smoothness	-0.855 ^{***}	-0.856 ^{***}	0.085	0.880 ^{***}	-0.925 ^{***}	-0.650 [*]	-0.068
Cleanliness	-0.662 [*]	-0.701 [*]	0.368	0.668 [*]	-0.914 ^{***}	-0.456	0.063
Adjustability	-0.581 [*]	-0.618 [*]	0.132	0.231	-0.149	-0.496	-0.012
Bond strength1	0.747 ^{**}	0.840 ^{***}	-0.399	-0.587 [*]	0.681 [*]	0.623 [*]	-0.048
Slipperiness	-0.081	-0.261	0.613 [*]	-0.248	-0.198	-0.136	-0.220
Hardness	-0.802 ^{**}	-0.775 ^{**}	0.134	0.893 ^{***}	-0.836 ^{***}	-0.600 [*]	-0.085
Deformation	0.612 [*]	0.552	0.139	-0.432	0.498	0.302	0.090
Disintegration	0.766 ^{**}	0.664 [*]	0.303	-0.759 ^{**}	0.747 ^{**}	0.438	0.186
Bond strength2	0.826 ^{***}	0.910 ^{***}	-0.499	-0.671 [*]	0.857 ^{***}	0.584 [*]	-0.025
Delamination	0.767 ^{**}	0.874 ^{***}	-0.598 [*]	-0.618 [*]	0.744 ^{**}	0.660 [*]	-0.046

Note:

- * - Significant at $0.05 \geq p \geq 0.01$
- ** - Significant at $0.01 \geq p \geq 0.001$
- *** - Significant at $p < 0.001$

5.8 RELATIONSHIPS BETWEEN INGREDIENTS AND GLUE STICK ATTRIBUTES

The relationships between ingredients and the attributes of the glue sticks had to be identified in order that the direction to improve the glue stick could be obtained. Correlations between ingredients and glue stick attributes are shown in Table 5.19.

Table 5.19 Correlations between ingredients and output variables

Ingredient	Output Variable	r
Stearic acid	Open time	-0.823 ^{***}
	Coverage	-0.821 [*]
	Smoothness	0.816 ^{**}
	Cleanliness	0.809 ^{**}
	Bond strength 2	-0.798 ^{**}
	Disintegration	-0.794 ^{**}
	Thickness	-0.731 ^{**}
	Dry glue/Area	-0.714 ^{**}
	Wet glue/Area	-0.708 ^{**}
	Delamination	-0.668 [*]
	Hardness(P)	0.652 [*]
	Deformation	-0.646 [*]
	Hardness(S)	0.577 [*]
NaOH	Visibility	0.683 [*]
	Hardness	-0.675 [*]
	Wet glue/ Area	0.604 [*]
Starch	Thickness	0.606 [*]
	Adjustability	-0.601 [*]
Glycerin	Slipperiness	0.644 [*]

Note:

- ^{*} - Significant at $0.05 \geq p \geq 0.01$
- ^{**} - Significant at $0.01 \geq p \geq 0.001$
- ^{***} - Significant at $p < 0.001$

It was found that stearic acid was the only ingredient which had significant effects on most of the attributes. Stearic acid increased physical hardness, perceived hardness, smoothness and cleanliness. It decreased disintegration, deformation, degree of coverage, wet glue and dry glue per area, open time, bond strength after drying and delamination. Sodium hydroxide decreased hardness and increased wet glue per area and visibility of glue trail. Starch increased thickness of glue coated on paper and decreased adjustability. Glycerin increased slipperiness while applying glue onto paper.

In the limits used for this experimentation, polyvinyl pyrrolidone and water were not correlated with any glue stick attributes.

Multiple regressions between ingredients and glue stick attributes were conducted and the results are shown in Table 5.20 and 5.21.

Table 5.20 Empirical equations showing relationship between ingredients and physical attributes

Physical attribute	Ingredient	t-ratio	R ²
Wet glue/ Area	16.303*NaOH	8.13 ^{***}	0.99
	-5.429*Stearic acid	-8.77 ^{***}	
	2.064*Starch	5.50 ^{***}	
	1.026*Glycerin	2.64 [*]	
Dry glue/ Area	7.134*NaoH	5.84 ^{***}	0.99
	-2.104*Stearic acid	-5.55 ^{***}	
	1.106*Starch	4.62 ^{***}	
%Moisture	0.929*Water	6.86 ^{***}	0.99
	3.635*NaOH	2.22 [*]	
Hardness	0.767*Stearic acid	11.60 ^{***}	0.99
	-1.897*NaOH	-8.94 ^{***}	
	0.096*PVP	2.42 [*]	
	0.093*Starch	2.33 [*]	
Melting Point	4.184*NaOH	2.82 [*]	0.99
	1.273*PVP	4.47 ^{**}	
	0.999*Glycerin	3.44 [*]	
	0.873*Starch	3.06 [*]	
	0.406*Water	2.59 [*]	
Peel Strength	0.608*NaOH	2.23 [*]	0.98
	0.137*Starch	2.14 [*]	
Open time	12.745*NaOH	3.31 ^{**}	0.54
	-3.437*Stearic	-2.90 [*]	

Note: ^{*} - Significant at 0.05 ≥ p ≥ 0.01
 ^{**} - Significant at 0.01 ≥ p ≥ 0.001
 ^{***} - Significant at p < 0.001

Table 5.21 Empirical equations showing relationship between ingredients and sensory attributes

Sensory Attribute	Ingredient	t-ratio	R ²
Smoothness	0.140*Water	4.41**	0.99
	0.471*Stearic	3.97**	
Cleanliness	0.117*Water	6.34***	0.99
	0.302*Stearic	5.60***	
	0.101*Starch	4.31**	
	0.076*Glycerin	3.17*	
	0.68*PVP	2.89*	
Adjustability	0.208*Water	31.52***	0.99
Hardness(S)	0.763*Stearic	30.61***	0.99
Deformation	0.129*Water	2.67*	0.98
	0.277*Starch	2.00	
Disintegration	0.426*Glycerin	3.93**	0.98
	0.289*Water	3.07*	
Coverage	1.342*NaOH	2.92*	0.98
	0.354*Glycerin	2.83*	
Thickness	0.538*Starch	21.41***	0.97
Visibility	2.209*NaOH	18.86***	0.97
Bond Strength before drying	0.395*PVP	18.87***	0.97
Slipperiness	0.419*Glycerin	20.50***	0.97
Bond Strength after drying	0.382*Starch	10.07***	0.89
Delamination	0.248*PVP	5.10***	0.68

Note:

- * - Significant at $0.05 \geq p \geq 0.01$
- ** - Significant at $0.01 \geq p \geq 0.001$
- *** - Significant at $p < 0.001$

From the empirical equations, stearic acid decreased the amount of glue applied per area but increased hardness. Starch increased hardness, peel strength and amount of glue applied per area. In order to increase stickability (bond strength before and after drying and delamination) polyvinyl pyrrolidone and starch had to be increased.

However, increasing amount of starch would also result in increasing of glue stick deformation. Water increased smoothness, cleanliness, adjustability and also increased disintegration and deformation. Glycerin increased slipperiness and also increased disintegration.

5.9 DISCUSSION

5.9.1 Effect of Ingredients on Attributes of Glue Sticks

Most of the sensory attributes of the glue stick prototype from the formulation at the centre point of the design were close to those of the commercial ones. The attributes that had to be improved were slipperiness, disintegration and bond strength after drying. From the experimentation, it was found that in order to reduce disintegration, stearic acid had to be increased, starch and solvent had to be decreased. However, if bond strength after drying were to be increased, amount of starch in the formulation had to be increased and stearic acid had to be decreased. Slipperiness can be increased by increasing the amount of solvent in the formulation.

It was decided at this stage that the ingredients were grouped into the major components; adhesive, solvent and gel-forming agent. With these components, it should be easier to assess the effect of these components on glue stick attributes and to find the optimum level of each component.

5.9.2 The Suitable Levels of Basic Ingredients for Starch Based Glue Stick

From the comparison with commercial products and the product profiles, the attributes of the sample from centre point formulation were closest to those of the commercial glue sticks so it was decided that this formulation would be used as the basic formulation to develop prototypes for consumer testing. This formulation was: 14.8% modified tapioca starch, 14.8% polyvinyl pyrrolidone, 42.7% water, 12.0% glycerin, 11.4% stearic acid, 3.5% sodium hydroxide and 3.5 grams of glyceryl monostearate for every 100 grams of the glue mixture, i.e. 29.6% adhesive, 55.5% solvent, and 14.9% gel forming agent.

5.9.3 Selection of Physical Attribute Measures

It was found that some physical attributes were highly related to sensory attributes of glue sticks. Therefore those physical attributes could be used to assess the intensity of the sensory attributes.

The physical attributes to be used for testing of the prototypes in the further study were:

- * Amount of wet glue applied per area
- * Amount of dry glue applied per area
- * Percent moisture content
- * Hardness of the stick
- * Open time
- * Peel strength

5.9.4 Selection of Sensory Attributes for Consumers Testing

As there were 13 sensory attributes used in the sensory evaluation of glue stick, it was necessary to reduce the number of attributes to be tested. The decision on which attributes to be dropped from the test was based on the correlations between the attributes. Disintegration and deformation were significantly correlated. Since disintegration could also be used to predicted other attributes like effect on paper (smoothness and cleanliness) and stickability of glue (adjustability, bond strength before and bond strength after drying), disintegration was chosen for further study. Hardness was also related with disintegration. However, the trained panel found that it was difficult to rate perceived hardness if there was only a small difference between samples and it was not considered as a very important attribute by the consumers so it was dropped from the test.

Adjustability was correlated with bond strength before drying. Both of them could be used to predict the ability to reposition the paper after applying. Adjustability was considered more suitable for consumer testing since it was the term which consumers used to describe important attributes of glue stick in the consumer study. Bond strength after drying and delamination were highly correlated. Bond strength after drying was

chosen because it represented the ability of glue to stick paper together. It was found that degree of coverage and thickness were significantly correlated, and from the consumer study, degree of coverage was considered important so only degree of coverage was selected to be used for further sensory testing. Slipperiness of glue when applying was not correlated to any other attributes and it was considered a very important attribute so it would be used further. Smoothness and cleanliness were highly correlated, smoothness was chosen since it could also be used for evaluating wrinkling caused by lumps of glue and also too much moisture on the paper.

The sensory attributes to be used for consumer testing of glue stick were:

- * Slipperiness of glue when applying
- * Disintegration of glue stick
- * Degree of glue coverage on paper
- * Adjustability of paper after applying glue
- * Smoothness of finished work
- * Bond strength after drying of glue

Although some of sensory attributes could be predicted using physical attributes, those sensory attributes were still used in consumer testing in order that the study of consumer evaluation of glue sensory attributes could be obtained.

5.10 CONCLUSIONS

It could be concluded that modified tapioca starch could be used as adhesive substance in glue stick product together with polyvinyl pyrrolidone. The glue stick prototypes obtained from adding tapioca starch in the formulation possessed attributes in the ranges of the commercial glue sticks. However, there were some attributes that had to be improved: slipperiness, disintegration and bond strength after drying. The next experiment was conducted in order to investigate the effect of the glue stick major components on the attributes of glue sticks particularly acceptability to the target consumers.

CHAPTER 6

PRODUCT FORMULATION DEVELOPMENT WITH CONSUMERS

From the previous mixture design experiments, based on the formulation of commercially available glue sticks, a glue stick basic formulation using modified tapioca starch as the adhesive substance was developed. In this part of the thesis, further experimentation was conducted in order to study the relationships between the ingredients and the glue stick attributes in the modified tapioca starch based system. The first part of this experiment was conducted at Massey University where glue stick product prototypes were made. As the product was targeted towards Thai consumers, the glue stick samples were then taken to Thailand to be tested with a Thai consumer panel. Three consumer panels - university students, office workers and school children were used to evaluate sensory attributes of the glue stick prototypes. The panel used a sensory profile method to evaluate the affective attributes and sensory attributes of the glue sticks on linear scales. Affective attributes included 'acceptability', 'purchase intention' and 'price to buy'. Sensory attribute scores for the prototypes and for the ideal glue stick were also determined. The effects of glue stick components on attributes were identified and empirical equations showing relationships between glue stick components and the glue stick attributes as determined by consumers were developed.

6.1 AIM AND OBJECTIVES

The aim of this part of the project was to study the effect of formulation components (adhesive, solvent, gel-forming agent) on glue stick sensory attributes using a consumer panel as the subjective method and to generate empirical equations showing the relationships between components and consumer sensory evaluation scores for use in product optimization.

The objectives were to:

- * Make prototypes derived from a systematic experimental plan for use in consumer panel testing in Thailand.

- * Study consumers’ performance in the sensory testing of a glue product.
- * Evaluate the differences between consumers from different target market segments in their response to the glue stick.
- * Study the relationships between components and sensory evaluation scores.

6.2 EXPERIMENTAL METHODS

6.2.1 Basic formulation

The basic formulation obtained from the previous experimentation was:

	grams
Modified tapioca starch	14.8
Polyvinyl pyrrolidone	14.8
Glycerin	12.8
Water	42.7
Stearic acid	11.4
Sodium hydroxide	<u>3.5</u>
	100.0
Glyceryl monostearate	3.5

In this experiment, the ingredients used were grouped into three major components: adhesive, solvent and gel-forming agent. The ‘adhesive’ was starch and polyvinyl pyrrolidone, the ‘solvent’ was glycerin and water, and the ‘gel-forming agent’ was stearic acid in combination with sodium hydroxide. Using the formulation above as the basic formulation, the ratio of ingredients in each component was:

Components	Ingredients	Ratio
Adhesive	Starch : PVP	1.00:1.00
Solvent	Glycerin : Water	1.00:3.34
Gel-forming agent	NaOH : Stearic acid	1.00:3.26

Glyceryl monostearate was held constant at 3.5 grams for every 100 grams of the 3 component mixture.

6.2.2 Experimental Design

A constrained mixture design was used for this experiment. Using the results from the previous experiment, the constraints for the three components were defined and the ingredient levels of the basic formulation became the centre point of the design. The ranges of the three components used in this experiment are shown below:

	Low level	High level
Adhesive	23	38
Solvent	42	62
Gel-forming agent	10	20

The complete mixture space showing the feasible area is shown in Figure 6.1. The limits on the three components restrained the experimentation to the shaded feasible region with the vertices shown in Table 6.1.

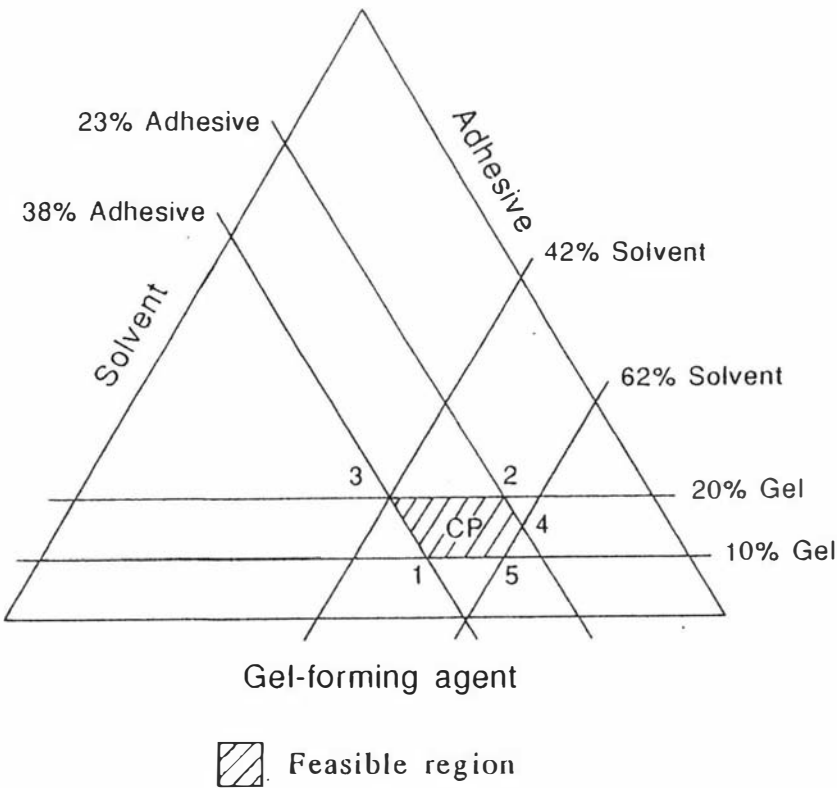


Figure 6.1 Complete mixture space showing feasible area for experimentation

Table 6.1 Experimental plan for mixture design with three components

Experimental run	Adhesive	Solvent	Gel-forming agent
1	38	52	10
2	23	57	20
3	38	42	20
4	23	62	15
5	28	62	10
6 (centre point)	30	55	15
7 (centre point)	30	55	15

The seven samples were made in the laboratory using the method described in Section 3.5. Each sample was made in a 100 g batch. Samples were left to cool down at room temperature for one hour then cut into sticks and placed in commercial type containers. The samples were aged for at least 5 days before any testing was conducted.

6.3 PHYSICAL TESTING

The physical testing methods described in Section 3.3 were used to measure the following attributes of the glue stick prototypes:

- * wet glue per area
- * dry glue per area
- * moisture content
- * hardness
- * open time
- * peel strength

6.4 SENSORY EVALUATION BY CONSUMER PANEL IN THAILAND

The sensory evaluation of the prototypes were conducted with the target consumers in Thailand. In this project, quantitative descriptive analysis using line scale was employed in order to obtain quantitative data which would be used for generation of models

relating product ingredients with sensory attributes. During the test the consumers indicated their ideal product which would be used as a guideline to optimize the product. Floating ideal - consumers indicated their own ideal product - was used since they were not trained for this particular testing.

6.4.1 Consumer Panel in Thailand

Three groups of consumers were selected for the consumer panel to be used for product testing of the prototypes. These were:

- * University students - undergraduate and post-graduate students at Kasetsart University, Bangkok, Thailand aged between 18-25 year old.
- * School students - high school students at Kasetsart University Demonstration School, Bangkok, aged between 15-17 years old.
- * Office workers - clerks and typists who worked at Kasetsart University and the government offices in Kasetsart University campus.

These panelists were glue stick users and were expected to be the target market segments for the new glue stick product. There were 30 panelists in each group.

6.4.2 Sample Preparation

Glue stick samples were coded with 3 digit numbers. Each panelist was given fresh samples for the test. The seven samples were tested by university students. Only six samples were tested with the other two groups; school students and office staff. This was because the glue stick mixture from experimental run No. 3 was not homogeneous and gave a soft stick which deformed easily. However this sample was tested by the university students in order that its attributes could be evaluated. Only the university student panel was selected for testing this prototype because of the limitation of the samples available and the time available from university students. To ensure that this glue stick prototype would not affect the evaluation of the other samples, it was tested after the university students had finished testing the other six samples.

6.4.3 Questionnaire

The questionnaire used for sensory evaluation of the glue stick prototypes is in Thai language. The questionnaire and the English translation are given in Appendix 6.1. The questionnaire included an introduction and instructions for glue stick testing as well as the set of testing forms. The first form included 3 line scales for evaluation of 'acceptability', 'purchase intention' and 'price to buy'. The second form included 5 line scales for evaluation of sensory attributes: slipperiness, disintegration, degree of coverage, adjustability and smoothness. The third form included a line scale for stickability evaluation. At the end of the test, consumers were asked to indicate their ideal product on the same line scale for each attribute in the second and third forms.

6.4.4 Preparation for the Consumer Panel Test

The necessary materials were prepared the day before the test date as follows:

- Samples

- Questionnaires

- Paper for testing the glue samples which included two pieces - one large piece (14.9 cm x 21.0 cm) and one small piece (7.4 cm x 10.5 cm) of 80 gsm white paper

- Bonded paper prepared from the glue samples

- Pencils and rubbers

- Mechanical pencils as gifts

The bonded paper was prepared by rubbing a glue stick sample on a small piece of paper (7.4 cm x 10.5 cm), six coats on each edge of paper. The coated paper was then placed on a large piece of paper (14.9 cm x 21.0 cm) and pressed down with four passes (twice in each direction) of a 2 kg roller. This bonded paper was prepared about 24 hours before the test.

6.4.5 Consumer Testing Procedure

Two post-graduate students from the Product Development Department, Kasetsart University and the author were the interviewers. Training of the interviewers was done the day before the test date.

The test was conducted in three different places, one for each consumer group, because of the need to make the testing as convenient as possible for the consumers.

* University students

The test was conducted in the Product Development Department, Kasetsart University. Panelists were invited to the test room which was a room lit with daylight fluorescent. They were seated separately to avoid any distraction. The test was done in 5 sessions with 6 panelists in each session so the panelists could chose to come at the time they were available.

* Office workers

Permission for a consumer test was requested one week in advance. Seven offices were contacted and 4-5 panelists from each office took part in the test. The test was done in either a meeting room or in their own office whichever was suitable. The rooms were also lit with fluorescent light.

* School students

Permission for conducting the consumer test in Kasetsart University Demonstration School was requested two weeks in advance. The test was conducted after school hours at 4:00-5:00 p.m. in a classroom where there was no interference. The room was also lit with fluorescent light. The test was done in two sections with 15 students in each section.

A set of samples, a pencil, a rubber and test papers including bonded papers were distributed to each panelist. Before starting the test, the panelists were asked to read the instructions given at the beginning of the test. Then the meaning of each attribute term was explained by the interviewer to avoid misinterpretation. The interviewers had all been trained to give the same explanation for each term. The panelists were told how the questionnaire should be completed as well as how the samples should be tested. A large number of samples could be evaluated as it did not result in testing fatigue. The samples were simultaneously presented to the panelists in random order. Panelists were asked to rub the sample on the given paper before starting the test in order to smooth the tip of the stick and also to remove any small bits of glue which might affect the evaluation of the sample.

In the first part of the test, panelists were given the first form and were asked to test glue stick samples on the given paper and evaluate 'acceptability', 'purchase intention' and 'price to buy' for every sample. Panelists were told to mark the line at the position representing their perception of the attribute with the coded number of the particular sample. For 'price to buy', the price of the commercial product, UHU, was indicated on the scale in order that the panelist would give the price of the sample in comparison with the commercial product.

After panelists finished the first part, the first form was collected and they were given the second form. They were asked to test the glue stick samples again and to evaluate the sensory attributes of the samples. This was done after panelists finished the first part so that the sensory attributes would not affect the evaluation of the affective testing. They were also asked to mark their ideal point on the scale for every attribute.

In the third part, panelists were given the bonded paper prepared from each sample. They were asked to peel the bonded paper apart and evaluate the stickability for each sample as well as the ideal for stickability.

Panelists could ask questions during the test from the interviewers. After the panelist finished testing, the interviewers checked the results to make sure that panelists had completed all the questionnaires. After the test, each panelist was reward with a pencil for their participation. The test lasted about 45 to 60 minutes.

6.5 DATA PROCESSING AND ANALYSIS OF RESULTS

The scores on the line scale for each attribute were measured in centimetres from the zero end of the scale and were called 'sample scores'. 'Ideal scores' for each attribute were also measured. 'Ideal ratio scores' were calculated as the ratio of the 'sample score' to the 'ideal score'. This was done using the scores from individual panelists. An ideal ratio score less than 1 meant that the attribute was less than the ideal. An ideal ratio score greater than 1 meant that the attribute was greater than the ideal, an ideal ratio score of 1 indicated that the attribute was 'ideal'. 'Log of ideal ratio scores' were obtained by taking logarithms of the ideal ratio scores.

The mean score and standard deviation for each glue stick sensory attribute for each group of panelists as well as for all the panelists were computed for sample and ideal scores as well as ideal ratio scores and log of ideal ratio scores. Means of log of ideal ratio scores were transformed back to sample ideal ratio scores. VP Planner was used to calculate the means and standard deviations of the scores. Differences in the mean attribute scores for each group in the consumer panel were analyzed using analysis of variance (ANOVA) which was run on the Minitab 8.2 computer programme. The mean sensory scores of the sensory profiles from the three groups of consumers in the panel were correlated using Minitab 8.2. This programme was also used to generate correlations and the empirical equations showing the relationships between glue stick attributes and the components in the formulation.

6.6 PHYSICAL ATTRIBUTES OF THE PROTOTYPES

Physical testing results of the glue product prototypes are shown in Table 6.2.

Table 6.2 Physical attributes of the prototypes

Run No.	Wet glue per area (g/m ²)	Dry glue per area (g/m ²)	Moisture content (%)	Hardness (Newton)	Open time (minute)	Peel strength (Newton)
1	237.9 (6.8) ^a	133.0 (3.7) ^a	39.3 (0.2) ^f	3.66 (0.65) ^c	14.00 (0.00) ^a	4.55 (0.07) ^a
2	50.8 (5.4) ^d	25.6 (3.2) ^c	47.9 (0.7) ^c	3.78 (0.44) ^c	0.25 (0.00) ^f	4.77 (0.32) ^a
3	152.9 (14.3) ^b	102.1 (12.0) ^b	29.3 (0.4) ^e	3.59 (0.85) ^c	12.00 (0.35) ^b	4.32 (0.28) ^a
4	40.6 (3.2) ^e	17.2 (1.6) ^e	51.9 (0.1) ^a	5.28 (0.55) ^a	0.25 (0.00) ^f	4.70 (0.52) ^a
5	59.0 (0.9) ^{cd}	25.7 (0.2) ^c	50.2 (0.1) ^b	4.57 (0.49) ^b	10.25 (0.35) ^c	5.20 (0.72) ^a
6	64.6 (1.1) ^c	32.3 (0.6) ^c	45.2 (0.4) ^d	4.58 (0.57) ^b	6.00 (0.00) ^e	5.30 (0.89) ^a
7	64.3 (2.2) ^c	31.7 (0.8) ^c	43.7 (0.5) ^e	4.36 (0.74) ^b	6.50 (0.00) ^d	5.10 (0.85) ^a

Note: (1) - The numbers in the parentheses are standard deviations.
 (2) - Mean scores within the column followed by a different letter are significantly different at $p < 0.05$

Prototype Run 1 gave the highest amount of wet glue and dry glue per area and open time followed by Run 3. Both prototypes had high amounts of adhesive in the formulations. Prototype Runs 2 and 4 had the lowest amounts of adhesive and gave the lowest wet glue and dry glue per area and open time. Peel strengths were not significantly different between the samples. Hardness of Run 4 was highest followed by Runs 5, 6, and 7. Moisture contents of the samples were significantly different. Run 3 had lowest moisture content (29.3%) followed by Run 1 (39.3%); the other samples ranged from 43.7 to 51.9%.

Table 6.3 Comparison between physical attributes of the prototypes and commercial products

Physical Attributes	Commercial	Prototype
Wet glue per area (g/m ²)	31.9-45.8	40.6-237.9
Dry glue per area (g/m ²)	10.3-14.9	17.2-133.0
Moisture content (%)	57.0-67.3	29.3-51.9
Hardness (Newtons)	2.42-3.55	3.59-5.28
Open time (Minutes)	12.25-99.00	0.25-14.00
Peel strength (Newtons)	3.65-6.30	4.32-5.30

The physical properties of these prototypes were compared with those of the commercial ones from Section 5.3. It was found that amount of glue residue per area (wet glue and dry glue per area) of the prototypes were very much higher than the commercial glue sticks. Only Run 4 gave wet glue per area in the commercial range. The moisture contents were very low compared to those of the commercial ones. Although hardness was higher than the commercial glue stick, it was consider acceptable since lower hardness would give high amount of glue residue per area. Only open time of Runs 2 and 4 were too low, the other prototypes' open time were acceptable. Peel strength of the prototypes was in the acceptable range.

Therefore in the optimization stage, it was necessary to reduce the amount of glue residue per area and increase the moisture content of the glue stick. Open time should be at least one minute as recommended by Pletcher and Wong (1978).

6.7 SENSORY ATTRIBUTES OF THE PROTOTYPES EVALUATED BY CONSUMER PANEL

From the consumer testing, each panelist rated each sample on affective and sensory attributes. The sensory attributes' scores of each glue stick sample including the scores of the consumer's ideal product obtained from each individual from the three consumer panels are shown in Appendix 6.2.

6.7.1 Affective Attributes

Group mean scores and total mean scores of the glue stick acceptability, purchase intention and price to buy were computed and are shown in Table 6.4.

Table 6.4 Acceptability, purchase intention and price to buy of the prototypes

Samples	Groups	Acceptability	Purchase Intention	Price to buy
1	University	5.5 (3.4)	4.6 (3.5)	2.4 (2.4)
	Office	5.1 (4.4)	4.0 (4.3)	2.4 (3.1)
	School	4.9 (3.6)	3.6 (3.4)	2.6 (3.2)
	TOTAL	5.2 (3.8) ^d	4.1 (3.7) ^e	2.4 (2.9) ^d
2	University	6.7 (3.8)	5.9 (4.0)	3.3 (2.6)
	Office	5.3 (3.9)	4.9 (4.7)	2.9 (2.8)
	School	5.2 (4.0)	4.4 (4.6)	2.4 (3.1)
	TOTAL	5.7 (3.9) ^d	5.1 (4.4) ^d	2.9 (2.9) ^d
4	University	9.9 (3.8)	9.4 (4.3)	5.4 (3.4)
	Office	9.5 (3.5)	7.7 (5.1)	5.0 (3.8)
	School	8.8 (4.1)	8.6 (4.9)	5.1 (3.9)
	TOTAL	9.4 (3.8) ^b	8.6 (4.8) ^b	5.2 (3.6) ^b
5	University	11.2 (2.8)	10.8 (3.3)	6.5 (2.9)
	Office	10.4 (3.2)	9.4 (4.2)	5.8 (3.6)
	School	10.0 (3.3)	9.5 (3.5)	6.5 (3.7)
	TOTAL	10.5 (3.1) ^a	9.9 (3.7) ^a	6.3 (3.4) ^a
6	University	7.2 (3.9)	6.2 (4.2)	3.6 (2.8)
	Office	8.1 (3.5)	6.9 (4.4)	4.4 (3.3)
	School	7.0 (3.5)	6.0 (3.7)	4.1 (3.5)
	TOTAL	7.5 (3.6) ^c	6.4 (4.1) ^c	4.1 (3.2) ^c
7	University	6.8 (3.6)	6.1 (4.0)	3.6 (2.8)
	Office	7.3 (3.7)	5.8 (4.7)	3.9 (3.9)
	School	7.2 (3.5)	6.3 (4.1)	4.2 (3.7)
	TOTAL	7.1 (3.6) ^c	6.1 (4.2) ^c	3.9 (3.5) ^c

- Note: (1) Samples from Run 3 were not tested.
 (2) The number in the parentheses are standard deviations
 (3) Scores are on scale 0 to 15
 Acceptability 0 = not acceptable 15 = very acceptable
 Purchase intention 0 = never buy 15 = certainly buy
 Price to buy 0 = 8 baht 15 = 20 baht
 (4) Mean scores within the column followed by a different letter are significantly different at $p < 0.05$

Although the results had high standard deviations, which was expected in the test with consumers, the analysis of variance (shown in Appendix 6.2) showed that the three consumer groups were not significantly different in evaluating acceptability ($p=0.073$), purchase intention ($p=0.050$) and price to buy ($p=0.949$). This indicated that the three

groups perceived these attributes in the same way.

Run 5 had the highest acceptability, purchase intention and price to buy scores followed by Run 4. Run 1 had the lowest affective scores followed by Run 2. These two prototypes were very different in the level of components in their formulation. Run 1 contained the highest level of adhesive substance and lowest level of gel-forming agent while Run 2 had the lowest level of adhesive substance and highest level of gel-forming agent.

Acceptability
score

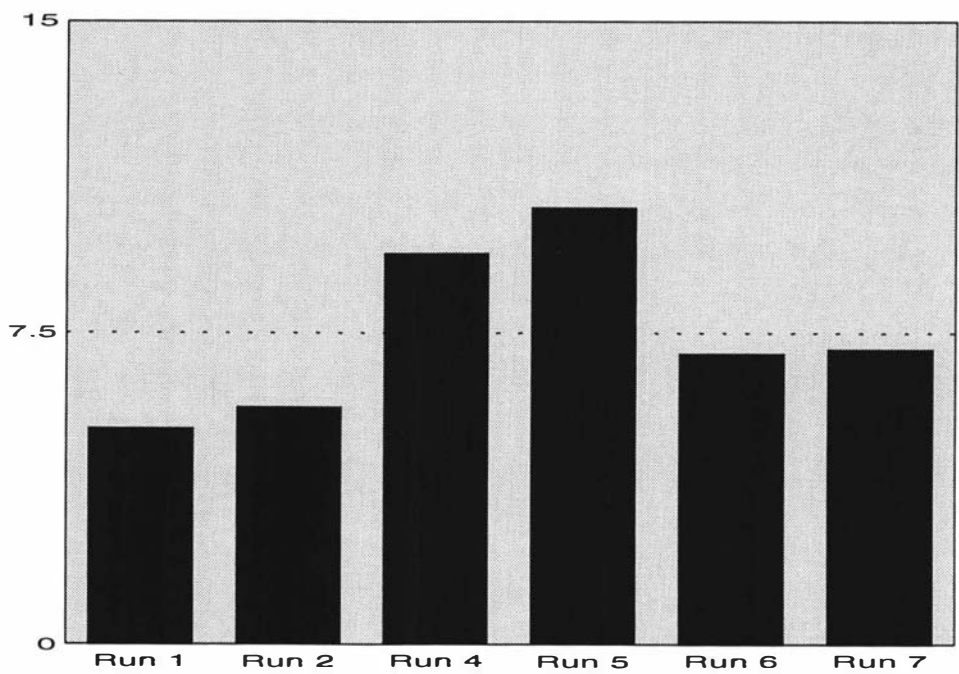


Figure 6.2 Acceptability of the prototypes

6.7.2 Sensory Attributes

The mean scores of sensory attributes of glue stick prototypes obtained from the consumer testing were calculated and are summarised in Table 6.5.

Table 6.5 Sensory attributes of the prototypes

Samples	Groups	Slip	Disintegrate	Coverage	Adjust	Smooth	Stick
1	Univ.	5.1 (3.6)	9.3 (3.6)	7.2 (3.7)	8.0 (4.1)	7.9 (4.4)	10.5 (3.0)
	Office	4.4 (3.7)	8.9 (4.0)	7.3 (3.7)	6.2 (4.0)	6.5 (4.2)	9.4 (4.1)
	School	2.8 (2.5)	9.8 (3.9)	7.3 (3.8)	5.3 (3.3)	7.9 (4.0)	9.7 (4.1)
	TOTAL	4.1 (3.4) ^c	9.4 (3.8) ^a	7.2 (3.7) ^c	6.5 (3.9) ^a	7.4 (4.2) ^c	9.9 (3.7) ^b
2	Univ.	8.2 (2.9)	10.2 (4.0)	7.2 (3.0)	8.9 (3.5)	9.0 (4.2)	9.2 (3.2)
	Office	4.9 (3.4)	10.6 (3.8)	7.0 (3.7)	7.8 (4.0)	7.9 (3.9)	9.5 (4.2)
	School	8.7 (3.7)	10.0 (4.5)	6.5 (3.7)	8.0 (4.2)	8.8 (4.4)	7.3 (4.6)
	TOTAL	7.2 (3.7) ^b	10.3 (4.1) ^a	6.9 (3.5) ^c	8.2 (3.9) ^a	8.6 (4.2) ^b	8.7 (4.1) ^c
4	Univ.	12.1 (2.4)	3.0 (3.3)	10.6 (4.2)	9.2 (4.2)	12.6 (1.5)	9.4 (3.2)
	Office	12.4 (2.1)	4.0 (3.9)	8.9 (3.7)	10.3 (3.2)	11.2 (3.4)	8.3 (4.3)
	School	11.3 (3.8)	4.4 (4.8)	8.1 (4.4)	7.8 (4.2)	11.1 (2.9)	6.0 (4.2)
	TOTAL	11.9 (2.9) ^a	3.8 (4.1) ^c	9.2 (4.2) ^b	9.1 (4.0) ^a	11.6 (2.8) ^a	7.9 (4.2) ^c
5	Univ.	11.2 (1.4)	3.7 (3.3)	11.4 (2.2)	7.5 (4.6)	12.3 (2.4)	11.6 (2.1)
	Office	11.0 (2.8)	5.2 (4.1)	10.3 (2.8)	10.3 (3.5)	11.3 (3.1)	11.3 (3.3)
	School	10.3 (3.2)	4.2 (3.7)	10.0 (3.8)	8.1 (4.0)	10.4 (3.9)	10.2 (3.6)
	TOTAL	10.8 (2.6) ^a	4.3 (3.7) ^c	10.6 (3.0) ^a	8.7 (4.2) ^a	11.3 (3.3) ^a	11.0 (3.1) ^a
6	Univ.	7.5 (3.3)	8.1 (3.3)	9.1 (2.7)	7.5 (3.9)	9.5 (3.5)	10.8 (3.3)
	Office	7.1 (3.3)	7.5 (3.2)	9.6 (2.7)	8.9 (3.3)	9.2 (3.5)	10.9 (3.3)
	School	7.5 (2.8)	6.7 (3.7)	8.4 (2.7)	6.6 (3.4)	9.5 (3.9)	9.5 (3.5)
	TOTAL	7.4 (3.1) ^b	7.5 (3.4) ^b	9.0 (2.7) ^b	7.7 (3.6) ^a	9.4 (3.1) ^b	10.4 (3.4) ^{ab}
7	Univ.	6.7 (3.2)	7.6 (3.9)	8.6 (3.5)	9.1 (3.5)	9.2 (3.7)	10.6 (3.2)
	Office	6.6 (3.4)	7.5 (4.1)	9.1 (3.1)	7.8 (3.9)	8.0 (4.1)	11.2 (3.5)
	School	7.1 (3.8)	6.4 (3.9)	8.5 (3.8)	7.2 (3.5)	8.9 (3.4)	10.2 (3.4)
	TOTAL	6.8 (3.6) ^b	7.1 (4.0) ^b	8.7 (3.5) ^b	8.0 (3.7) ^a	8.7 (3.9) ^b	10.7 (3.3) ^{ab}

Note: (1) The number in the parentheses are standard deviation values
 (2) Scores are on scale 0 to 15
 Slipperiness 0 = drags 15 = slips
 Disintegration 0 = low 15 = high
 Adjustability 0 = very difficult 15 = very easy
 Smoothness 0 = very wrinkly 15 = very smooth
 Stickability 0 = easy to peel 15 = paper stuck very strongly
 (3) Mean scores within the column followed by a different letter are significantly different at $p < 0.05$

The data in Table 6.5 show that Runs 5 and 4, which had the highest affective scores, also had the highest scores in terms of slip, coverage, adjustability and smoothness, both had lowest scores on disintegration. Run 5 also had the highest stickability but Run 4 had lowest stickability.

The scores for sensory attributes of the ideal glue stick obtained from the consumers are shown in Table 6.6.

Table 6.6 Ideal scores of the sensory attributes of the prototypes (Group mean scores)

Group	Slip	Disintegrate	Coverage	Adjust	Smooth	Stick
University	12.1 (1.5)	1.6 (2.1)	12.9 (1.5)	10.1 (4.2)	13.4 (1.4)	11.3 (2.5)
Office	12.8 (2.0)	2.4 (2.7)	12.7 (2.1)	12.1 (2.7)	13.2 (1.8)	11.6 (3.2)
School	12.3 (2.9)	1.4 (2.0)	13.0 (2.4)	11.1 (3.2)	13.9 (1.3)	11.4 (3.6)
TOTAL	12.4 (2.2)	1.8 (2.3)	12.9 (2.0)	11.1 (3.5)	13.5 (1.5)	11.4 (3.1)

Note: The number in the parentheses are standard deviation values

The analysis of variance showed that there were no significant differences for the ideal scores between the three consumer panels for every attribute ($p > 0.05$). This indicated that consumers from the three groups had similar ideal products. The ideal scores for adjustability and stickability had high standard deviations. This might have happened because there were a few panelists who gave very low ideal scores for these attributes.

6.8 RESPONSE OF CONSUMERS IN DIFFERENT MARKET SEGMENTS

Relationships between consumer sensory evaluation scores from each group were studied. Correlations between the sensory attribute scores are shown in Table 6.7.

Table 6.7 Correlations between sensory scores obtained from three groups of consumers

Attribute	Correlation Coefficient ⁽¹⁾	
	Office	School
Acceptability	University	.927***
	Office	.984****
Purchase Intention	University	.942***
	Office	.963***
Price to buy	University	.939***
	Office	.974****
Slipperiness	University	.921***
	Office	.814*
Disintegration	University	.978****
	Office	.949***
Coverage	University	.864**
	Office	.950***
Adjustability	University	-.080
	Office	.743*
Smoothness	University	.974****
	Office	.975****
Stickability	University	.809*
	Office	.871**

Note: (1) * - Significant at $0.1 > p \geq 0.05$
 ** - Significant at $0.05 > p \geq 0.01$
 *** - Significant at $0.01 > p \geq 0.001$
 **** - Significant at $p < 0.001$

The critical value of the Pearson product moment correlation coefficients were used to determine the significant level of correlations. There were good correlations between the scores obtained from the three groups in terms of affective attributes, slipperiness, disintegration, coverage and smoothness. There was only slight correlation for stickability. There was no correlation for adjustability. This might have occurred because the adjustability of the samples were not significantly different.

At this stage, since the results from the three groups of consumers were parallel, it was decided that the total data from the three consumer panels be combined and used in further analysis of the consumer results.

6.9 IDEAL RATIO SCORES AND LOG OF IDEAL RATIO SCORES OF THE SENSORY ATTRIBUTES OF THE PROTOTYPES

6.9.1 Ideal Ratio Scores of the Sensory Attributes of the Prototypes

Ideal ratio scores of the glue stick attributes were calculated by dividing the attribute score by the ideal score from each individual - floating ideal scores were used. The ideal ratio scores from all consumer panelists are shown in Appendix 6.3. The mean ideal ratio scores of the glue stick attributes were calculated and are shown in Table 6.8

Table 6.8 Ideal ratio scores of the sensory attributes of the prototypes (Original data)

Samples	Slip	Disintegrate	Coverage	Adjust	Smooth	Stick
1	0.3 (0.3)	25.9 (36.4)	0.6 (0.3)	2.7 (14.3)	0.6 (0.3)	0.9 (0.5)
2	0.6 (0.4)	28.4 (42.0)	0.6 (0.3)	2.5 (12.7)	0.7 (0.3)	1.0 (1.6)
4	1.0 (0.4)	9.4 (25.9)	0.7 (0.3)	1.7 (5.8)	0.9 (0.2)	1.0 (2.8)
5	0.9 (0.3)	11.2 (22.9)	0.8 (0.2)	1.3 (4.8)	0.9 (0.3)	1.6 (5.8)
6	0.6 (0.3)	19.8 (31.4)	0.7 (0.2)	1.6 (7.2)	0.7 (0.3)	2.0 (10.1)
7	0.6 (0.4)	17.0 (25.2)	0.7 (0.3)	2.9 (14.9)	0.7 (0.3)	2.7 (15.8)

Note: The number in the parentheses are standard deviation values

When the data were transformed to ideal ratios, standard deviations of some attributes were high: disintegration, adjustability and stickability. This was because the placing of the floating ideal varied a great deal for these attributes, see Table 6.6. Hence, it was decided to use log of ideal ratios to compare the prototypes with the ideal product and to reduce the effect of high scoring panelists.

6.9.2 Log of Ideal Ratio Scores of the Attributes of the Prototypes

Log of ideal ratio scores of the glue stick attributes obtained from the 3 groups of consumer panel are shown in Appendix 6.4.

Ideal ratio scores of the glue stick attributes obtained from the logarithm transformation are shown in Table 6.9

Table 6.9 Ideal ratio scores of the sensory attributes of the prototypes (Transformed data)

Samples	Slip	Disintegrate	Coverage	Adjust	Smooth	Stick
1	0.2	9.4	0.5	0.5	0.4	0.8
2	0.5	10.4	0.5	0.7	0.5	0.7
4	0.9	2.4	0.6	0.8	0.8	0.6
5	0.9	3.1	0.8	0.7	0.8	1.0
6	0.5	7.6	0.7	0.7	0.6	0.9
7	0.5	6.7	0.6	0.7	0.5	1.0

Note: Ratios were analyzed using logarithms

Calculation of ideal ratio scores using logarithm transformation reduced the effect of some panelists who gave ideal scores very low for disintegration and very high for adjustability and stickability.

From the ideal ratio scores in Table 6.9, Runs 4 and 5 were closest to the ideal (1.00) in all attributes except that Run 4 was furthest in terms of in stickability. The disintegration was too high for all samples. Generally all the other attributes needed to be increased slightly.

6.10 RELATIONSHIPS BETWEEN ATTRIBUTES OF THE PROTOTYPES

6.10.1 Physical Attributes

From correlations between physical attributes in Table 6.10, wet glue and dry glue per area were highly correlated ($p < 0.001$) and were slightly correlated with open time ($p < 0.10$). Hence, open time was dependent on the amount of glue applied per area. It was found that moisture content had negative correlation with wet glue and dry glue per area. It can be said that glue sticks which had low moisture contents, i.e. high amount of solid in the formulation - mainly adhesive substance - gave high glue residue per area.

Table 6.10 Correlations between physical attributes of the prototypes from mixture design experiment with three components

	Wet glue/area	Dry glue/area	Moisture	Hardness	Open time
Dry glue/area	0.999 ^{***}				
%Moisture	-0.813 [*]	-0.822 [*]			
Hardness	-0.621	-0.636	0.709		
Open time	0.765	0.747	-0.650	-0.413	
Peel strength	-0.532	-0.543	0.190	0.316	0.047

Note:

- * - Significant at $0.05 \geq p \geq 0.01$
- ** - Significant at $0.01 \geq p \geq 0.001$
- *** - Significant at $p < 0.001$

6.10.2 Sensory Attributes

From Table 6.11, it was found that disintegration was negatively correlated with degree of coverage, slipperiness, and smoothness of finished work. It can be said that glue stick with high disintegration would give low slipperiness while applying, leave low degree of glue covered on paper and cause wrinkly finished work.

Table 6.11 Correlations between sensory attributes of the prototypes from mixture design experiment with three components

	Acceptability	Purchase	Price	Slip	Disintegrate	Coverage	Adjust	Smooth
Purchase	0.996 ^{***}							
Price	0.998 ^{***}	0.995 ^{***}						
Slipperiness	0.906 [*]	0.923 ^{**}	0.888 [*]					
Disintegrate	-0.946 ^{**}	-0.927 ^{**}	-0.928 ^{**}	-0.867 [*]				
Coverage	0.942 ^{**}	0.917 ^{**}	0.951 ^{**}	0.728	-0.893 [*]			
Adjust	0.761	0.793	0.752	0.931 ^{**}	-0.695	0.564		
Smooth	0.954 ^{**}	0.960 ^{**}	0.937 ^{**}	0.985 ^{***}	-0.920 ^{**}	0.815 [*]	0.862 [*]	
Stick	0.131	0.098	0.184	-0.273	-0.019	0.416	-0.329	-0.164

Note:

- * - Significant at $0.05 \geq p \geq 0.01$
- ** - Significant at $0.01 \geq p \geq 0.001$
- *** - Significant at $p < 0.001$

From the correlations, it was found that acceptability, purchase intention and price to buy were highly correlated ($p < 0.001$), see Table 6.11. This indicated that acceptability could be used to predict purchase intention and the price consumers were prepared to pay for this product. For further analysis, only acceptability was used in analysis of results.

6.10.3 Acceptability and Sensory Attributes

Correlations between acceptability and sensory attribute scores are shown in Table 6.12. Smoothness, disintegration and degree of coverage were highly correlated with acceptability. This indicated that these attributes could be used to indicate acceptability of the product. Adjustability was correlated with acceptability at $p < 0.10$. Stickability was not correlated with acceptability even though from the previous survey, stickability was found to be an important attribute for glue stick.

Table 6.12 Correlation between acceptability and sensory attributes

Attribute	Correlation coefficient ⁽¹⁾
Smoothness	0.954***
Disintegration	-0.946***
Coverage	0.942***
Slipperiness	0.906**
Adjustability	0.761*
Stickability	0.131

Note: * - Significant at $0.01 > p \geq 0.05$
 ** - Significant at $0.05 > p \geq 0.01$
 *** - Significant at $0.01 > p \geq 0.001$

6.10.4 Sensory Attributes and Physical Attributes

Correlations between sensory attributes and physical attributes are shown in Table 6.13.

Table 6.13 Correlations between sensory attributes and physical attributes

Sensory attributes	Physical attributes	Correlation coefficients
Acceptability	Hardness	0.813***
	Moisture	0.775**
Slipperiness	Moisture	0.954****
	Hardness	0.852***
Disintegration	Hardness	-0.900***
Adjustability	Moisture	0.959****
	Dry glue per area	-0.892***
	Wet glue per area	-0.884***
Coverage	Hardness	0.747*
Smoothness	Moisture	0.877***
	Hardness	0.877***

Note:

- * - Significant at $0.01 \geq p \geq 0.05$
- ** - Significant at $0.05 > p \geq 0.01$
- *** - Significant at $0.01 > p \geq 0.001$
- **** - Significant at $p < 0.001$

It was found that hardness, moisture content, wet glue and dry glue per area were correlated with most of the sensory attributes of glue stick. Hardness and moisture content significantly correlated with acceptability, slipperiness and smoothness, therefore they could be used to assess perception of the consumers toward these attributes. If hardness and moisture content of glue stick increased those sensory attributes also increased. Disintegration and degree of coverage were also dependent on hardness, the harder the glue the lower the disintegration and higher degree of coverage. Adjustability increased with the increasing of moisture content but the decreasing of wet glue and dry glue per area. Open time and peel strength were not related to any sensory attributes.

6.11 RELATIONSHIPS BETWEEN THE COMPONENTS AND ATTRIBUTES OF THE PROTOTYPES

Correlations between the components and attributes of prototypes were calculated and are shown in Table 6.14.

Table 6.14 Correlations between components and attributes of the prototypes

Glue stick component	Attributes	Correlation coefficient
	SENSORY ATTRIBUTES	
Adhesive	Adjustability	-0.896**
Solvent	Slipperiness	0.975****
	Smoothness	0.950***
	Adjustability	0.919***
	Acceptability	0.897**
	PHYSICAL ATTRIBUTES	
Adhesive	Open time	0.906**
	Moisture	-0.885**
	Wet glue/area	0.879**
	Dry glue/area	0.873**
Solvent	Moisture	0.959***
Gel-forming agent	Open time	-0.871*

Note:

*	-	Significant at $0.01 > p \geq 0.05$
**	-	Significant at $0.05 > p \geq 0.01$
***	-	Significant at $0.01 > p \geq 0.001$
****	-	Significant at $p < 0.001$

From the correlation coefficients, it appeared that the solvent had significant effects on acceptability and sensory attributes such as slipperiness, smoothness, and adjustability; adhesive had an effect on adjustability. This agrees with the results from the previous experiment (see Chapter 5). Adhesive had effects on most of the physical attributes which was not found in the previous experiment. Gel-forming agent affected open time, similar to previous experiments.

Empirical equations obtained from multiple regression between sensory and physical attribute and glue stick components are shown in Table 6.15.

Table 6.15 Empirical equations showing relationships between components and attributes of the prototypes

Attributes	Regression Equations	R ²
SENSORY ATTRIBUTES		
Acceptability	-0.156*Adhesive +0.293*Solvent -0.332*Gel	0.99
Slipperiness	-0.315*Adhesive +0.372*Solvent -0.296*Gel	0.99
Disintegration	0.243*Adhesive	0.89
Coverage	0.151*Solvent	0.99
Adjustability	-0.052*Adhesive +0.166*Solvent	0.99
Smoothness	0.167*Solvent	0.99
Stickability	0.168*Adhesive +0.086*Solvent	0.99
PHYSICAL ATTRIBUTES		
Wet glue/area	2.660*Adhesive -0.265*Solvent	0.99
Dry glue/area	1.491*Adhesive -0.233*Solvent	0.99
Moisture	-0.020*Adhesive +0.882*Solvent +0.121*Gel	0.99
Hardness	-0.012*Adhesive 0.083*Solvent	0.99
Open time	0.564*Adhesive -0.005*Solvent -0.688*Gel	0.95
Peel strength	0.043*Adhesive +0.055*Solvent +0.040*Gel	0.99

From this mixture design experiment, linear equations fitted the data very well with high R-squared values and there was no need to go to a higher level equation. The equations obtained were used later for glue stick optimization.

6.12 DISCUSSION

This study showed that quantitative descriptive analysis can be used effectively with consumers in measuring glue stick sensory attributes and to generate the ideal product profile. Although the consumer panelists did not undergo any sensory training, with only some instruction for sensory testing, they could perform the task which would be normally conducted by the trained sensory panel. The results from the test showed that consumers from different groups gave similar results for the affective tests and also the sensory attributes, except adjustability. This could have happened because the panelists could not identify the differences between adjustability of the prototypes.

The results from this consumer testing showed that some of the prototypes were reasonably accepted by the consumers. However, in order to decide in which direction the product should be improved, the ideal product profile assigned by the consumers could be used as a guideline. By using only sample scores without an ideal, the researcher cannot decide how good the product is, while using 'ideal ratio' he/she can tell how different the product attribute is from the ideal attribute and in what direction. Sinthavalai (1986) compared using scores and ideal ratio scores. She concluded that using scores only, ideals needed to be shown so that the difference of the product in magnitude and direction from what the consumers desired could be determined. Ideal ratio had advantage over product attribute scores in that they were quick to present, read and interpret.

During the test, each consumer was asked to indicate his/her own ideal glue stick product on the scale for each attribute. It was found that some consumers gave a very low or a very high ideal attribute score compared with other consumers in the group. This is the problem with normally occurs in using floating ideals, consumers tend to use different part of the scales and the ratio values vary greatly. In this study, using a mean of the ideal ratio scores, some large ratios affected the results markedly but when the data were logarithmically transformed, the effects of these few 'outsider' scores were reduced. In the sensory testing of a Nham product using floating ideals, Wiriyacharee (1990) found that when ideal ratio scores were transformed to the logarithms of the ideal ratio scores, it gave a greater confidence in analysis.

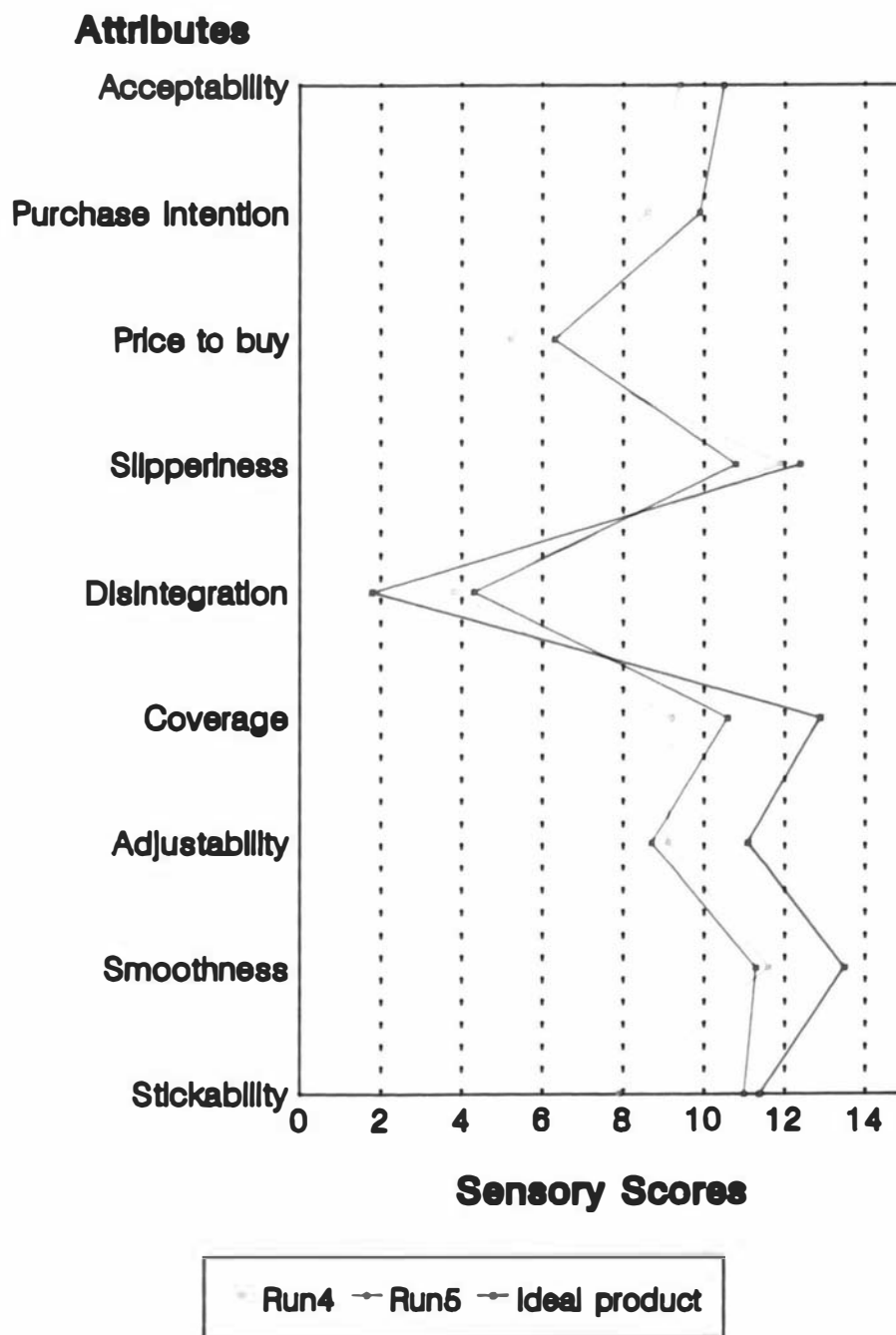


Figure 6.3 Product profiles of the prototypes compared with ideal product profile

The ideal ratios of each prototype, which were obtained from the logarithm transformation, were compared against '1.0' - the consumers' ideal product. There were 2 prototypes, Runs 4 and 5, closer to the ideal product than the others. Both were slightly low on slipperiness, coverage, adjustability, and smoothness, however, the disintegration was markedly too high. Run 5 was ideal on stickability. The profiles of Run 4 and 5 against the ideal profile are shown in Figure 6.3.

Physical attributes of Run 4 and 5 also were closer to those of the commercial products. The wet glue per area, dry glue per area and hardness were only slightly higher and moisture content and open time were slightly lower than the commercial products.

So the formulations from these two prototypes could be used as a guidance for further product optimization. These prototypes had the following formulations:

	Adhesive (%)	Solvent (%)	Gel-forming agent (%)
Run 4	23	62	15
Run 5	28	62	10

The solvent in these formulations were higher than the other prototypes and from the relationships between ingredients and sensory attributes, solvent increased acceptability, slipperiness, adjustability, smoothness and stickability. This indicated that in order to improve these attributes - move them closer to the ideal attributes - amount of solvent in the formulation should be increased. The level of adhesive and gel-forming agent of Runs 4 and 5 were at the lower level and middle of the ranges used in the experimentation. It was found from the ingredient/sensory attribute relationships that adhesive and gel-forming agent decreased acceptability and slipperiness. Adhesive also decreased adjustability and increased disintegration of glue stick. It was decided that the level of these two components should be decreased. Although decreasing of amount of adhesive in the formulation would result in decreasing of stickability, in order to increase acceptability and improve other attributes the stickability had to be traded off.

In this study, it was found that acceptability, purchase intention and price to buy were highly correlated with each other ($p < 0.001$). This indicated that the product which obtained high acceptability would have high opportunity to be purchased and the

consumer would be prepared to pay a high price for that product.

Moskowitz (1983) stated that purchase interest ratings, often paralleled acceptability ratings. Those products which score highest on over all acceptability usually score highest on purchase interest ratings. However, he also mentioned that from time to time, acceptability and purchase interest may correlate only modestly with each other, or even correlate negatively. This will occur in the case that panelists purchase the product for reasons other than sensory attributes or overall acceptability, e.g. breath fresheners which often have highly unacceptable flavours but these flavours signal efficacy.

In this study, acceptability was positively correlated with physical hardness, moisture content, slipperiness, degree of coverage and smoothness and negatively correlated with disintegration. Consequently these attributes can be used to indicate product acceptability. The consumers accepted the products with high slipperiness, degree of coverage and smoothness but low disintegration.

Peel strength was not correlated with any sensory attributes which agreed with the results from previous study. This indicated that the peel strength testing method used in this study cannot be used to determine perceived stickability of glue stick at least for the ranges of components used in this study. Therefore, if glue stick was made commercially it was necessary to find another suitable method which could be used to predict consumers' reactions towards stickability.

6.13 CONCLUSIONS

Consumer panels can be used as a subjective method in identifying the quantitative effect of ingredients on sensory attributes of non-food products, in this case glue stick product. They can be used to identify differences between products. Consumers had no trouble in using the line scale and most of them had no difficulty with scoring their ideal product. There were no differences between the three consumer groups in terms of acceptability, purchase intention, price to buy and most of the sensory attributes, it can be concluded that the target consumers can be regarded as having identical needs

in the product. It was also found that with non-food products like glue stick, consumers were able to test the samples up to 6 to 7 samples without any difficulty. Significant linear models relating the components with glue stick attributes were also obtained.

The use of consumer ideal product profile as the reference to compare the developed prototypes was found very useful since glue stick was a new product compared to other existing glue products, no standards had been set for the physical testing and for suitable levels of physical attributes. At the same time, the direction in which the product should be improved was also obtained.

In the next stage in which the optimization technique was used to generate optimum glue stick formulation, the limits of each ingredient would be as followed:

	Lower limit (%)	Upper limit (%)
Adhesive	15	30
Solvent	60	70
Gel-forming agent	10	15

Consumer ideal profile would be used to set limits for sensory constraints, with the upper and lower bounds being calculated by adding 2 and substituting 2 from the ideal attribute levels. This was done in order to allow a realistic distance that the optimum product could be from the ideal. The physical attributes of commercial glue stick would also be used to generate upper and lower bounds of physical attribute constraints.

CHAPTER 7

PRODUCT OPTIMIZATION

Linear programming is a mathematical technique used in product formulation problems to determine the optimum formulation, subject to certain constraints, and to either maximize or minimize a specified objective. At this stage, linear programming would be applied to generate optimum glue stick formulations. Empirical equations showing relationships between glue stick attributes and components in the formulation were used to develop constraints for the linear programming model. The product ideal profile obtained from consumers indicated the direction in which the product should be improved and was used to generate upper and lower bound for the sensory constraints. Physical attributes of commercial glue sticks were also used to generate upper and lower bounds for physical constraints. Glue stick formulations were then derived from either acceptability maximization or cost minimization.

It was found that in the initial model, there were too many constraints and some of the sensory constraints were too tight and a feasible solution could not be obtained. Adjustments were made to the constraints. Glue sticks using formulations from selected feasible solutions were made and then tested by a laboratory sensory panel. The formulation which obtained the highest acceptability was selected for a pilot scale production.

7.1 AIM AND OBJECTIVES

The aim of this product optimization was to obtain a tapioca starch based glue stick product which was highly acceptable to the target consumers at a low cost and could compete with the products already in the market.

The objectives were to:

- * Use attribute/ingredient relationships and the ideal product profile obtained from the previous mixture design experiment to develop sensory constraints.
- * Generate optimal formulations from the linear programming model by acceptability maximization or cost minimization.
- * Select the optimum formulation obtained from the linear programming model to be used in pilot scale production.

7.2 OPTIMIZATION PLANNING

During the optimization process, linear programming was used to generate the optimum glue stick formulations. Formulations were selected and made in the laboratory. Physical measurements were conducted on the samples. Selected samples were then tested with the laboratory sensory panel. The sample which obtained highest acceptability was chosen for further consumer testing. The optimization plan was as follows:

- * Develop a linear programming model from the empirical equations of sensory attribute/ingredient relationships, acceptability/ingredient relationship, and physical attribute/ingredient relationships.
- * Make the product prototypes from the optimum solutions obtained from the linear programming model.
- * Measure the physical attributes of the prototypes.
- * Measure the sensory attributes of the selected prototypes using a laboratory panel.
- * Select the formulation which obtained highest acceptability for pilot scale production and final consumer testing.

7.3 DEVELOPMENT OF LINEAR PROGRAMMING MODEL

Linear programming model comprised three major components; objective function, decision variables and constraints.

7.3.1 Objective Functions

Although cost is the important factor in formulation of a commercial product, for a consumer product, consumer acceptability is another important factor to be considered. Therefore, in this study, the objective function of the linear programming models was either to minimize cost of the optimum glue stick formulation or to maximize consumer acceptability. In the minimization of glue stick cost, costs of all ingredients were used to create a cost equation which was used as an objective function to generate a low cost formulation. In the maximization of consumer acceptability, the empirical equation relating acceptability and ingredients was used as an objective function to generate a product with high acceptability. The reason that these two objective functions were used in the linear programming model was to compare the formulations and their product attributes obtained from both cost minimization and acceptability maximization then the decision was made on which formulation to be used further for final consumer testing.

The cost of each ingredient used in glue stick formulation was as shown in Table 7.1. These costs were industrial prices obtained from the suppliers in Bangkok.

Table 7.1 Costs of the ingredients used in glue stick formulation

Ingredients	Cost (Baht/kg)
Modified tapioca starch	25.00
Polyvinyl pyrrolidone	495.00
Glycerin	50.00
Stearic acid	20.00
Sodium hydroxide	18.00
Glyceryl monostearate	120.00

The cost of each component was calculated based on the ratio and the costs of the ingredients in each component. They are shown in Table 7.2. These component costs were entered into the model as cost in Baht per kilogram.

Table 7.2 Costs of the components used in glue stick formulation

Components	Cost (Baht/kg)
Adhesive	260.00
Solvent	11.65
Gel-forming agent	19.53
Glyceryl monostearate	120.00

Since 3.5 grams of glyceryl monostearate was added into every 100 gram of the three component mixture, so the objective was to minimize the cost of a 103.5-kg batch of the glue stick product. Therefore, the objective function was to:

minimize

$$Z = 260(\text{Adhesive}) + 11.65(\text{Solvent}) + 19.53(\text{Gel}) + 120(\text{GMS})$$

where the value of ingredients were the weights (in kilograms) of the components and the coefficients were the per-unit costs. Water was assumed to have no cost.

Acceptability equation was developed from the multiple regression of acceptability with glue stick components (Table 6.14). The objective function was to:

maximize

$$Z = -0.156(\text{Adhesive}) + 0.293(\text{Solvent}) - 0.332(\text{Gel-forming agent})$$

7.3.2 Decision Variables

The decision variables for the glue stick formulation were the 3 components used in the previous mixture design experiment together with glyceryl monostearate (see Table 7.3.)

Table 7.3 Decision variables in glue stick formulation

Components	Variables
Adhesive	x_1
Solvent	x_2
Gel-forming agent	x_3
Glyceryl monostearate	x_4

7.3.3 Constraints

Constraints were set on the component level, batch size, sensory attributes and physical attributes of the product. The constraints used in the glue stick linear programming model are shown in Figure 7.1. The component constraints were included in order to control the level of each component in the suitable range suggested by the previous experiment. The physical constraints were used so that the physical attributes of the optimum formulation would be in the ranges of the commercial products which were assumed to be products acceptable to the consumers. The sensory constraints would constrain the product to get closer to the consumers’ ideal product.

Batch size constraint

Constraint (1) was the batch size constraint. The batch size of 103.5 kg was fixed so that the final values of the decision variables could be interpreted as either kilograms or percent of total of three components, not including glyceryl monostearate.

$$x_1 + x_2 + x_3 + x_4 = 103.5 \text{ kg}$$

Component Constraints

Constraints (2) to (8) were glue stick component constraints. The upper and lower bounds of glue stick components were derived from the component levels of the previous mixture design experiment.

BATCH SIZE CONSTRAINTS

TOTAL	$(\text{ADHESIVE} + \text{SOLVENT} + \text{GEL} + \text{GMS}) = 103.5$	(1)
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COMPONENT CONSTRAINTS

ADHESIVE	$\text{ADHESIVE} \geq 15$	(2)
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ADHESIVE	$\text{ADHESIVE} \leq 30$	(3)
----------	---------------------------	-----

SOLVENT	$\text{SOLVENT} \geq 60$	(4)
---------	--------------------------	-----

SOLVENT	$\text{SOLVENT} \leq 70$	(5)
---------	--------------------------	-----

GEL-FORMING AGENT	$\text{GEL} \geq 10$	(6)
-------------------	----------------------	-----

GEL-FORMING AGENT	$\text{GEL} \leq 15$	(7)
-------------------	----------------------	-----

GLYCERYL MONOSTEARATE	$\text{GMS} = 3.5$	(8)
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SLIPPERINESS	$-.315 * \text{ADHESIVE} + .372 * \text{SOLVENT} - .296 * \text{GEL} \geq 10.5$	(9)
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SLIPPERINESS	$-.315 * \text{ADHESIVE} + .372 * \text{SOLVENT} - .296 * \text{GEL} \leq 14.5$	(10)
--------------	---	------

DISINTEGRATION	$.243 * \text{ADHESIVE} \geq 0$	(11)
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DISINTEGRATION	$.243 * \text{ADHESIVE} \leq 4.0$	(12)
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COVERAGE	$.151 * \text{SOLVENT} \geq 11$	(13)
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COVERAGE	$.151 * \text{SOLVENT} \leq 15$	(14)
----------	---------------------------------	------

ADJUSTABILITY	$-.052 * \text{ADHESIVE} + .166 * \text{SOLVENT} \geq 9$	(15)
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ADJUSTABILITY	$-.052 * \text{ADHESIVE} + .166 * \text{SOLVENT} \leq 13$	(16)
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SMOOTHNESS	$.167 * \text{SOLVENT} \geq 11.5$	(17)
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SMOOTHNESS	$.167 * \text{SOLVENT} \leq 15$	(18)
------------	---------------------------------	------

STICKABILITY	$.168 * \text{ADHESIVE} + .086 * \text{SOLVENT} \geq 9.5$	(19)
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STICKABILITY	$.168 * \text{ADHESIVE} + .086 * \text{SOLVENT} \leq 13.5$	(20)
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ACCEPTABILITY	$-.156 * \text{ADHESIVE} + .293 * \text{SOLVENT} - .332 * \text{GEL} \geq 13$	(21)
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PHYSICAL CONSTRAINTS

WET GLUE/AREA	$2.66 * \text{ADHESIVE} - .265 * \text{SOLVENT} \geq 31$	(22)
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WET GLUE/AREA	$2.66 * \text{ADHESIVE} - .265 * \text{SOLVENT} \leq 46$	(23)
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DRY GLUE/AREA	$1.491 * \text{ADHESIVE} - .233 * \text{SOLVENT} \geq 10$	(24)
---------------	---	------

DRY GLUE/AREA	$1.491 * \text{ADHESIVE} - .233 * \text{SOLVENT} \leq 15$	(25)
---------------	---	------

MOISTURE CONTENT	$-.02 * \text{ADHESIVE} + .882 * \text{SOLVENT} + .121 * \text{GEL} \geq 56$	(26)
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MOISTURE CONTENT	$-.02 * \text{ADHESIVE} + .882 * \text{SOLVENT} + .121 * \text{GEL} \leq 68$	(27)
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HARDNESS	$-.012 * \text{ADHESIVE} + .083 * \text{SOLVENT} \geq 2$	(28)
----------	--	------

HARDNESS	$-.012 * \text{ADHESIVE} + .083 * \text{SOLVENT} \leq 6$	(29)
----------	--	------

OPEN TIME	$.564 * \text{ADHESIVE} - .005 * \text{SOLVENT} - .688 * \text{GEL} \geq 2$	(30)
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OPEN TIME	$.564 * \text{ADHESIVE} - .005 * \text{SOLVENT} - .688 * \text{GEL} \leq 100$	(31)
-----------	---	------

PEEL STRENGTH	$.043 * \text{ADHESIVE} + .055 * \text{SOLVENT} + .04 * \text{GEL} \geq 3.6$	(32)
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PEEL STRENGTH	$.043 * \text{ADHESIVE} + .055 * \text{SOLVENT} + .04 * \text{GEL} \leq 6.3$	(33)
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Figure 7.1 Constraints for glue stick linear programming model

Sensory Constraints

Sensory constraints, constraints (9) to (20), were developed from the empirical equations showing relationships between glue stick components and sensory attributes obtained from regression analysis in Section 6.11. In the cost minimization, acceptability constraint, (21), could also be used in the model. The upper and lower bounds of the sensory constraints were calculated by adding and subtracting 2 from the mean product ideal attribute scores obtained from consumer testing in Table 6.6. Those ranges were used in order to allow enough space to obtain a feasible solution. However, these bounds could be adjusted in order to get a feasible solution. The lower bound of acceptability was set at 13.

Physical constraints

Physical constraints, constraints (22) to (33), were developed from the empirical equations showing relationships between glue stick components and physical attributes. The upper and lower bounds of physical attributes were derived from the ranges of commercial glue stick physical attributes, so that the physical attributes of the optimum formulation would be in the ranges of commercial products.

7.4 DEVELOPMENT OF OPTIMUM FORMULATIONS FROM LINEAR PROGRAMMING

There were two objective functions to be used in generating optimum formulation for glue stick: cost minimization and acceptability maximization. The formulations were developed from one of these two objective functions, together with sensory constraints and/or physical constraints.

7.4.1 Cost Minimization

Linear Programming Model (1) which was comprised of cost minimization objective function, batch constraint (1) and the component constraints (2) to (8) was used as the basic model for cost minimization. Model (1) is shown in Figure 7.2.

MINIMIZE	$Z_c = 260*ADHESIVE + 11.65*SOLVENT + 19.53*GEL + 120*GMS$	
SUBJECT TO		
	$ADHESIVE + SOLVENT + GEL + GMS = 103.5$	(1)
	$ADHESIVE \geq 15$	(2)
	$ADHESIVE \leq 30$	(3)
	$SOLVENT \geq 60$	(4)
	$SOLVENT \leq 70$	(5)
	$GEL \geq 10$	(6)
	$GEL \leq 15$	(7)
	$GMS = 3.5$	(8)

Figure 7.2 Model (1) for cost minimization

Minimize cost with sensory attributes (F1)

Sensory constraints (9) to (20) were added to Model (1) in order to generate glue stick formulation with desired sensory attribute levels at the lowest cost. In the first running of the model on the computer using LP88 computer programme, no feasible solution was obtained. It was found that the sensory constraints were too tight. Therefore, adjustments were made to these constraints until the feasible solution was obtained. The constraints were changed as follows:

- * Slipperiness constraint, from 10.5-14.5 to 10.5-15.0
- * Disintegration constraint, from 0.0-4.0 to 0.0-4.5
- * Coverage constraint, from 11.0-15.0 to 9.0-15.0
- * Smoothness constraint, from 11.5-15.0 to 10.5-15.0
- * Stickability constraint, from 9.5-13.5 to 8.5-13.5

These adjusted constraints were also used in the other linear programming models.

Minimize cost with acceptability (F2)

Only acceptability constraint was added to Model (1) in order to obtain glue stick formulation which had high acceptability at the lowest cost but did not take other constraints of glue stick attributes into account.

Minimize cost with sensory and acceptability (F3)

In this linear programming model, both sensory constraints, constraints (9)-(20), and acceptability constraint, constraint (21) were added to Model (1). The model was run on the LP88 programme, but no feasible solution was obtained. The upper bound of slipperiness had to be increased to 17 in order to get a feasible solution.

Minimize cost with physical attributes (F4)

Only physical attribute constraints, constraints (22)-(33), were added to model (1) in order to obtain a glue stick formulation with desired attribute levels at a lowest cost.

Minimize cost with physical and sensory attributes (F5)

Physical constraints and sensory constraints were added to Model (1) so a glue stick formulation with desired sensory and physical attribute levels could be obtained at a lowest cost. The lower bound of open time had to be adjusted in order to get a feasible solution.

Minimize cost with physical attributes and acceptability (F6)

Physical constraints and acceptability constraints were added to Model (1). From this model a glue stick formulation with desired levels of acceptability and physical attribute levels was obtained.

Minimize cost with physical and sensory attributes and acceptability (F7)

All glue stick attribute constraints were added to Model (1). In order to get a feasible formulation, slipperiness upper bound constraint had to be increased to 16 and lower bound constraint of open time had to be decreased to 1.98.

The optimum formulations are shown in Table 7.4.

Table 7.4 Glue stick optimum formulations and their expected attribute levels obtained from cost minimization

	F1	F2	F3	F4	F5	F6	F7
Adhesive	17.73	15.00	15.00	18.51	18.31	18.51	18.51
Solvent	67.27	70.00	70.00	68.73	66.69	68.73	68.70
Gel-forming agent	15.00	15.00	15.00	12.76	15.00	12.76	12.79
GMS	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Slipperiness	15.0	(16.9)	16.9	(16.0)	14.6	(16.0)	16.0
Disintegration	4.3	(3.7)	3.7	(4.5)	4.5	(4.5)	4.5
Coverage	10.2	(10.6)	10.6	(10.4)	10.1	(10.4)	10.4
Adjustability	10.3	(10.8)	10.8	(10.5)	10.1	(10.5)	10.4
Smoothness	11.2	(11.7)	11.7	(11.5)	11.1	(11.5)	11.5
Stickability	8.8	(8.5)	8.5	(9.0)	8.8	(9.0)	9.0
Wet glue/area	(29.3)	(21.3)	(21.3)	31.0	31.0	31.0	31.0
Dry glue/area	(10.8)	(6.1)	(6.1)	11.6	11.8	11.6	11.6
Moisture	(57.6)	(60.5)	(60.5)	58.4	56.9	58.4	58.4
Hardness	(5.37)	(5.63)	(5.63)	5.48	5.32	5.48	5.48
Open time	(0.02)	(-1.51)	(-1.51)	2.00	0.34	2.00	1.98
Peel strength	(5.06)	(5.10)	(5.10)	5.09	5.06	5.09	5.09
Costs (Baht)	6106	5428	5428	6282	6249	6282	6281
Acceptability	(12.0)	13.2	13.2	(13.0)	(11.7)	13.0	13.0

Note: Number in the parentheses were the attributes which were not limited by the constraints

7.4.2 Acceptability Maximization

For product acceptability maximization, linear Programming Model (2) comprised of acceptability maximization objective function, batch constraint (1) and the component constraints (2) to (9) was used as the basic model. The model is shown in Figure 7.3.

MAXIMIZE	$Z_a = -1.156*ADHESIVE+.293*SOLVENT-.332*GEL$	
SUBJECT TO		
	$ADHESIVE+SOLVENT+GEL+GMS = 103.5$	(1)
	$ADHESIVE \geq 15$	(2)
	$ADHESIVE \leq 30$	(3)
	$SOLVENT \geq 60$	(4)
	$SOLVENT \leq 70$	(5)
	$GEL \geq 10$	(6)
	$GEL \leq 15$	(7)
	$GMS = 3.5$	(8)

Figure 7.3 Model (2) for acceptability maximization

Maximize acceptability (F8)

Model (2) was run on the computer without any other glue stick attribute constraints. This was to get optimum glue stick formulation with highest expected acceptability.

Maximize acceptability with sensory attributes (F9.1)

Sensory attribute constraints, constraint (10)-(20) were added to Model (2). Two other formulations were derived from formulation F9.1 by varying the solvent level in the formulation.

Formulation F9.2 was obtained by setting solvent constraint at 60-65%. In this model, the disintegration upper bound constraint had to be increased to 4.86 in order to get a feasible solution. Expected stickability was more than that of F9.1 but disintegration was higher.

Formulation F9.3 was obtained by setting solvent at constraint 60-67% and disintegration upper bound constraint had to be increased to 5.6 so a feasible solution could be obtained.

Maximize acceptability with physical attributes (F10)

Physical attribute constraints, constraints (22)-(33), were added to Model (2).

Maximize acceptability with sensory and physical attributes (F11)

Both sensory attribute constraints and physical attribute constraints were added to Model (2).

Optimum formulations obtained are shown in Table 7.5.

Table 7.5 Glue stick optimum formulations and their expected attribute levels obtained from acceptability maximization

	F8	F9.1	F9.2	F9.3	F10	F11
Adhesive	20.00	18.52	20.00	23.00	20.00	20.00
Solvent	70.00	67.29	65.00	67.00	70.00	70.00
Gel-forming agent	10.00	14.19	15.00	10.00	10.00	10.00
GMS	3.50	3.50	3.50	3.50	3.50	3.50
Slipperiness	(16.8)	15.0	13.4	14.7	(16.8)	16.8
Disintegrate	(4.9)	4.5	4.9	5.6	(4.9)	4.9
Coverage	(10.8)	10.2	9.8	10.1	(10.6)	10.6
Adjustability	(10.6)	10.2	9.8	9.9	(10.6)	10.6
Smoothness	(11.7)	11.2	10.9	11.2	(11.7)	11.7
Stickability	(9.4)	8.9	9.0	9.6	(9.4)	9.4
Wet glue/area	(34.7)	(31.1)	(36.0)	(43.4)	34.7	34.7
Dry glue/area	(13.5)	(11.9)	(14.7)	(18.7)	13.5	13.5
Moisture	(62.6)	(57.3)	(55.1)	(55.7)	62.6	62.6
Hardness	(5.57)	(5.36)	(5.16)	(5.29)	5.57	5.57
Open time	(4.05)	(1.02)	(1.29)	(6.43)	4.05	4.05
Peel strength	(5.11)	(5.06)	(5.04)	(5.07)	5.11	5.11
Costs (Baht)	6631	6296	6670	7376	6631	6631
Acceptability	14.1	12.1	11.0	12.7	14.1	14.1

Note: Number in the parentheses were the attributes which were not limited by the constraints.

7.5 SELECTION OF FORMULATIONS OBTAINED FROM LINEAR PROGRAMMING

The feasible formulations obtained from linear programming were selected to be made in the laboratory. Formulations F4, F6 and F7 were similar, so F7 which included all constraints was chosen. Formulations F1 and F5 gave similar predicted sensory

attributes but some physical attributes of F1 were out of the range of commercial glue sticks hence, F5 was chosen. Formulations F2 and F3 had the same levels of components in the formulations so F3 was chosen.

Since F8, F10 and F11 were the same formulation, F11 was used. F9.1, F9.2 and F9.3 were selected since these formulation showed sensitivity to decreasing upper bound of solvent constraint.

The formulations selected from linear programming and the predicted scores on product attributes are shown in Table 7.6.

Table 7.6 Selected formulations obtained from linear programming

	F3	F5	F7	F9.1	F9.2	F11	F9.3
Adhesive	15.00	18.31	18.51	18.52	20.00	20.00	23.00
Solvent	70.00	66.69	68.70	67.29	65.00	70.00	67.00
Gel-forming agent	15.00	15.0	12.79	14.19	15.00	10.00	10.00
Slipperiness	16.9	14.6	16.0	15.0	13.4	16.8	14.7
Disintegration	3.7	4.5	4.5	4.5	4.9	4.9	5.6
Coverage	10.6	10.1	10.4	10.2	9.8	10.6	10.1
Adjustability	10.8	10.1	10.4	10.2	9.8	10.6	9.9
Smoothness	11.7	11.1	11.5	11.2	10.9	11.7	11.2
Stickability	8.5	8.8	9.0	8.9	9.0	9.4	9.6
Wet glue/area	21.3	31.0	31.0	31.1	36.0	34.7	43.4
Dry glue/area	6.1	11.8	11.6	11.9	14.7	13.5	18.7
Moisture	60.5	56.9	58.4	57.3	55.1	62.6	55.7
Hardness	5.63	5.32	5.48	5.36	5.16	5.57	5.29
Open time	-1.51	0.34	1.98	1.02	1.29	4.05	6.43
Peel strength	5.10	5.06	5.09	5.06	5.04	5.11	5.07
Costs (Baht)	5428	6249	6282	6296	6670	6631	7376
Acceptability	13.2	11.7	13.0	12.1	11.0	14.1	12.7

Figure 7.4 shows the positions of these formulations on the mixture space. The glue sticks were made from these optimum formulations using the processing method described in Section 3.5. The samples were aged for at least 5 days before the testing was conducted.

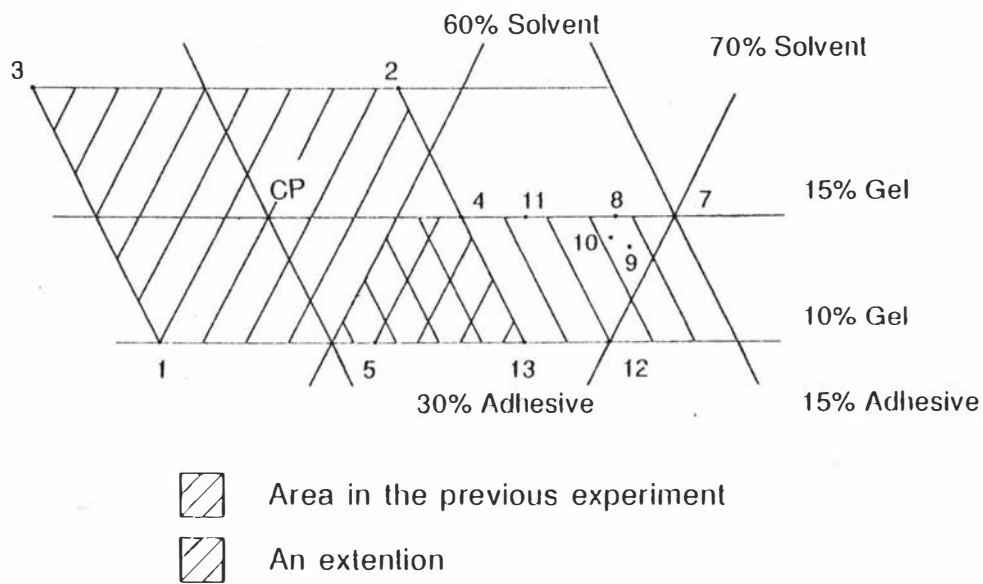


Figure 7.4 Positions of the optimum formulations on the mixture space

7.6 PHYSICAL ATTRIBUTES OF GLUE STICKS DEVELOPED FROM LINEAR PROGRAMMING MODELS

Physical attributes of the optimum glue sticks were measured using the same methods as described in Section 3.3.

Table 7.7 Physical attributes of the glue sticks developed from linear programming models

Samples	Wet glue/area (g/m ²)	Dry glue/area (g/m ²)	Moisture content (%)	Hardness (Newton)	Open time (minute)	Peel strength (Newton)
F3	26.4	9.8	58.9	3.86	0.00	4.05
F5	32.0	12.7	55.4	3.58	1.50	4.78
F7	35.9	13.7	56.8	4.01	2.50	4.75
F9	34.9	13.1	55.6	3.62	2.00	4.60
F9.2	31.1	11.1	59.9	4.63	0.00	4.32
F9.3	31.5	12.2	57.2	4.01	3.00	4.81
F11	36.5	13.9	57.5	3.96	1.50	4.52

Apart from open time, the physical attributes of most samples from the formulations developed from linear programming models were in the commercial ranges. Only the sample from formulations F3 and F9.2 had lower wet glue and dry glue per area than the commercial range. The open time of all the samples were much lower than those of the commercial glue sticks. Samples from formulations F5, F7, F9, F9.3 and F11 had open time between 1.50-3.00. Formulation F3 and F9.2 had no open time.

The samples were selected for sensory testing by the laboratory sensory panel. Since formulation F3 and F9.2 had low amounts of glue residue left on paper and their open time was 0.00, they were not tested any further.

7.7 SENSORY TESTING

7.7.1 Selection of Samples for Sensory Testing

Formula F5, F7, F9, F9.3 and F11 from linear programming were chosen to be tested by a laboratory panel. These samples were presented to the panelists together with the Runs 4 and 5 from the second mixture design experiment (Section 6.2), in order that the results between optimum formulation from linear programming could be compared with the best glue stick samples from the previous mixture design experiment.

7.7.2 Sample Preparation

The samples were allowed to age for at least 5 days before the test was conducted. They were coded with 3 random digit numbers.

7.7.3 Method of Sensory Testing

Sensory evaluation was carried out by 10 panelists: 8 post graduate students and 2 non-academic staff at the Product Development Department, Kasetsart University, all of whom had already participated in the first consumer testing. This panel will be mentioned as 'pseudo-consumer panel' subsequently. Samples were presented simultaneously to the panelists. The questionnaire used in this test was in Thai, the

same as the one used in consumer testing described in Section 6.4.3 and the method of testing was as in Section 6.4.5.

7.7.4 Sensory Attributes

Mean scores of the sensory attributes of the glue stick samples were calculated, the results are shown in Table 7.8.

Table 7.8 Sensory attributes of the glue sticks developed from linear programming model (mean scores)

Samples	Accept	Slip	Disintegr.	Coverage	Adjust	Smooth	Stick
F9.3	11.0 ^a	11.8 ^a	3.4 ^c	11.1 ^a	10.8 ^a	12.5 ^a	11.2 ^{ab}
F7	10.2 ^{ab}	10.9 ^{ab}	5.9 ^{abc}	10.9 ^a	10.8 ^a	11.6 ^{ab}	12.0 ^{ab}
F11	9.9 ^{ab}	11.3 ^{ab}	6.1 ^{ab}	10.4 ^a	8.8 ^a	12.0 ^{ab}	11.8 ^{ab}
F9.1	9.7 ^{ab}	10.4 ^b	5.7 ^{abc}	10.0 ^a	9.7 ^a	11.2 ^{bc}	9.7 ^c
F5	8.4 ^c	11.2 ^{ab}	7.4 ^a	9.9 ^a	10.3 ^a	10.6 ^c	12.1 ^a
RUN4	10.0 ^{ab}	9.1 ^c	4.1 ^{bc}	10.3 ^a	10.0 ^a	12.6 ^a	10.2 ^{bc}
RUN5	9.3 ^{bc}	7.8 ^d	4.2 ^{bc}	10.3 ^a	9.4 ^a	12.2 ^a	12.2 ^a

Note: Mean scores within the column followed by a different letter are significantly different at p < 0.05, using t-test.

The sample from formulation F9.3 obtained highest acceptability and lowest disintegration. It also scored higher for acceptability than Runs 4 and 5, the best samples from the previous experiment. In general, F9.3 had better sensory attributes than Run 4 and 5. Degree of coverage and adjustability were not significantly different between samples.

Ideal ratio scores of samples were calculated by dividing the sample scores by the mean ideal scores obtained from consumer testing in Table 6.6. The results are shown in Table 7.9.

Table 7.9 Sensory attribute ideal ratio scores of the glue sticks developed from linear programming

Samples	Slip	Disintegrate	Coverage	Adjust	Smooth	Stick	Total Difference from 1.0
F9.3	0.95	1.85	0.86	0.97	0.93	0.98	1.16
F7	0.88	3.23	0.85	0.97	0.86	1.05	2.72
F11	0.91	3.32	0.81	0.79	0.89	1.03	2.95
F9.1	0.84	3.14	0.77	0.88	0.83	0.85	2.97
F5	0.90	4.07	0.77	0.93	0.79	1.06	3.74
RUN4	0.74	2.25	0.80	0.90	0.93	0.90	1.98
RUN5	0.63	2.31	0.80	0.85	0.91	1.07	2.19

Note: Total difference from 1 was calculated from sum of the difference of ideal ratio scores from 1.

From the mean ideal scores, sample F9.3 was closest to the consumers’ ideal glue stick. Hence, formulation F9.3 was chosen for pilot plant scale production. F7 was not chosen even though some of its attributes were close to the ideal product and the formulation cost was lower than that of F9.3 because the disintegration was much higher and other sensory attributes were slightly lower.

7.7.5 Optimum Formulation

The profile of the optimum formulation (F9.3) is shown in Figure 7.5 in comparison with the consumers’ ideal product profile. The slipperiness, adjustability, smoothness and stickability were quite close to the ideal product. Disintegration was higher and degree of coverage was lower.

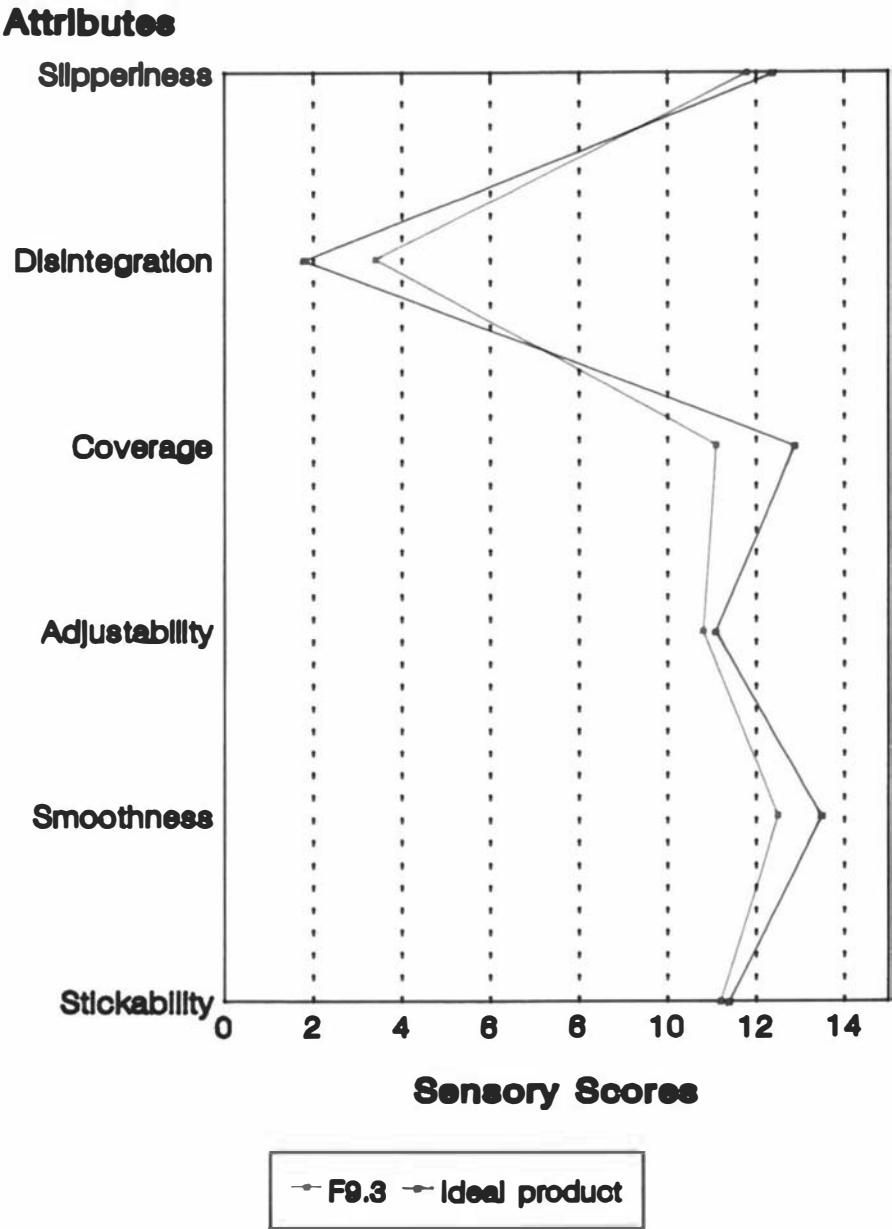


Figure 7.5 Product profile of optimum formulation compared with ideal product profile

7.8 DISCUSSION

7.8.1 Comparison of Optimum Formulation with Commercial Products and Consumers' Ideal Product

Table 7.10 shows the attributes of the optimum formulation compared with attributes of commercial glue sticks and ideal product.

Table 7.10 Attributes of optimum glue stick compared with commercial products and ideal product

Attributes	Optimum Product	Commercial Ranges	Ideal Product
<u>Sensory attribute</u>			
Slipperiness	11.8	5.9-9.6	12.4
Disintegration	3.4	3.8-8.1	1.8
Coverage	11.1	10.2-11.4	12.9
Adjustability	10.8	8.5-10.4	11.1
Smoothness	12.5	10.5-12.2	13.5
Stickability	11.2	9.4-10.7	11.4
<u>Physical attributes</u>			
Wet glue/area	31.5	31.9-45.8	
Dry glue/area	12.2	10.3-14.9	
Moisture	57.2	57.0-65.3	
Hardness	4.01	2.42-3.55	
Open time	3.00	12.3-99.0	
Peel strength	4.81	3.65-6.30	

The sensory attributes of optimum product were quite close to those of the ideal product. Disintegration of the optimum product was higher than the ideal but still lower than the commercial product. Other sensory attributes of the optimum product were slightly higher than the commercial ranges. Physical attributes were in the range of commercial products except open time which was much lower.

7.8.2 Comparison between Cost minimization and Acceptability Maximization

The cost and sensory attributes of formulation from cost minimization and acceptability maximization are compared in Table 7.11

Table 7.11 Comparison between using cost minimization and acceptability maximization

	Cost Minimization	Acceptability Maximization
Cost (Bahts/103.5 kg)	5,428-6,282	6,296-7,376
<u>Sensory attributes</u>		
Acceptability	8.4-10.2	9.7-11.0
Slipperiness	10.9-11.2	10.4-11.8
Disintegration	5.9-7.4	3.4-6.1
Coverage	9.9-10.9	10.0-11.1
Adjustability	10.3-10.8	8.8-10.8
Smoothness	10.6-11.6	11.2-12.5
Stickability	12.0-12.1	9.7-11.2
<u>Physical attributes</u>		
Wet glue/area	26.4-35.9	31.1-36.5
Dry glue/area	9.8-13.7	11.1-13.9
Moisture	55.4-58.9	55.6-59.9
Hardness	3.58-4.01	3.62-4.63
Open time	0-2.50	0.00-3.00
Peel Strength	4.05-4.78	4.32-4.81

With acceptability maximization the cost of product formulations were higher than those from cost minimization. This was because there was high amount of adhesive substance in the formulations obtained from acceptability maximization. The acceptability of the formulation obtained from acceptability maximization were higher, sensory attributes were similar. Most physical attributes from acceptability maximization were higher.

7.8.3 Use of Linear Programming in Glue Stick Optimization

Linear programming was found useful for the formulation of a tapioca based glue stick with sensory constraints, cost limitation and high acceptability. It was conclusively shown that the relationships between sensory attributes and glue stick ingredients obtained from the consumer panel could be used in developing a linear programming model. Mean ideal scores was also useful for guiding the upper and lower bounds of sensory attributes.

Although sensory attribute constraints had already been included in the linear programming model, physical attribute constraints were included as well in order to control the physical properties of glue stick at the levels of commercial glue sticks. Kavanagh (1978) successfully used physical attributes of commercial products as standards in the optimization of paint and resin formulation. Chan and Kavanagh (1988) also used a similar method in the formulation of light duty liquid detergent.

With using cost as an objective constraint, it was possible to obtain a product with high acceptability. However, when acceptability was used, the formulations gave product with higher acceptability but a higher cost. So it should be considered carefully which objective function is to be used. Although the formulation chosen to be made in the pilot scale did not give the lowest formulation cost, its sensory attributes were considered close to the ideal product and the acceptability was highest. This glue stick had potential to be accepted by the target consumers.

The advantage of using this method is that it allows the researcher with no experience with the product to reach an acceptable formulation in a finite number of steps. However, the disadvantage is the need for linear relationships between product attributes and ingredients in the formulation therefore the ingredients used in the experimentation have to be limited in a narrow compositional ranges.

7.9 CONCLUSIONS

The linear programming model using the linear relationships between sensory attributes and ingredients as constraints of the model was used successfully to optimize the formulation during the product optimization process in order to obtain a highly acceptable glue stick to consumers. Since the consumers' ideal product profile was used to create upper and lower bounds in the linear programming model, it was possible to generate an optimum product which possessed the attribute levels near those of the consumers' ideal product.

It is suggested that this system could be used successfully for any product, in which the relationships between the product's attributes and the ingredients are linear. The constraints to be used in the model could include component levels, sensory attributes as an ideal product profile and physical properties specification. The minimum number of constraints should be used so that a feasible solution is obtained. If the relationships between sensory and physical attributes are correlated. There might be no need for sensory constraints. Product optimization using linear programming as a tool to optimize sensory attribute levels is an excellent method to obtain the optimum product if the sensory/ingredient relations are linear and the interaction between ingredients are negligible.

The use of linear programming was found suitable for glue stick formulations if it was combined with mixture experimental design. The proportions of the main ingredients in the glue system were interrelated and factorial designs could not be used. With linear programming, the optimum formulation can be obtained easily but with other methods such as response surface methodology it is more difficult to interpret the results. However, with the use of linear models, the range of ingredients which could be used are limited since moving outside the specified range the relationship may not be linear.

The final product possessed attributes close to the consumers' ideal product in terms of slipperiness, adjustability, smoothness, and stickability. Degree of coverage was slightly lower and disintegration was higher than those of the ideal product. Most of physical attributes were in the ranges of the commercial products except open time which was lower than the commercial products. However, the recommended open time

was at least one minute so this was considered acceptable.

The glue stick optimum formulation obtained from linear programming model and its cost are shown below:

	%
Starch	11.11
Polyvinyl pyrrolidone	11.11
Glycerin	14.93
Water	49.81
Stearic acid	7.39
Sodium hydroxide	2.27
Glyceryl monostearate	<u>3.38</u>
	100.00
Cost(Baht/100 kg)	7126.43
Cost per 8 g stick (Baht)	0.57

(estimate at no loss in the processing)

The formulation from the linear programming model which obtained highest consumer acceptability was chosen to be made in pilot plant scale. This optimum glue stick product obtained had potential to be accepted by the target consumers. However, this product had to be tested for acceptability in home-use testing before launching to the market to ascertain that it could compete with the products already in the market.

The processing method used in the laboratory scale was to be applied and used in the pilot scale production of glue stick. Pilot scale equipment was to be developed with the same principle as the laboratory equipment.

CHAPTER 8

PRODUCTION TRIAL

The optimum formulation from the previous study was used to make glue stick in the pilot plant development stage. At this stage, the product was made at the pilot plant level which was the small scale of the commercial manufacturing. The product was then tested against the product from the same formulation in the previous study, and a commercial product. The effect of storage on the product attributes was also studied.

8.1 AIM AND OBJECTIVES

In the previous section, an optimum glue stick was made on a laboratory scale. It was expected that when the glue stick was produced commercially, it should have the same properties as those of the one developed in the laboratory scale. Therefore, the aim of this production trial study was to confirm that the formulation and process developed in the laboratory could be transferred into industrial production, and that the product would have the same acceptability to consumers as the product from the laboratory experiments.

The objectives were to:

- * Design a suitable system to convert the raw materials into a product with the specified properties.
- * Compare glue stick from the pilot scale with the laboratory scale and a commercial product.
- * Generate samples for final consumer testing.

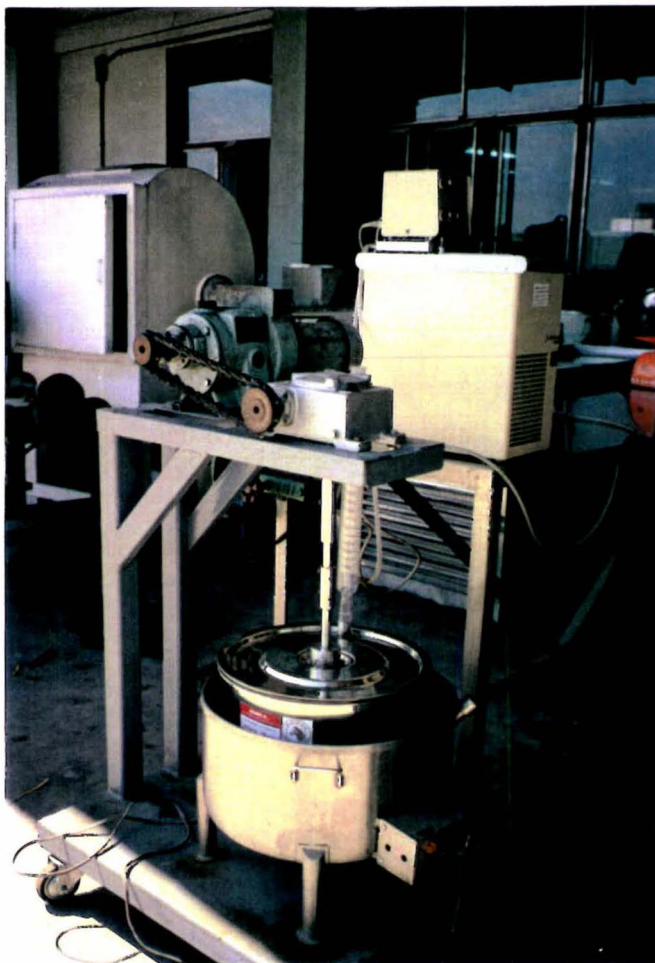


Figure 8.1 Pilot scale equipment

8.2 PILOT SCALE PRODUCTION

8.2.1 Equipment

The equipment used in the pilot scale production is shown in Figure 8.1. A mechanical stirrer was developed at the Department of Product Development, Kasetsart University. The stirrer was rotated by a 1/4 HP motor. The speed was controlled by a gear box and this could be turned on and off by a switch. The stainless steel stirrer was a double-paddle form, with rectangular blades (size 4 cm x 12.5 cm). The top blade and bottom blade were set 3.5 cm apart, so that it could stir and sweep the glue mixture from the bottom and the side of the pot. The stirrer was attached to an adjustable axle so that it could be lifted up or lowered down as desired.

A 32 cm diameter and 20 cm deep stainless steel pot was used. The pot was covered with a lid which had one hole in the middle for the stirrer and one hole at 2 cm from the edge for the condenser. A spiral glass condenser was used to provide a reflux system for the process with 17 °C input water from the cooling system. A rubber gasket was attached around the edge of the lid in order to prevent any leaking of the steam. The temperature of the mixture during processing was measured using a thermometer. The pot was placed in a water bath which was electrically heated.

8.2.2 Formulation

The formulation which was obtained from the product optimization was used. The product was made in 6210 g batches. Table 8.1 shows percentage and amount of each ingredient used in the production.

Table 8.1 Levels of glue stick ingredients used in the pilot scale production

Ingredient	Percentage	Quantity (grams)
Modified tapioca starch	11.11	690
Polyvinyl pyrrolidone	11.11	690
Water	49.81	3093
Glycerin	14.93	927
Stearic acid	7.39	459
Sodium hydroxide	2.27	141
Glyceryl monostearate	<u>3.38</u>	<u>210</u>
Total	100.00	6210

The ingredients used in this stage were the same as those used in the laboratory scale except the sodium hydroxide was industrial grade instead of laboratory grade.

8.2.3 Processing Method

The processing method was similar to that employed in the laboratory scale. The cooking time was extended from 60 minutes to 90 minutes in order to allow for the heating time necessary for the large amount of raw materials.

The liquid ingredients were put in the stainless steel pot. Then the modified starch was gradually stirred into the liquid, followed by polyvinyl pyrrolidone, stearic acid, glyceryl monostearate and sodium hydroxide. The mixture was stirred manually until it became a homogeneous mixture. The pot was then put in the water bath at 90 °C and covered with the lid which had the stirrer attached to it. Then the stirrer was connected to the motor, and the mixture was stirred at 15 rpm. At this stage the temperature of the water in the water bath was increased up to about 100 °C. The mixture was then heated for a further 90 minutes.

The pot was taken out of the water bath and the hot mixture was poured into a 48 cm x 38.5 cm x 5 cm stainless steel tray. This tray was placed in a bigger tray which contained hot water, about 90°C, so that the mixture temperature would not drop too quickly. The finished glue stick mixture was allowed to cooled down at room temperature for 24 hours and then manually cut into sticks using a 1.5 cm dia. x 12 cm height PVC plastic cylinder. Each stick was then put into a lip stick type plastic container normally used for 8 gram commercial glue stick.

8.2.4 Testing of the Finished Product

Physical and sensory testing was conducted on the finished product. Glue sticks were randomly sampled for the test. For sensory testing, the finished product was presented to the panel together with the laboratory scale sample. The same laboratory sensory panel, comprised of 10 panelists, which did the product testing in the final product optimization was used in this study. The questionnaire used for the test was the same as that described in Section 6.4.3 and the method of testing was as in Section 6.4.5.

The glue sticks were tested at 3, 5, 10, 17 and 30 days after the process finished - from the time that the glue mixture was poured into the tray. This was done in order to see how much the glue stick changed with time in terms of sensory and physical attributes of glue sticks and to consider whether the age of glue stick would affect the acceptability of the glue stick to the target consumers in the home-use test.

8.3 YIELD AND COSTS IN GLUE STICK PRODUCTION

Yield of the glue stick made in the pilot scale was investigated in order that the costing of glue stick production could be established. Glue stick was made in a 6.21 kg batch, which gave 5.25 kg finished glue stick mixture, i.e. a 84.5% yield. It might be expected that the losses would be less in full scale production as most was lost because of sticking to the pan.

It was assumed that if all of the finished glue stick mixture could be made into 8 g sticks, 10,562 sticks could be obtained from 100 kg batch. Hence, the raw materials cost for an 8 g glue stick could be calculated as follows:

Cost per 100 kg of ingredients	=	7126	Bahts
Hence, cost per stick	=	0.67	Bahts

Cost for glue stick production was calculated from raw material cost, processing cost, factory overhead, company profit (10%), whole sale mark up (5%) and retail mark up (15%). The pricing was very approximate but it was predicted as followed:

* Processing costs	- labour	1500.00
(Baht/100kg of finished product)	- operating	5000.00
Total processing cost		6500.00
Processing cost of one glue stick (Baht)		0.52

- * Factory overhead was estimated as 3.35 Bahts per stick
- * Container for 8 g stick was estimated as 3.50 Bahts

The results shown in Table 8.2 are the cost in producing an 8 g glue stick at different percent weight losses.

The predicted retail price of the new glue stick was 10.70 baht which was lower than the average sale price of commercial glue stick, about 15 baht. This indicated that the new glue stick could be priced competitively with the products already in the market.

Table 8.2 Costs incurred in producing an 8 g glue stick

Type of Cost	Value (Baht/stick)		
	15.5% loss	10% loss	5% loss
Raw material costs	0.67	0.63	0.60
Processing costs (1)	0.52	0.52	0.52
Packaging costs (8 g container)	3.50	3.50	3.50
Factory overheads (2)	<u>3.35</u>	<u>3.35</u>	<u>3.35</u>
Total production cost	8.04	8.00	7.97
Company profit	0.81	0.80	0.80
Company price	8.85	8.80	8.77
Wholesale price	9.30	9.24	9.20
Retail price	10.70	10.63	10.58

Note: (1) This includes all labour and operating costs.
(2) This includes foremens’ wages, office staff salaries, rent repair and maintenance, plant depreciation and other miscellaneous cost plus sales force salaries, administration cost and distribution costs.

8.4 CHANGES OF PRODUCT ATTRIBUTES DURING 30 DAY STORAGE

The results from the sensory and physical testing during storage are shown in Tables 8.3 and 8.4.

Table 8.3 Physical attributes of glue stick at different storage times

Days	Wet glue/area (g/m ²)	Dry glue/area (g/m ²)	Moisture (%)	Hardness (Newtons)	Open time (Minutes)
3	33.4	13.3	56.9	3.91	3.1
5	32.7	13.1	56.9	4.04	3.0
10	32.6	13.0	57.0	4.16	3.1
17	32.4	12.7	57.6	4.12	2.8
30	32.4	12.7	57.5	4.16	2.8

Table 8.4 Sensory attributes of glue sticks at different storage time

Days	Accept	Slip	Disintegrate	Coverage	Adjust	Smooth	Stick
3	10.8	11.8	2.2	11.6	11.0	13.0	12.2
5	11.9	12.0	3.3	11.3	11.6	12.3	10.7
10	11.3	11.3	3.8	11.8	11.9	12.5	12.2
17	11.5	11.8	2.9	12.2	12.7	12.5	12.5
30	11.6	12.2	3.8	12.1	11.6	12.5	11.5

There was some small changes of physical attributes of glue stick after processing. There appeared to be some trends: the stick tended to harden, open time tended to decrease a little bit. However, these changes were not statistically significant. It was also found that the sensory attributes of the stored glue stick samples were not significantly different, only for stickability was the sample stored for 5 days slightly lower from the others, this might have resulted from differences between panel evaluations or some variation in the sticks.

This indicates that the age of glue stick within 30 days after processing would not affect the attributes of the glue stick and consequently should not affect the perception of consumers toward the glue stick in the home-use tested.

8.5 PRODUCT VARIABILITY BETWEEN BATCHES

The variability of the product from different batches was investigated in order to investigate the reproducibility of the processing method and the equipment developed for the pilot scale production. Product made from two different batches were tested and the results are shown in Table 8.5 and 8.6.

Table 8.5 Physical attributes of glue sticks from different batches

Attributes	Batch 1	Batch 2	T-tests	p
Wet glue per area	33.4	33.2	0.44	0.698
Dry glue per area	13.3	13.4	0.51	0.659
Moisture	56.9	57.2	0.69	0.614
Hardness	3.93	3.97	0.27	0.793
Open time	3.13	3.00	1.00	0.423

Table 8.6 Sensory attributes of glue sticks from different batches

Attributes	Batch 1	Batch 2	T-tests	p
Acceptability	11.6	12.0	1.05	0.309
Slipperiness	12.2	12.5	1.31	0.213
Disintegration	3.8	2.1	2.09	0.056
Coverage	12.1	12.4	0.91	0.378
Adjustability	11.6	12.3	1.12	0.280
Smoothness	12.5	11.7	1.56	0.141
Stickability	11.5	11.4	0.39	0.700

Note: Samples from Batch 2 were tested against 30 day samples from Batch 1

From the t-tests, there were no significant differences between physical and sensory attribute of glue stick samples from the two batches.

8.6 PRODUCT VARIABILITY BETWEEN STICKS FROM DIFFERENT LOCATIONS ON THE TRAY

To ensure that the location of the glue stick in the rectangular tray had no effect on its properties, various glue sticks were sampled from different locations on the tray: middle and the two extreme sides.

The results are shown in Table 8.7 and Table 8.8.

Table 8.7 Physical attributes of glue sticks from different locations on the tray

Location	Wet glue/area (g/m ²)	Dry glue/area (g/m ²)	Moisture (%)	Hardness (Newtons)	Open time (Minutes)
1	33.4	13.3	56.9	4.03	3.1
2	32.7	13.1	56.9	4.04	3.0
3	32.6	13.0	57.0	4.11	3.1

Note: 1 - Width side of the tray
2 - Length side of the tray
3 - In the middle of the tray

Table 8.8 Sensory attributes of glue sticks from different locations on the tray

Position	Accept	Slip	Disintegrate	Coverage	Adjust	Smooth	Stick
1	12.0	12.5	2.1	12.5	12.3	13.0	11.4
2	11.8	12.5	2.1	12.5	12.5	13.0	11.4
3	11.8	12.6	2.1	12.5	12.4	13.0	11.5

There were no significant differences between physical and sensory attributes of glue stick samples from different location on the tray, although the wet glue per area were slightly different. This indicated that the glue stick mixture was homogeneous.

8.7 PRODUCT VARIABILITY BETWEEN LABORATORY SCALE AND PILOT SCALE SAMPLES

The glue sticks made in the pilot scale were compared with the ones made in the laboratory scale in order to confirm that the process and equipment used in pilot scale production could produce glue sticks which had the same attributes’ intensities as those from the laboratory. The results of the physical and sensory testing of samples made from two pilot scale batches were compared.

Table 8.9 Physical attributes of pilot scale and laboratory scale samples

Attributes	Pilot scale	Laboratory scale	T-tests	p
Wet glue per area (g/m ²)	33.3	31.5	1.62	0.248
Dry glue per area (g/m ²)	13.3	13.2	1.95	0.192
Moisture content (%)	56.9	57.2	0.72	0.601
Hardness (Newtons)	3.93	4.01	0.28	0.800
Open time (Minutes)	3.13	3.00	1.00	0.423

Note: The results of 3 day laboratory sample were compared with the results of 3 day sample from Batch 1

The results in Table 8.9 show that the physical attributes of the sample from pilot scale were not significantly different from the one produced on the laboratory scale.

Table 8.10 Sensory attributes of pilot scale and laboratory scale samples

Attributes	Pilot scale	Laboratory Scale	T-tests	p
Acceptability	11.4	11.9	4.30	0.023
Slipperiness	11.7	12.0	2.77	0.069
Disintegration	3.1	2.6	0.97	0.402
Coverage	11.6	12.0	1.93	0.149
Adjustability	11.8	11.7	0.59	0.597
Smoothness	12.5	12.8	2.00	0.140
Stickability	11.9	11.8	0.49	0.660

The glue stick made in the pilot scale production had slightly lower acceptability, slipperiness, degree of coverage and smoothness scores than those of the ones made in the laboratory scale. Stickability, adjustability scores were slightly higher.

From the t-test, it was found that there was a significant difference between the laboratory scale and pilot scale samples only for acceptability at $p = 0.023$. There were no significant differences in terms of sensory attributes. This indicated that the glue sticks made from the pilot scale and laboratory scale were only slightly different.

8.8 COMPARISON OF NEW GLUE STICK WITH A COMMERCIAL GLUE STICK

A sample from the pilot scale production was also tested against the commercial product to identified how different the new product was from the commercial one. UHU glue stick was used in this study since it was the glue stick most consumers used according to the consumer survey.

Table 8.11 Sensory attributes of new glue stick and a commercial glue stick

Attributes	New glue stick	Commercial glue stick	T-tests	p
Acceptability	12.0	12.3	0.84	0.416
Slipperiness	12.5	12.9	1.90	0.078
Disintegration	2.1	2.1	0.02	0.988
Coverage	12.4	12.5	0.56	0.587
Adjustability	12.3	11.6	1.18	0.257
Smoothness	11.7	13.2	1.07	0.303
Stickability	11.4	12.6	3.31	0.005

Most of the physical attributes of the new glue stick were similar to those of ‘UHU’ glue stick except the open time. Open time of the new glue stick was very much lower than the commercial one. This indicated that the new glue stick should have less drying time. However 3 minute open time should be enough for readjusting the paper when consumers used glue stick.

Although the new glue stick, compared with UHU glue stick, had slightly lower sensory scores for acceptability and some attributes; from the analysis of variance, there were no significant differences between the new glue stick sample and commercial glue stick (UHU). With the exception of stickability, it can be said that this new glue stick had attributes which were comparable to that of the commercial glue stick.

8.9 DISCUSSION

The process which was used to make the glue stick on a small scale was used successfully in the production of pilot scale samples. It was expected that similar equipment could be used in a commercial process for the manufacture of glue stick. However, suitable packaging equipment should be developed so that the glue stick could be automatically mounted to the container.

The yield of the product from the process can be improved in the commercial scale production in which a double jacketed kettle could be used and the finished product

could be discharged from the bottom so the temperature of the product in the container could be maintained until totally discharged.

Although it was found that the attributes of glue stick stored for 30 days after processed were not significantly changed, the shelf life of the glue stick needs to be tested for a longer period for production and selling because it may remain on the retailers' shelves for 6-12 months.

The new product made in the pilot scale had the same properties as the one from the laboratory scale. The sensory attributes of these two products were not significantly different although the acceptability of the glue stick made in the pilot plant was very slightly lower. It was found that the new product was different from the most popular commercial product only in terms of open time. However in the sensory testing the new product was not significantly different from the commercial product in acceptability and product attributes.

8.10 CONCLUSIONS

From this study, it can be concluded that there was no change in the physical and sensory attributes of the glue stick in the scaling up from the laboratory scale to the pilot scale production as they had similar properties.

From a comparison of the physical and sensory attributes, it was shown that the glue stick that was developed in this study possessed attributes which were comparable to those of the most popular commercial glue sticks so it was expected the new glue stick would be accepted by the target consumers.

Based on the above results, glue stick samples from this pilot scale production would be used in the final consumer testing to measure consumer acceptability of the new product. The attributes that needed further improvement would also be identified.

CHAPTER 9

FINAL CONSUMER TESTING OF PRODUCT

In the previous chapter, glue stick was made in the pilot scale production and tested with the small consumer panel. The results showed that the product was acceptable and the product attributes were comparable to a commercial glue stick. Therefore, it was decided that the product should be tested with the target consumers to see how consumers reacted to the product and how they compared the new product with the one they currently used. The product was tested with four groups of consumers: university students, school students, office workers in government offices and in private offices.

9.1 AIM AND OBJECTIVES

The aim of this study was to measure product acceptability of the new glue stick.

The objectives were to:

- * Establish the performance of the developed product in relation to competitive products.
- * Determine consumer purchase intention towards the developed product.
- * Determine the potential target market for the developed product.
- * Obtain information from consumers on how the developed product should be launched into the market.

9.2 METHOD OF CONSUMER TESTING

9.2.1 Selection of Consumers

Consumers used for the final glue stick testing were selected from glue stick users, who used glue stick at least once a month, so that the new product could be compared with the product consumers currently used. Four groups of consumer were selected. They were 2 groups of students: university student (60), school student (60) and 2 groups of office workers: government officers (35), private officers (35). These people were considered as target consumers for the developed product. The total number of consumers was 190.

The university students from Kasetsart University and the school students from Kasetsart Demonstration School were selected because of the convenience to ask for permission and conduct the test.

The government officer and private officer were chosen since they were glue stick users and most of them used glue stick.

9.2.2 Sample Preparation

Glue stick samples were packed in a commercial glue stick container. No brand name or information about the glue stick was printed on the container. Samples were aged for at least 7 days before the test was conducted.

9.2.3 Questionnaire

The questionnaire was written in Thai. The questionnaire in both the Thai and English languages is shown in Appendix 9.1. The questionnaire had both check list and open-ended questions relating to the new glue stick as well as a section with demographic details of the consumers.

The questionnaire was kept as short as possible. Easy words were used in order not to cause any misunderstanding or confusion. The questionnaire was pre-tested with 16

consumers, 4 from each group of consumers and the questionnaire was changed where necessary to make it easier for the consumer to answer.

9.2.4 Testing of the Product

The questionnaire together with the glue stick were put into a brown envelope and given to the respondents themselves or to the representatives of the group of consumers. The respondents were allowed about one week to use the glue stick sample in the same way as they normally used glue stick. They could use the product at home or at school for the students and in the office for the office workers. After they had tried the sample for at least 2-3 times then they answered the questions in the questionnaire.

9.3 DATA PROCESSING AND ANALYSIS OF RESULTS

The questionnaires were checked by the author before processing was conducted. The data were coded and entered in the VP Planner spreadsheet. The entered data were then analyzed using the SPSS/PC+™ programme where cross-tabulation and chi-square analysis were conducted. The results are shown in Appendix 9.2.

9.4 PATTERN OF GLUE STICK USAGE OF THE CONSUMERS

Sixty questionnaires were given to each group of students and 35 questionnaires were given to each group of office workers. There were 55, 53, 34 and 30 questionnaires returned from university students, school students, government office workers and private office workers respectively, i.e. a total of 172.

9.4.1 Frequency of Glue Stick Usage

Consumers were asked how often they used glue stick. The results are shown in Table 9.1.

Table 9.1 Frequency of Glue Stick Usage

Frequency	Total	University	School	Gov.&Private
3-4 times a day	13 (7.6%)		1 (1.9%)	12 (18.8%)
once a day	11 (6.4%)	1 (1.8%)	2 (3.8%)	8 (12.5%)
2-3 times a week	56 (32.6%)	11 (20.0%)	27 (50.9%)	18 (28.1%)
2-3 times a month	63 (36.6%)	24 (43.6%)	18 (34.0%)	21 (32.8%)
once a month	29 (16.9%)	19 (34.5%)	5 (9.4%)	5 (7.8%)

It was found that there were differences in frequency of glue stick usage between the four groups of consumers. Office workers used glue stick more often than students. About 31 % of office workers used glue stick daily. School students used glue stick more often than university students, 34.5 % of university students and 9.4 % of school students only used glue stick once a month.

9.4.2 Source of the Glue Stick Consumers Used

Consumers were asked how they received the glue stick they normally used. The results are shown in Table 9.2.

Table 9.2 Source of Glue Stick Consumers Used

Source	Total	University	School	Gov.&Private
Buy	111 (64.5%)	51 (92.7%)	50 (94.3%)	10 (15.6%)
Provided by the office	57 (33.1%)	4 (7.3%)	3 (5.7%)	53 (82.8%)
Other	4 (2.3%)		3 (5.7%)	1 (1.6%)

Note: Some consumers selected more than one answer.

Most students bought the glue stick themselves, some were provided by their institute. Some school students were provided with glue stick by their parents. Most office workers obtained it from the office where they worked.

9.4.3 Brand Name of Glue Stick Consumers Used

Consumers were asked to give the brand name of glue stick they normally used. The results are shown in Table 9.3

Table 9.3 Brand Name of Glue Stick Consumer Normally Used

Brand name	Total	University	School	Gov.&Private
UHU	155 (90.1%)	54 (98.2%)	45 (84.9%)	56 (87.5%)
PRITT	8 (4.7%)	1 (1.8%)	7 (13.2%)	
PELIFIX	4 (2.3%)			4 (6.3%)
Others	5 (2.9%)		1 (1.9%)	4 (6.3%)

It was found that UHU was the glue stick used by most consumers (90.1 %), especially university students. A few office workers used PELIFIX and other brands as well and some school students used PRITT. Hence, it can be said that when the consumers used the new glue stick, most of them compared it with UHU.

9.4.4 Size of Glue Stick Consumers Used

Table 9.4 Size of Glue Stick Consumers Used

Size	Total	Univ&School&Priv	Gov. office
Small	115 (66.9%)	102 (73.9%)	13 (38.2%)
Medium	55 (32.0%)	36 (26.1%)	19 (55.9%)
Large	2 (1.2%)		2 (5.9%)

Most students and private office workers used a small size glue stick followed by a medium size glue stick. The government officers tended to use medium size rather than the small size. This was because they were heavy users so the medium size tended to suit their usage.

9.5 CONSUMER ACCEPTABILITY OF THE NEW PRODUCT

Consumer acceptability of the new glue stick was measured. Consumers were asked to make the decision whether the sample was acceptable or not. They could respond only yes or no.

About 68 percent of consumers accepted the new glue stick. Long drying time and a not very strong bond were the reasons that some of them did not accept the new glue stick. It was found that there were no significant differences ($p=0.915$) in acceptability pattern of consumers from different groups.

Consumers were asked to compare the developed product with the glue stick they normally used. About 45 % of the consumer thought that the new product was the same or better than the one they were using. The results are shown in Table 9.5. From chi-square analysis, there were no significant differences ($p=0.863$) between consumers from different groups.

Table 9.5 Comparison between the New Product and the Product Consumer Currently Used

Comparison	Number of consumers
Very much better	4 (2.3%)
Slightly better	25 (14.5%)
The same	49 (28.5%)
Slightly worse	72 (41.9%)
Very much worse	22 (12.8%)

The consumers gave their reasons why they thought the new product better or worse than the one they were using.

The reasons they thought that the new product was better were:

- * Long drying time allowed the time for adjusting the paper so the paper can be repositioned without any damage to the paper.
- * Bond not too strong
- * Not messy
- * Stronger bond strength
- * No bad smell, contained pleasant odour
- * Glue more cohesive not messy when used
- * Not make the paper wrinkle
- * No wrinkle when used with thin paper
- * Thinner layer of glue coated on the surface
- * Not stringy
- * Not stick to hand when used
- * Glue not come off in a lump

The reasons they thought that the new product was worse were:

- * Weaker bond strength
- * Glue not clear
- * Need more strength to rub glue on the working surface
- * Too slippery
- * Dries slower
- * Easy to peel the paper apart

It was found that about 66 % of the consumers who accepted the product thought that it had weaker bond strength than their glue stick (see Appendix 9.3).

9.6 CONSUMER BUYING INTENTION

There were no significance differences ($p=0.697$) in consumer buying intention pattern between consumers from different groups. About 57 % (98 respondents) of the consumers said that they were going to buy the new product. Amongst these consumers, 73.5 % thought that the developed product was better than or the same as their glue stick (see Table 9.6. and Appendix 9.4).

Table 9.6 Comparison between the developed glue stick and the glue stick consumers normally used (% of the consumers who said they would buy the product)

Source	Number of Consumers
Very much/Slightly better and The same	72 (73.5%)
Slightly worse	25 (25.5%)
Very much worse	1 (0.01%)

9.7 PRICE OF THE NEW GLUE STICK

The consumers who said they would buy the product were asked to recommend the price that the new glue stick should be sold. They were asked to give the price compared with the price of the glue stick they normally used. The results are shown in Table 9.7.

Table 9.7 Price that consumers who said they would buy the product recommended for the developed glue stick compared with their glue stick

Source	Number of consumers
Slightly higher and the same	26 (26.5%)
Slightly lower	68 (69.4%)
Very much lower	4 (4.1%)

There were no significance differences ($p=0.340$) between consumers from different groups in pattern of price that consumers thought this developed glue should be sold. About 26.5 % of the consumers that were willing to buy the developed product want the product to be sold at the price slightly higher or the same as the glue stick they were currently using. About 73.5 % thought that the developed glue should be sold at a price lower than the price of glue stick they normally used.

9.8 THE CHARACTERISTICS OF THE DEVELOPED GLUE STICK WHICH ATTRACTED CONSUMERS TO BUY

Consumers were given the list of the attributes which were supposed to be the attributes of the developed glue stick. They were asked to rate each attribute according to the degree of attraction that the attribute had toward their decision to buy or use the product.

Table 9.8 Characteristics which could attract consumers to buy or try the developed glue stick product

Characteristic	The most attractive	Second attractive	Third attractive	Not attractive
Safe	26 (26.5%)	20 (20.4%)	7 (7.1%)	45 (45.9%)
Environmental friendly	30 (30.6%)	18 (18.4%)	12 (12.2%)	38 (38.8%)
Made from Thai tapioca flour	21 (21.4%)	24 (24.5%)	8 (8.2%)	45 (45.9%)
Cheaper than the other glue sticks	18 (18.4%)	13 (13.3%)	17 (17.3%)	50 (51.0%)
Made in Thailand	10 (10.2%)	21 (21.4%)	17 (17.3%)	50 (51.0%)
New product	15 (15.3%)	14 (14.3%)	10 (10.2%)	59 (60.2%)

Note: The results were from consumers who were going to buy the developed glue stick. They could select more than one characteristics

Safe, environmental friendly, and 'made from Thai tapioca flour' were the images of the glue stick that attracted 52-60 % of them to buy or try it. This indicated that a significant proportion of consumers were interested in a product that would not do any harm to themselves or the environment and was made from raw material available in Thailand.

For 'environmental friendly', there were differences in the ranking pattern of consumers from different groups (see Table 9.9).

Table 9.9 Environmental friendly ranking by consumers

Source	The most attractive	Second attractive	Third attractive	Not attractive
School students	16 (53.3%)	6 (20.0%)	5 (16.7%)	3 (10.0%)
University student and Private company	14 (30.4%)	8 (17.4%)	4 (8.7%)	20 (43.5%)
Government officers		4 (18.2%)	3 (13.6%)	15 (68.2%)

Note: The results were from consumers who were going to buy the developed glue stick.

9.9 DISCUSSION

9.9.1 Reaction of the Target Consumers towards the Developed Glue Stick

Reaction of different groups of consumers towards the developed glue stick were quite similar. This agreed with the results from the prototype testing in which consumers from these target groups evaluated glue stick attributes in the same way. The product was accepted by 68 % of the consumers and 57 % said that they were going to buy the product. It was indicated from the survey that the consumers compared the product with 'UHU' which was a commercial glue stick which most consumers used normally. Therefore, the new product had a very good potential that if it was launched into the market about half of the target consumers would buy it.

However, according to the survey, only 26.5 % of the consumers were going to buy the product at the price slightly higher or the same as their glue stick (about 15 Bahts). About 68 % and 4 % were going to buy the product at prices slight lower and very much lower respectively than their present glue stick. Maybe the reason for this was that they thought the price of glue stick on the market was too high compared with other glue products so they wanted the price to be decreased.

9.9.2 Selection of Market Segment

Since there were no differences in product acceptability and purchase intention amongst the consumers from different groups, it can be said that the market segment would include both students and office workers. From the consumer testing, office workers used glue stick more often than students, therefore office workers can be considered as heavy users. However, the number of students are higher than office workers so these consumers can be included as target market as well. And most of the students buy glue stick to use themselves so they can make their decision about which brand of glue stick they use. Since the new glue stick could be sold at the price lower than the ones currently in the market this would urge the office especially the government office to buy the product and also the students who had a limited amount of money to spend on stationery.

9.9.3 Improvement of the Developed Product

Although the developed product was reasonable accepted by the target consumers, it is possible to increase the acceptability by improving or modifying some attributes. From the information obtained from consumer testing, the new product should be improved in terms of colour of the container, colour of glue stick, and odour/perfume. Since the containers of the samples used in glue stick testing were the same as that of UHU glue stick, in the real situation this could be easily avoided in order that consumers could differentiate between the products. The container could be redesigned in terms of method of winding glue up-down, lid, colour and design on the outside of the container. The container is the factor that make the price of the product very high, a refill-stick should be considered.

Some consumers liked the glue stick that gave colour on the paper when applied on the paper and the colour disappeared after the glue dried. This could also disguise the white colour of the new glue stick which consumers did not like because they were used to the transparent glue stick.

Perfume could be added into the glue stick mixture to give a glue stick with a pleasant odour. Flower perfume should be used in order to emphasize that the glue stick is

made from natural ingredients.

9.9.4 Future Research

A market test on the product would have to be conducted before the product is launched on to the market in order that other factors (price, packaging, brand name and advertising) which affect consumers' buying decision apart from the sensory attributes could be tested. Also in the market test, if the product was put side by side with the competitors, it should be possible to assess the influence of those products on consumer buying decision and the market share could be estimated.

9.4.5 Position of the Developed Product in the Market

The developed product differed from the glue sticks already in the market in terms of price, bond strength, raw materials. Therefore, it can be positioned as a low price glue stick with adjustable bond - the paper can be readjusted after a period of time without any damage but sticks strongly after drying. The product is considered more safe and environmental friendly since it has replaced 50 % of a synthetic polymer with a natural.

Since UHU glue stick is a very strong competitor, most of the glue stick users used this brand, the size of the market is difficult to predicted. However, with the cheaper price and other attributes which differentiate the developed product from the existing products: odour, bond strength, not stringy after rubbing and cleanliness of work, these should attract the consumers to buy the developed product. With the low price, it should also encourage the non-glue stick user who does not use glue stick because of the high price to buy the new glue stick as well.

9.10 CONCLUSIONS

A new glue stick product acceptable to the target consumers was developed. This glue stick had the general properties comparable to the commercial product except that the product had adjustable bond strength in which the paper could be repositioned after a specific of period and not damage the paper. From the preliminary costing, the

product could be sold at a lower price than the products in the market. It is possible that the price of packaging can be reduced in the long run since the original price included the design and developing the mould. This product was found worthwhile to be developed into a commercial product.

CHAPTER 10

DISCUSSION AND CONCLUSIONS

10.1 INTRODUCTION

The research in this thesis aimed at optimizing the acceptability and attributes of a glue stick product for Thai consumers. Consumers were directly involved in the product optimization process and the final glue stick product developed was considered acceptable by the consumers. The developed product was also comparable to the most popular commercial glue stick on the Thai market in terms of acceptability and sensory attributes. The developed product had a slightly higher adjustability and slightly lower stickability than the commercial glue stick tested so it could be considered as an adjustable bonding glue stick in which the paper can be repositioned without any damage.

10.2 OPTIMIZATION PROCESS

The product optimization process used in this study is similar to the processes that many product developers have successfully used. This process had been used mainly in food product development (Lagrange and Norback, 1987; Beausire et al., 1988) and there were few applications in the development of other products (Rabino and Moskowitz, 1980; Moskowitz, 1984). This study was the first time it had been used in the development of a glue product as recorded in the literature but of course it could have been used in a commercial company. An optimum product was obtained in only three steps, although the researcher had no experience in the product area being studied. This method could be even more useful for a researcher working in an area where the effects of ingredients on product attributes are well established. The optimum process used in this study can be summarized as shown in Figure 10.1

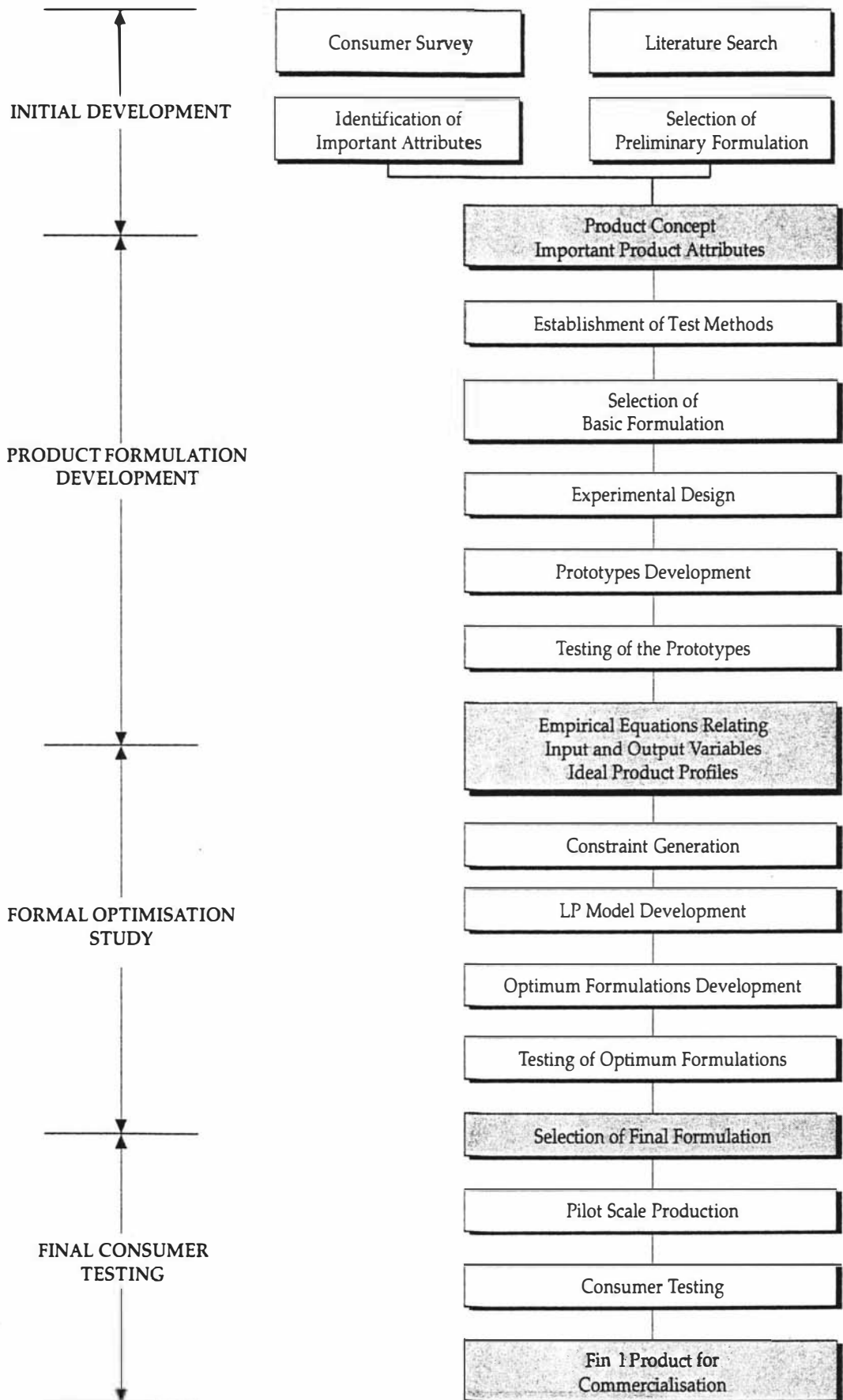


Figure 10.1 Steps in Glue Stick Optimization

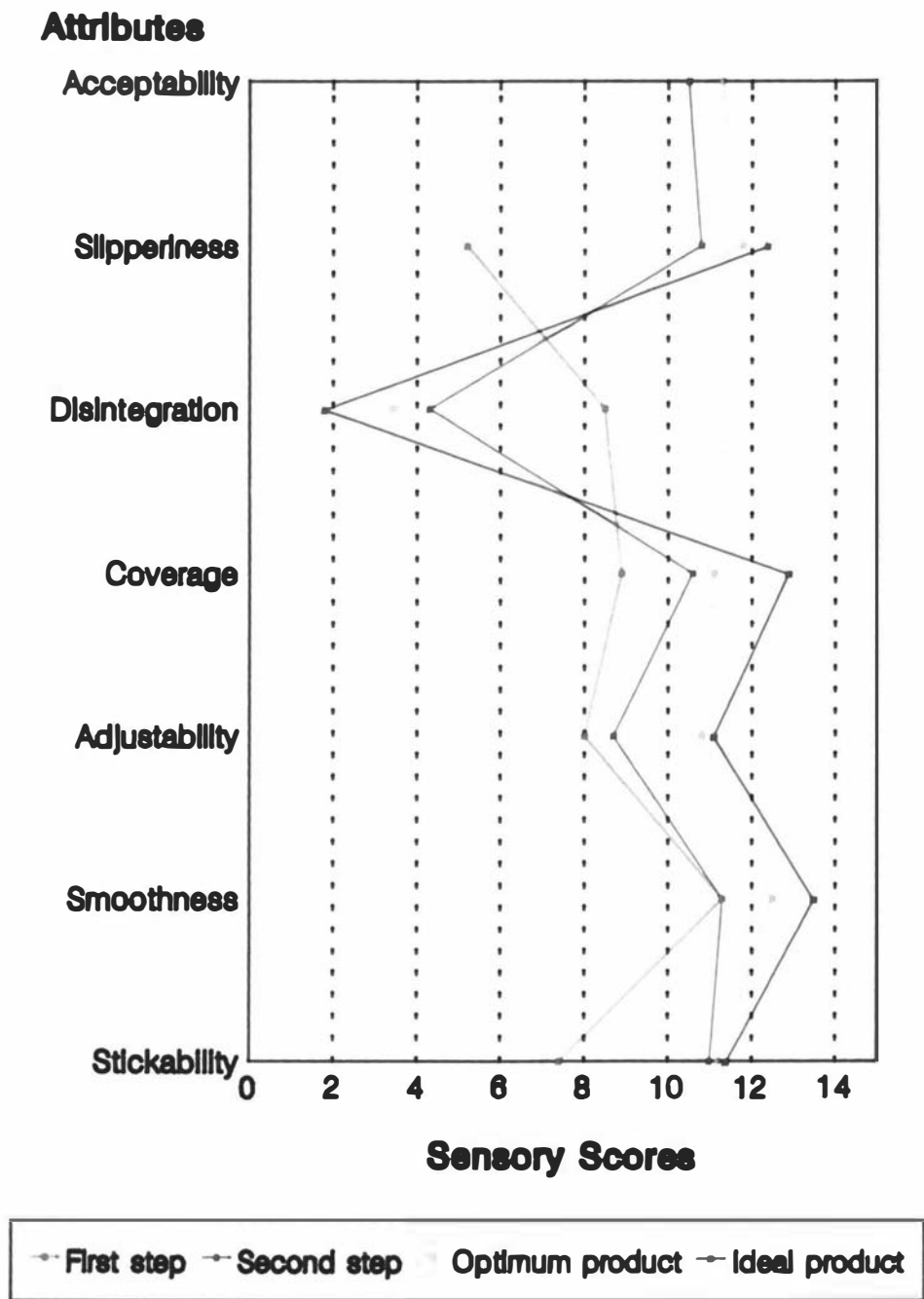


Figure 10.2 Comparison of prototypes from different steps during product optimization

With the use of this method, only 3 steps were needed to get the optimum formulation. It can be seen from Figure 10.2 that the product prototypes became closer to the consumers' ideal product after the second step. The optimum formulation obtained from applying the optimization technique, linear programming, gave a product with sensory attributes which were quite close to the ideal product.

This method would be beneficial for the situation in Thailand as there is the need to promote the use of agricultural products made in the country. Research needs to be carried out in order to increase the use of the available raw materials, e.g. use as a substitute for synthetic raw materials in certain products. With the use of this optimization technique, products could be developed more efficiently and more acceptable to consumers.

10.3 THE USE OF CONSUMER INPUT IN THE OPTIMIZATION PROCESS

In the optimization of a new product or an existing product, the main task is to investigate consumers' attitudes toward the product and the attributes of the product. In the area of glue products or similar products, although the researchers have recognised that the products have to meet the consumers' needs (Ando and Yamazaki, 1974; Palm, 1989), no research on consumers' reactions toward the products had been reported. In this study, consumer input was used at almost all stages: in initial development study, product prototypes, product formulation development, formal optimization study and final product testing, and the study showed that consumers could provide very valuable information to assist in the development of the product.

10.3.1 Benefits of Using Consumers throughout the Optimization Process

At the beginning of the study, consumers gave information in terms of the problems of glue usage particularly of glue sticks. They could provide guidance on how the existing products should be improved as well as generate the important attributes of the product. Sinthavalai (1986) also used information obtained from the target consumers to identify the attributes of a nutritionally-balanced snack product. The important attributes of glue sticks were used later in the sensory evaluation during the prototype

development and the final product optimization. This confirmed that the consumers can be used as an important tool in generation of the important attributes of products for which no information is available.

With the new type of product, temporary bonding glue stick, which they had never seen or used, a related product, self-adhering note pad, which had similar performance had to be used as an example to provide a general concept of the product. This technique was also used in the development of a facial scrub product (Moskowitz, 1984). However, when the self-adhering note pad was used as a reference product, the consumers recognised this product as an expensive product and therefore tended to find the new product not very acceptable because they thought it would be expensive. Hence, in using a reference product one must be careful that no characteristics are transferred to the new product concept which are not true.

Sensory scores for product attributes obtained from testing of the product prototypes with consumer panels were used to create empirical models relating ingredients with product sensory attributes. These models were employed as constraints in the product optimization stage using linear programming. Ideal product profile was used to generate upper and lower limits of sensory constraints for the linear programming. Although, the statistical accuracy of the results of a consumer panel is not as brilliant as that of the trained sensory panel, a consumer panel can help the product developer to measure consumer perception of product attributes and the overall acceptability and this can be related to product formulation. It was found that by using product profile with line scale, quantitative data could be obtained. The model relating the ingredients and the sensory attributes can be used in the formal optimization with reasonable accuracy.

In final product testing, Thai consumers evaluated the developed product in terms of acceptability in the home-use situation and compared the product with the commercial product they normally used. This was very important in considering how well the product performed compared with their usual brand. Consumers had opportunity to use the developed product in the same way as they normally used glue stick, as many times as they wanted, before they evaluated the product. Purchase intention and price which consumers were prepared to pay for the product were also obtained. This

information allowed the product developer to estimate the success of the product before the product was actually launched into the market.

It can be concluded that the consumer study and the consumer panels provided several advantages. Firstly, prediction of product success is based on the opinion of the individuals whose buying activities will determine the actual sales achieved directly or indirectly. Secondly, the consumer panel can be used during the product optimization process to get the potential consumers' preference and reaction to products so that the product can be improved before the final product is launched. There is also more confidence in launching a product that is acceptable to the consumer because of the continuous testing with consumers. However, in spite of the many advantages, there are also some disadvantages. Firstly, the primary research and data collection is time and cost consuming. Secondly, competitors may learn about the company's strategies from the public testing of the product and plan competitive actions.

10.3.2 Differences between Thai and New Zealand Consumers

No major differences in glue stick usage or important product attributes were found between Thai and New Zealand consumers. Although in generating the product attributes, New Zealanders appeared to generate more attributes than the Thais, some of these attributes were similar and could be grouped into the same category and some of them were not important. This showed a difference in the consumers' tendency to use descriptive terms to describe their perception of a particular product and product usage. Therefore, in conducting a consumer survey or testing of a product in Thailand, this factor have to be taken into account in the designing of the questionnaire. Thai consumers felt more easy with multi-choice questions or questions requiring brief answers. The questions have to be designed carefully in order to elicit as much information as possible from the consumers. Indirect questions may need to be used when the subject is directly involved with personal status such as price of the product.

10.3.3 Selection of the Important Attributes

The attributes emphasized in the study of the glue stick optimization were the usage attributes which included the attributes consumers perceived while applying glue stick as well as the effect of glue on the finished work and the glue performance. Although other attributes also had great impact on product acceptability such as: glue appearance, colour, aroma, packaging, price, and brand name, they were not included in the study. This was because this study was aimed at generating the optimum glue stick formulation using tapioca starch as substitute for synthetic adhesive substance - polyvinyl pyrrolidone, therefore only the effects of major ingredients on product attributes were focused. The effects of other ingredients: perfume and colour could be evaluated in future study and the effect of packaging, price and brand name should also be studied before the product is launched into the market.

It was found that the elicitation method was useful in generating the list of important attributes. This list not only helps the product developer in establishing the set of attributes for product testing but also helps in planning of marketing policy. The measurement of attribute importance by the elicitation method and direct-rating method gave similar results for the most important attributes, but slightly different for the less important ones. Price, which did not appear to be an important attribute by the direct rating method, was considered important by the elicitation method. This suggests that the selection of the importance measuring technique is vital and the type of product and type of consumers have to be taken into account. Although the consumers in general wanted the price of the glue stick product to be decreased, this attribute should not be directly mentioned in the advertising of the product as consumers might perceive the product as a low quality product.

10.3.4 Relationship of Acceptability to Purchase Intention and Price to Buy

It was found from the study that acceptability of the product was correlated highly with purchase intention and the price that consumers were prepared to pay for the product. Generally researchers have used acceptability, purchase intention and price to buy in the same manner. In testing of hand lotion, Moskowitz (1983) found that purchase intent varied with both liking and stated item price. Increases in liking or product

acceptability generated a relatively slowly increasing purchase intent. Changes in the formulation to increase purchase interest by increasing liking would show less of an effect than would pricing change. Moskowitz and Jacob (1988) found that price moderately influenced purchase intent in frankfurter development.

Although the product was tested in 'home use test' where the consumers were able to judge the performance of the product in an uncontrolled environment, a market simulation test should be conducted in order to obtain information on initial trial, repeat purchases and sales volume.

10.3.5 Comparison between Consumer Panel and Trained Panel

Use of the trained panel at the beginning of the development of the basic formulation helps to define the suitable area of the ingredients to be used in the design of the experiment. However, with the use of the consumer panel in the prototype testing, the perception of consumers toward the prototypes can be assessed. This provides the faster method to detect consumers' reaction and generates an ideal product profile which cannot be obtained by using a trained sensory panel. With the use of the ideal product profile, not only the prototypes can be compared with the ideal product but the direction in which the product should be developed is also identified. This profile can be used to set up the sensory constraints in the formal optimization study in which the optimization technique is used.

It was found that the Thai consumers were able to evaluate up to 10 product attributes using line scales. This confirms the results of the study by Lawless and Malone (1986) and Lawless (1988) that consumers could efficiently identify the difference between products by using line scales.

Although it was not possible to directly compare the results obtained from the consumer panel and the trained panel in this study since the set of samples used in the tests were different, it was found from correlations between attributes, that both panels evaluated most attributes in the same way.

10.4 USE OF EXPERIMENTAL DESIGNS IN PRODUCT OPTIMIZATION

Experimental design is an essential tool for product formulation development since it refers to the statistical design of experiments by which the researcher develops a matrix of systematically varied stimuli (Box et al., 1978). The statistical design lays out specific combination of the formulation variables so that a limited combination is generated.

Basic glue stick formulation is a mixture formulation, a change in the level of one ingredient in the formulation will also result in changes of the levels the other ingredients. Therefore, mixture designs were used during the product optimization process to study the effects of ingredients on physical and sensory attributes of starch based glue stick. This enabled the researcher to generate the subset of all possible samples which could be tested. The use of an experimental design to generate multi-products to be tested is considered more efficient than the traditional method of back-and-forth testing. The multi-product approach tests many prototypes and develops a model relating input variables and output variables.

The relationships between ingredients and attributes of the product obtained from the experimentation were used for directing the experimentation and were assigned as constraints in the linear programming model. In comparison with the sequential procedure followed by some optimization techniques, this method included all significant attributes and significant raw materials in the equations. Hence, it was very valuable for product optimization in which the product developer was not familiar with the product and could not predict which ingredients should have significant effects on the product.

Since the relationships between attributes and ingredients must be linear to be used in linear programming this may limit the use of this method in product optimization.

10.4.1 Selection of the Preliminary Formulation

Before the product prototypes could be developed, the preliminary formulation had to be chosen. In this study, the preliminary formulation was selected from the commercial formulations found in the literature. The formulation and the method of processing can

be used as a guidance only, the modification has to be done according to the purpose of the study and the resources: raw materials and equipment available. Normally simple formulation should be used at the beginning in the case where the relationships between the ingredients and product properties are not established, so the product developer can manage to identify those relationships.

10.4.2 Use of Ingredient/Product Attribute Relationship Models in Final Product Optimization

For the glue sticks, usage attributes were the important attributes, but some of these attributes acted counter to each other. This meant that to increase acceptability of one attribute, one needed to sacrifice the acceptability of other attributes.

Disintegration was one of the most important attributes of glue stick. It was correlated highly with product acceptability. Disintegration played an important role in glue stick usage in terms of ease of use, which included slipperiness, degree of coverage as well as the effect on paper. If disintegration was too high, it was likely that too much glue would be applied which was wasteful and could be messy and could cause wrinkling and curling of paper. On the other hand if the stick was too hard, inadequate adhesive was transferred to the surface to be adhered to allow a firm bond to be achieved. It was likely also that the surface was damaged by the hard force applied. It was found that disintegration could be decreased by increase of gel forming agent and reduction of adhesive substance in the formulation. However, this resulted in a reduction of stickability of glue stick. Therefore in order to obtain an optimum product, there had to be a trade-off between these attributes.

Fishken (1988) using response surface analysis in reformulation of pizza topping also found that it could be difficult to optimize two ingredients. He found that the optimal formulation did not seem to meet the consumer desire for more meat and cheese, since at the highest level of cheese, a level dictated by the physical limits of the crust, the optimal formulation included the lowest meat level tested. Therefore, with the inter-related attributes it may not be possible to maximize the liking of all attributes in the formulation of the product.

Moskowitz (1982) stated that normally the variation of two or more attributes simultaneously impacts on acceptance of a product. Sometimes these sensory attributes interact with each other. Variation in one attribute alone does not suffice to show the full range of acceptance levels. Furthermore, only by relating acceptance to the key attributes in combination can the product developer be sure of having generated the correct combination of sensory attributes.

Linear programming was used to generate the optimum formulation using these sensory attributes as constraints. This work extended the work done by Beausire et al. (1988), Kavanagh (1978), Chan and Kavanagh (1988) by adding to the model the empirical equations relating ingredients and attributes (physical and sensory attributes) of the product as well as including consumers' ideal product profile as the limit of sensory constraints. Also with the use of both consumer acceptability and sensory attributes during the product optimization, it is possible to know which attributes have to be improved and by how much in order to increase acceptability.

10.5 GLUE STICK FORMULATION AND ATTRIBUTES

10.5.1 Use of Tapioca Starch in Glue Stick

It was found that although modified tapioca starch used in this study (cross-linked and stabilized starch) could not totally replace polyvinyl pyrrolidone in glue stick formulation, it could effectively replace half of the polyvinyl pyrrolidone. In the past only 2-6 percent by weight of a carbohydrate or modified carbohydrate polymer was recommended in glue stick formulation (Werke H,u.M. Fischer, G.m.b.H., 1974). With use of modified starch in the formulation, it was also possible to shorten the processing time from 6-7 hours to only one hour at 90 °C.

Research on starch specially modified for use as adhesive substance in glue stick should be carried out in order that more starch can be used in the formulation. This could reduce the formulation cost as well as increase the use of natural raw material in the product.

development of skin lotion.

The prototypes developed during this study were compared with the commercially available glue sticks in order that the developed product possessed the physical attributes in the suitable ranges. This was to make sure that the product could perform the task it was supposed to do. However, some of the physical attributes of the commercial glue sticks were in a very wide range, and as a result some of the sensory attributes were far from the consumers' desired product. Therefore, in the optimization study, the consumer ideal product profile was used so as to develop a product which possessed the attributes close to those of the ideal product. The outcome of the optimization process gave a glue stick which possessed general properties similar to the commercial glue sticks, however the strength of the bond was slightly lower than that of the commercial products. With this type of bonding, there is enough time for paper to be readjusted or taken off from the receiving surface without any damage, but the bond will strengthen after a period of time.

10.6 RELATIONSHIP BETWEEN MARKET POSITIONING AND PRODUCT ATTRIBUTES

From both the consumer study at the beginning of the product optimization process and the consumer testing of the developed product, it was found that consumers wanted the glue stick to be sold at a price lower than the prices of the products already on the market. One reason was that consumers considered the prices of the commercial glue sticks were too high compared with other glue products in the market. Hence, if the developed product was sold at a lower price there was a high opportunity that the product could compete with the competitors in term of market share and it may be possible to make non-users to become glue stick users and increase the total market.

In terms of stickability, the developed product had lower bond strength than the commercial glue stick according to the consumers so it is likely that the product should be positioned as a weaker bonding glue stick.

10.7 RECOMMENDATIONS FOR FUTURE WORK

Although the final product was successfully developed and was reasonably acceptable, there were some points to be suggested for future work. Since the aim of the project was to study consumer input in the optimization of starch based glue stick, the type of starch which is most suitable for this type of product was not examined. Some more work could be done on the selection of suitable starch. In order to obtain a cheaper product formulation, a study is needed on reducing the amount of total adhesive substance or increasing the percentage of starch products which are cheaper than synthetic polymers as adhesive substance in the formulation.

Colour and fragrance can be added in the product formulation in order to improve the acceptability of the product. These attributes could be used to build the image of the product as a natural product by using sweet fragrance or flower like perfume and soft colour. These would also differentiate the product from the existing products which possess harsh colour and rather unpleasant aroma. As the product is aimed for the Thai market the packaging can be designed with Thai classical style which not only adds a value-for-money image but also attracts the consumers who prefer the classical Thai product. The packaging of the product including lid and the application method should be improved for more ease of use.

Although, there was no problem on deterioration of the product from microbiological spoilage during the study, no formal storage test was conducted. Since the developed glue stick is made from a starch product, therefore a storage test should be carried out to make sure that the product can be kept at room temperature without spoilage from microorganisms. If there is a need for use of preservatives, a study on suitable type of preservatives for the system should be carried out.

10.8 CONCLUSIONS

This study demonstrated the successful use of consumer inputs in the product optimization (product design) of a glue stick product for the target consumers in Thailand - school and university students, office workers. The consumers identified the important attributes of glue stick products as: effect on paper, cleanliness of work, ease of use and stickability. These attributes were used to assess the performance of the developed product prototypes. Consumers quantitatively evaluated the sensory attributes of the prototypes using line scales. In this study, consumer acceptability of glue sticks was correlated with physical hardness, moisture content, ease of use (disintegration, slipperiness, degree of coverage) and effect on paper (smoothness) of the products. The levels of these attributes in the glue sticks could be used to predict consumer acceptability.

The empirical equations showing relationships between each group of ingredients in the formulation: adhesive (modified starch and polyvinyl pyrrolidone), solvent (water and glycerin), gel-forming agent (stearic acid and sodium hydroxide) and the consumers' acceptability and perceived sensory attributes were established. A linear programming model developed from these relationships together with cost and component constraints was found useful in helping to generate the optimum formulation in terms of cost minimization and acceptability maximization. It was found that with the use of the consumer ideal profile to set limits for sensory constraints, it was possible to generate products which had high acceptability.

The study showed that physical attributes and sensory attributes of the products should both be considered in order to obtain optimum formulations. It is recommended that physical testing is concurrently used with the sensory testing during the optimization of the product formulation. If a suitable physical test is correlated with a sensory attribute, then the sensory test can be replaced by the physical test in the routine work. In this study, physical hardness, moisture content, amount of glue applied per area were correlated with the sensory attributes.

The final product testing by the target consumers in Bangkok showed that the product could be a success in the market and the project was believed to be worth continuing

for commercialization by the private sector. However, it was believed that further improvements could be made to the product itself, in terms of colour and aroma, as well as packaging, and a market test should be conducted in order to measure the potential success of the product against the competitors.

With the use of representative consumers as navigators and also for objective measurement throughout the process, the researcher can obtain the optimum product in a minimum number of steps. This research confirm that consumer testing with representatives of the target population remains critical to the product optimization process and cannot be substituted.

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APPENDIX 3.1

PRESCREENING QUESTIONNAIRE FOR A GLUE STICK PANEL

NAME: _____
PHONE (HOME) _____

TIME

What time during the week will you be available on a regular basis (between 9-6 pm weekdays)

Are you using glue stick regularly?

____ Yes ____ No

(If no, have you ever used glue stick? ____ Yes ____ No)

Answer each question in your own words, as best as you can.

1. When you rub an oily film on your skin, how do your fingers move?

____ Slip or ____ Drag (check one)

2. What is the difference between lumpy and gritty?

3. How do you describe the feeling of your fingers

3.1 when you touch sellotape on the side coated with adhesive

3.2 when you move your fingers along the length of sellotape on the side coated with adhesive

4. Please describe your ideal adhesive

5. Please describe your ideal glue stick

SCALING EXERCISES

INSTRUCTIONS: Mark on the line at the right to indicate the proportion of the area that is shaded.

1.  NONE _____ ALL

2.  NONE _____ ALL

3.  NONE _____ ALL

4.  NONE _____ ALL

5.  NONE _____ ALL

6.  NONE _____ ALL

7.  NONE _____ ALL

8.  NONE _____ ALL

9.  NONE _____ ALL

10.  NONE _____ ALL

APPENDIX 3.2

Descriptive Terms Developed by the Trained Panel

TERM DEFINITIONS

APPEARANCE	Wind up the stick and evaluate the appearance of the stick
Whiteness	- Whiteness of the adhesive stick. Rated as 'coloured - white'.
Opacity	- Opacity of the stick. Rated as 'transparent - opaque'.
Evenness	- Homogeneity of the stick. Rated as 'uneven - very even'.
Smoothness	- Smoothness of the stick surface. Rated as 'very rough - very smooth'.
Moistness	- Moistness of the stick surface. Rated as 'very dry - very wet'.
Hardness	- Perceived hardness by visual inspection. Rated as 'very soft - very hard'.

SENSORY ATTRIBUTES WHILE APPLYING GLUE STICK

* Ease of applying	Rub the stick along the surface of paper and spread adhesive to cover the area to be bonded.
Slipperiness	- The feeling of force between working surface of the stick and paper while rubbing the stick along the paper. Rated as 'drags - slips'.
Spreadability	- Ease of spreading adhesive on the paper. Rated as 'difficult to spread - easy to spread'.
* Perceive attribute of the stick while applying	While using the stick the following attributes are evaluated:
Hardness	- Perceive hardness of the stick. Rated as 'very soft - very hard'.
Deformation	- Tendency to deform when apply with hard force. Rated as 'low - high'.
Disintegration	- The tendency to disintegrate when apply with hard force. Rated as 'low - high'.
Stickiness	- Ease of taking the stick away from the paper at the end of rubbing. Rated as 'not sticky - very sticky'.
Shininess	- Shininess of the stick after use. Rated as 'very dull - very shiny'.

GLUE RESIDUE ON PAPER The following attributes are evaluated by visual inspection

Evenness	- Evenness of adhesive coated on paper after applying adhesive on paper. Rated as 'uneven - very even'.
Degree of coverage	- Degree of adhesive cover the area of paper after applying one coat. Rated as 'none - total'.
Thickness	- Amount of adhesive left on paper after applying one coat. Rated as 'very thin - very thick'.
Visibility of glue trail	- Ease of seeing the glue trail on paper. Rated as 'invisible - very visible'.

EFFECT ON PAPER Place another piece of paper on top of the coated paper and rub repeatedly with fingers then evaluate effect on paper by feeling the surface of the papers with fingers and using visual inspection.

Wetness	- The amount of moistness left on the paper after applying adhesive. Rated as 'very dry - very wet'.
Smoothness	- Unevenness of paper surface may cause by moisture or lump of adhesive. Rated as 'very wrinkly - very smooth'.
Cleanliness of work	- Adhesive residue left on top surface of (degree of stain) paper which makes paper dirty and sticky. Rated as 'very dirty - very clean'.
Visibility of glue trail	- The degree of glue trail which can be seen through the paper. Rated as paper 'invisible - very visible'.

STICKABILITY

Adjustability	- Ease of repositioning the paper. Rated as 'very difficult - very easy'.
Bond strength	- Strength of adhesive bond between two surfaces. Rated as 'very weak - very strong'.
Before drying	- Evaluate by peeling bonded paper immediately after two surfaces are placed to contact each other.
After drying	- Evaluate by peeling after adhesive dried out (30 minutes after placing two surfaces to contact each other).
Delamination of paper	- Degree of delamination of paper after peeling the bonded papers. Rated as 'none - all'.

APPENDIX 3.3

GLUE STICK SENSORY TESTING

NAME _____ DATE _____

INSTRUCTIONS: You will receive a number of glue stick samples. Please evaluate the samples according to the following order:

PRODUCT SAMPLES _____

Please use the sample as the following instructions and evaluate each sample for the specified attributes then place a mark (X) on the scale at the point representing the perceived intensity of the attribute along with the sample number.

EXAMPLE

Thickness

very thin _____ very thick

A. Wind up the stick and rub the stick along the surface of paper and spread adhesive to cover the area to be bonded. Then place the coated paper on top of another piece of paper and rub repeatedly with fingers. Do this for **all** samples to be tested and keep these papers for the final test.

B. Rub the stick along the surface of paper and spread adhesive to cover the area to be bonded. Score the product for 'sensory attributes while applying glue stick' on line scale in the questionnaire. After application score attributes for 'glue residue on paper' attributes.

SENSORY ATTRIBUTES WHILE APPLYING GLUE STICK

Slipperiness

_____ slips

Hardness

very soft _____ very hard

Deformation

low _____ high

Disintegration

low _____ high

GLUE RESIDUE ON PAPER

Degree of coverage

none _____ total

Thickness

very thin _____ very thick

Visibility of glue trail

invisible _____ very visible

C. Use a new piece of paper. Rub the stick along the surface of paper and spread adhesive to cover the area to be bonded. Place this coated paper on top of another piece of paper and rub repeatedly with fingers. Score the product for 'effect on paper' attributes.

EFFECT ON PAPER

Smoothness of paper

very wrinkly very smooth

Cleanliness of work

very dirty very clean

D. Use a new piece of paper. Rub the stick along the surface of paper and spread adhesive to cover the area to be bonded. Place the coated paper on top of another piece of paper, try adjusting the position of paper then rub many times with fingers. Score the attribute for 'stickability' attributes.

STICKABILITY

Adjustability

very difficult very easy

Bond strength - peel the bonded papers as soon as the rubbing finish

very weak very strong

* Please come back to do the folowing part after you finished evaluation every sample for the above attributes in order to allow about 30 minutes drying time *

F. Use the bonded papers prepared at the beginning of the test and evaluate the following attributes.

Bond strength - peel the prepared bonded paper

very weak very strong

Delamination of paper

none all

APPENDIX 4.1

QUESTIONNAIRE

I am a Ph.D student studying product development at Massey University. I am gathering information to use in the development of a glue stick product.

Could you please answer the following questions?

NAME _____ DATE _____

PART I

1. Which of the following products have you ever used to stick paper together or to other materials or for other purposes?

- () Glue stick
- () Liquid glue
- () PVA glue
- () Paste glue
- () Cellotape
- () 2-sided tape
- () Self-adhering note pads (e.g. 3M's 'Post-it' note pads)
- () Other glue products (please specify)

2. Which products in Question 1 do you use most often and how often?

Please select from the following frequency:

- | | |
|------------------------|------------------|
| Every day | 3-4 times a week |
| Twice a week | Once a week |
| Once a month | |
| Other (please specify) | |

Product	Frequency
2.1 _____	_____
2.2 _____	_____
2.3 _____	_____

3. What do you use those products for?

Product 2.1 _____
 Product 2.2 _____
 Product 2.3 _____

4. What are the characteristics of those products you think should be improved?

PART II

The products which you received are a sample of commercial glue stick products and a sample of self-adhering note pads available on the market. Please use them in the same way as you usually use these products then answer the following questions.

1. Please list the characteristics that are important to you in evaluating a glue stick to buy.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____

2. Please list the characteristics that are important to you in evaluating a self-adhering note pads to buy.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____

PART III

1. The following phrases are attributes of glue sticks.

Please rate the importance of these product attributes, use the score from 0 to 10;

0 = not important to 10 = very important.

- _____ Size
- _____ Colour of glue
- _____ Nice perfume
- _____ No awful smell
- _____ Hardness of the stick
- _____ The thickness of adhesive film left on the paper when applying each coat of the glue
- _____ Uniformity of coating
- _____ Amount of glue needed to stick paper together
- _____ Drying time
- _____ No curling or wrinkling of paper after applying glue
- _____ Brand name
- _____ Price
- _____ Ease of use
- _____ Versatility
- _____ Keeping quality

2. The following phrases are attributes of self-adhering note pads. Please rate the importance of these product attributes, use the score from 0 to 10;

0 = not important to 10 = very important.

- _____ Colour of paper
- _____ Uniformity of glue coated on the paper
- _____ The force needed to pull the paper after it is stuck on other paper or other materials
- _____ Damage on other surface after pulling the paper away from that surface
- _____ Brand name
- _____ Price
- _____ Ease of use
- _____ Versatility
- _____ Keeping quality

Thank you very much for your cooperation.

แบบสอบถามเกี่ยวกับการพัฒนาผลิตภัณฑ์กาวแท่ง

เรียน ผู้ตอบแบบสอบถาม

แบบสอบถามที่ท่านได้รับนี้เป็นส่วนหนึ่งของโครงการวิจัยเกี่ยวกับ "ผลิตภัณฑ์กาวแท่ง" ซึ่งทำจากแป้งที่ผลิตได้ในประเทศไทย โครงการวิจัยนี้จัดทำโดยนักศึกษาคณะวิทยาศาสตร์พัฒนาผลิตภัณฑ์ มหาวิทยาลัยแม่โจ้ ประเทศนิวซีแลนด์ ผู้วิจัยต้องการทราบข้อมูลเกี่ยวกับการใช้ผลิตภัณฑ์กาว และข้อคิดเห็นเกี่ยวกับผลิตภัณฑ์กาวแท่ง ซึ่งจะได้มีการพัฒนาปรับปรุงในโครงการวิจัยนี้

ผลิตภัณฑ์กาวแท่งที่จะได้มีการพัฒนาและปรับปรุงในโครงการวิจัยนี้ ได้แก่

1). ผลิตภัณฑ์ ก. - กาวแท่งชนิดติดฉนวนผลิตจากแป้งมันสำปะหลัง

ผลิตภัณฑ์นี้จะมีลักษณะเป็นแท่ง บรรจุในหลอดคล้ายหลอดลิปสติก ซึ่งสามารถหมุนขึ้นเมื่อต้องการใช้ และหมุนลงเมื่อใช้งานเสร็จแล้ว โดยปกติกาวแท่งมีคุณสมบัติดีกว่ากาวชนิดอื่น ๆ คือใช้สะดวก แห้งเร็ว ไม่เลอะเทอะ ไม่ทำให้กระดาษยับหรืองอ พกติดตัวได้ง่าย ผลิตภัณฑ์จะได้รับการปรับปรุงให้มีคุณสมบัติดีกว่ากาวแท่งที่มีอยู่แล้วในท้องตลาด และจะมีราคาถูกกว่าเนื่องจากใช้วัตถุดิบที่ผลิตได้ในประเทศในการผลิต

2). ผลิตภัณฑ์ ข. - กาวแท่งชนิดติดชั่วคราวผลิตจากแป้งมันสำปะหลัง

ผลิตภัณฑ์นี้จะมีลักษณะเหมือนกาวแท่งทั่วไป แต่จะมีคุณสมบัติที่ต่างออกไปคือ เมื่อใช้ติดกระดาษเข้าด้วยกัน หรือติดกระดาษกับวัสดุอื่นแล้ว สามารถดึงออกแล้วติดซ้ำใหม่ได้อีกหลายครั้ง กาวแท่งนี้จะมีคุณสมบัติเหมือนกับกาวที่เคลือบบนกระดาษโน้ตมีกาวในตัว เช่น กระดาษโน้ตสีเหลือง "โพสท์-อิท" (Post-it) ของ 3M ซึ่งสามารถนำไปติดบนเอกสาร โຕะ บอร์ด หรือผนัง โดยเมื่อดึงออกไม่ทำให้เกิดความเสียหายกับพื้นผิวที่นำกระดาษไปติด นอกจากนี้ผลิตภัณฑ์ ข. ยังสามารถใช้ติดรูปในการทำรายงาน ด้วยเอกสาร วลา ซึ่งสามารถแกะออกแล้วจัดตำแหน่งได้ใหม่ตามต้องการ โดยไม่ทำให้กระดาษขาดหรือเป็นรอย

ข้อมูลที่ได้ในครั้งนี้จะนำไปใช้ในการพิจารณาว่าผลิตภัณฑ์ทั้ง 2 ชนิดควรจะได้รับการพัฒนาและปรับปรุงอย่างไร ซึ่งจะเป็นประโยชน์อย่างมากสำหรับงานวิจัยในลำดับต่อไป ผู้วิจัยจึงใคร่ขอความร่วมมือจากท่านมา ณ ที่นี้ด้วย

ขอขอบพระคุณอย่างสูง

หทัยรัตน์ เอื้อพิทักษ์

ผู้วิจัย

คำถามในแบบสอบถามนี้ แบ่งเป็น 4 ตอน ได้แก่ :

- ตอนที่ 1 - คำถามทั่วไปเกี่ยวกับการใช้ผลิตภัณฑ์กาว โดยเฉพาะกาวแท่ง รวมทั้งลักษณะที่สำคัญของผลิตภัณฑ์กาว
- ตอนที่ 2 - คำถามเกี่ยวกับการพัฒนาและปรับปรุงผลิตภัณฑ์กาวแท่งชนิดติดฉนวน ซึ่งผลิตจากแป้งมันสำปะหลัง (ผลิตภัณฑ์ ก)
- ตอนที่ 3 - คำถามเกี่ยวกับการพัฒนาผลิตภัณฑ์กาวแท่งชนิดติดชั่วคราวซึ่งผลิตจากแป้งมันสำปะหลัง (ผลิตภัณฑ์ ข)
- ตอนที่ 4 - คำถามเกี่ยวกับผู้ตอบแบบสอบถาม

* ตัวอย่างที่ท่านได้รับพร้อมกับแบบสอบถามนี้ เป็นตัวอย่างของกาวแท่งชนิดติดฉนวนที่มีอยู่แล้วในท้องตลาด กรุณาลองใช้กาวนี้เพื่อประกอบในการตอบแบบสอบถาม

ตอนที่ 1

1. ผลิตภัณฑ์ใดบ้างดังต่อไปนี้ที่ท่านเคยใช้ในการติดกระดาษกับกระดาษ หรือกับวัสดุอื่น และท่านใช้ผลิตภัณฑ์ดังกล่าวบ่อยแค่ไหน

ความถี่ (โปรดขีดข้อลึงเกิดข้างล่าง)

- () กาวแท่ง _____
- () กาวน้ำ _____
- () แป้งเปียก _____
- () กาวลาเทกซ์ _____
- () สกอตเทปใส _____
- () เทปกาวชนิด 2 หน้า _____
- () อื่น ๆ (โปรดระบุ) _____

ข้อสังเกต : โปรดเลือกความถี่ต่อไปนี้ในการตอบคำถามข้อ (1)

- ก. ทุกวัน
- ข. สัปดาห์ละ 3-4 ครั้ง
- ค. สัปดาห์ละ 2 ครั้ง
- ง. สัปดาห์ละ 1 ครั้ง
- จ. เดือนละ 1 ครั้ง
- ฉ. อื่น ๆ (โปรดระบุ) _____

2. ท่านซื้อผลิตภัณฑ์ดังกล่าวในข้อ (1) ที่ไหน
- * ถ้าท่านไม่ได้ซื้อผลิตภัณฑ์ดังกล่าวด้วยตัวท่านเอง โปรดตอบคำถามข้อ (3)
- () ร้านขายเครื่องเขียน
- () แผนกขายเครื่องเขียนในห้างสรรพสินค้า
- () ร้านขายของชำ
- () ซูเปอร์มาร์เกต
- () อื่น ๆ (โปรดระบุ)
3. ท่านได้รับผลิตภัณฑ์ดังกล่าวมาอย่างไร
- () ที่ทำงาน (ในกรณีที่ท่านใช้สำหรับงานในสำนักงาน)
- () อื่น ๆ (โปรดระบุ) _____
4. ในการเลือกใช้กาวเพื่อติดกระดาษ ลักษณะต่อไปนี้มีความสำคัญในการตัดสินใจของท่านอย่างไร

ข้อสังเกต : กรุณาให้คะแนนตั้งแต่ 1 ถึง 5 ในช่อง [] ที่กำหนดให้

- 1 = ไม่สำคัญ
- 2 = ค่อนข้างไม่สำคัญ
- 3 = สำคัญปานกลาง
- 4 = ค่อนข้างสำคัญ
- 5 = สำคัญมาก

คะแนน

- [] กลิ่น
- [] ความสม่ำเสมอของกาวที่เคลือบบนกระดาษ
- [] ปริมาณกาวที่ต้องใช้ในการติดกระดาษเข้าด้วยกัน
- [] เวลาที่ต้องรอให้กาวแห้ง
- [] ผลกระทบต่อกระดาษ เช่น กระดาษบ่น หรืองอ
- [] ความสามารถในการติดกระดาษเข้าด้วยกัน
- [] ความสะอาดในการใช้
- [] ราคา
- [] ความสะดวกในการใช้
- [] ความสามารถในการใช้กับวัสดุได้หลายชนิด
- [] คุณสมบัติในการเก็บไว้ได้นานโดยไม่เสื่อมคุณภาพ

5. กรุณาประเมินความพอใจของท่านต่อผลิตภัณฑ์ต่อไปนี้ ตามลักษณะที่กำหนดให้ (ตอบเฉพาะผลิตภัณฑ์ที่ท่านเคยใช้)

ข้อสังเกต : กรุณาให้คะแนนตั้งแต่ 1 ถึง 5 ในช่อง [] ที่กำหนดให้

- 1 = ไม่เป็นที่น่าพอใจ
- 2 = ค่อนข้างไม่เป็นที่น่าพอใจ
- 3 = เป็นที่น่าพอใจปานกลาง
- 4 = ค่อนข้างเป็นที่น่าพอใจ
- 5 = เป็นที่น่าพอใจมาก

	กาวแห้ง	กาวน้ำ	กาวลาเทกซ์	สกอตเทปใส
1. กลิ่น	[]	[]	[]	[]
2. ความสม่ำเสมอของกาวที่เคลือบบนกระดาษ	[]	[]	[]	
3. ปริมาณกาวที่ต้องใช้ในการติดกระดาษเข้าด้วยกัน	[]	[]	[]	
4. เวลาที่ต้องรอให้กาวแห้ง	[]	[]	[]	
5. ผลกระทบต่อกระดาษ เช่น กระดาษบ่น หรืองอ	[]	[]	[]	[]
6. ความสามารถในการติดกระดาษ	[]	[]	[]	[]
7. ความสะอาดในการใช้	[]	[]	[]	[]
8. ราคา	[]	[]	[]	[]
9. ความสะดวกในการใช้	[]	[]	[]	[]
10. ความสามารถในการใช้กับวัสดุได้หลายชนิด	[]	[]	[]	[]
11. คุณสมบัติในการเก็บไว้ได้นานโดยไม่เสื่อมคุณภาพ	[]	[]	[]	[]

6. ท่านใช้กาวแท่งเป็นประจำหรือไม่

() ใช่ ถ้าใช่, กรุณาตอบคำถามข้อ (7)

() ไม่ใช่ ถ้าไม่ใช่, กรุณาตอบคำถามข้อ (10)

7. ท่านใช้กาวแท่งยี่ห้ออะไร

8. ท่านชอบกาวแท่งที่ท่านใช้ประจำหรือไม่

() ชอบ ถ้าชอบ, กรุณาตอบคำถามตอนที่ 2

() ไม่ชอบ ถ้าไม่ชอบ, กรุณาตอบคำถามข้อ (9)

9. กรุณาให้เหตุผลที่ทำให้ท่านไม่ชอบกาวแท่งที่ท่านใช้อยู่

10. กรุณาให้เหตุผลที่ทำให้ท่านไม่ใช้กาวแท่ง

ตอนที่ 2

ผลิตภัณฑ์ ก. กาวแท่งชนิดติดถาวรผลิตจากแป้งมันสำปะหลัง

กรุณาตอบคำถามต่อไปนี้ เพื่อประโยชน์ในการพัฒนาและปรับปรุงผลิตภัณฑ์ ก.

1. ในการเลือกซื้อกาวแท่ง ท่านคิดว่าลักษณะต่อไปนี้มีความสำคัญต่อการตัดสินใจของท่านอย่างไร กรุณาให้คะแนนตั้งแต่ 1 ถึง 5 ในช่อง [] ที่กำหนดให้

1 = ไม่สำคัญ

2 = ค่อนข้างไม่สำคัญ

3 = สำคัญปานกลาง

4 = ค่อนข้างสำคัญ

5 = สำคัญมาก

คะแนน

[] ความแข็งแรงของแท่งกาว

[] ความสม่ำเสมอของกาวที่เคลือบบนกระดาษ

[] ความหนากาวที่ติดอยู่บนกระดาษ เมื่อทาแล้วแต่ละครั้ง

[] ปริมาณกาวที่ต้องใช้ในการติดกระดาษ

[] เวลาที่ต้องรอให้กาวแห้ง

[] ผลกระทบต่อกระดาษ เช่น กระดาษบ่น หรืองอ

[] ความสามารถในการติดกระดาษเข้าด้วยกัน

[] ความสะอาดด้านนอกของภาชนะบรรจุ

[] ความสะอาดของงาน

ถ้าท่านคิดว่ามีลักษณะอื่น ๆ ที่สำคัญ โปรดระบุพร้อมกับให้คะแนนความสำคัญของแต่ละลักษณะ

คะแนน

[] _____

[] _____

[] _____

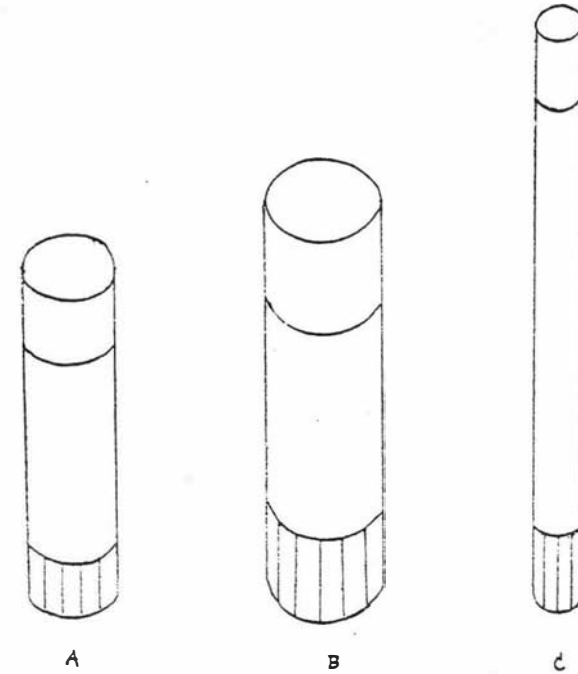
[] _____

2. ท่านคิดว่าผลิตภัณฑ์กาวแท่งที่มีขายในท้องตลาด ควรได้รับการปรับปรุงอย่างไรบ้าง

3. ถ้าผลิตภัณฑ์ ก. ได้รับการพัฒนาและปรับปรุงตามที่ท่านแนะนำ ท่านคิดว่าจะซื้อผลิตภัณฑ์นี้หรือแนะนำผลิตภัณฑ์นี้ให้กับที่ทำงานของท่านหรือไม่

- () จะซื้อแน่นอน/จะแนะนำแน่นอน
() อาจจะซื้อ/อาจจะแนะนำ
() ไม่แน่ใจ
() อาจจะ ไม่ซื้อ/อาจจะ ไม่แนะนำ
() ไม่ซื้อแน่นอน/ไม่แนะนำแน่นอน

* ถ้าท่านเลือกตอบไม่ซื้อแน่นอน/ไม่แนะนำแน่นอน กรุณาให้เหตุผล แล้วข้ามไปตอบคำถาม
ตอนที่ 3



4. จากรูป ท่านคิดว่าผลิตภัณฑ์ ก. ควรมีขนาดเท่าใด
- () ขนาด A (น้ำหนักเนื้อกาว 9 กรัม)
() ขนาด B (น้ำหนักเนื้อกาว 18 กรัม)
() ขนาด C (น้ำหนักเนื้อกาว 9 กรัม)
() อื่น ๆ (โปรดระบุ) _____
5. ถ้าผลิตภัณฑ์ ก. มีขนาดเท่ากับตัวอย่างที่แจกให้ (น้ำหนักเนื้อกาว 9 กรัม) ท่านคิดว่า จะใช้ได้นานเท่าใด ก่อนที่ท่านต้องซื้อใหม่ หรือเปลี่ยนแท่งใหม่
- () ประมาณ 1 เดือน
() ประมาณ 2 เดือน
() ประมาณ 3-4 เดือน
() ประมาณ 6 เดือน
() อื่น ๆ (โปรดระบุ) _____

6. ถ้าผลิตภัณฑ์ ก. มีขนาดเท่ากับตัวอย่างที่แจกให้ (น้ำหนักเนื้อกาว 9 กรัม) ท่านคิดว่า ราคาที่เหมาะสมสำหรับผลิตภัณฑ์นี้ควรเป็นเท่าใด
- () น้อยกว่า 10 บาท
- () 10 บาท
- () 12 บาท
- () 15 บาท
- () 18 บาท
- () มากกว่า 18 บาท

ตอนที่ 3

ผลิตภัณฑ์ ข. กาวแท่งชนิดติดชั่วคราวผลิตจากแป้งมันสำปะหลัง

ผลิตภัณฑ์ ข. เป็นผลิตภัณฑ์ที่ยังไม่มีจำหน่ายในท้องตลาด กาวนี้มีคุณสมบัติเหมือน กาวที่เคือบบนกระดาษได้มีกาวในตัว เช่น กระดาษโน้ตสีเหลือง "โพสท์-อิท" ของ 3M กาวนี้เหมาะสำหรับใช้ติดเป็นการชั่วคราว เช่น ติดกระดาษโน้ตบนเอกสาร โปะ บอร์ด ผัง วลา กรุณาตอบคำถามต่อไปนี้ เพื่อประโยชน์ในการพัฒนาผลิตภัณฑ์ ข.

- ท่านใช้กระดาษโน้ตมีกาวในตัว เช่น "โพสท์-อิท" เป็นประจำหรือไม่

() ใช่ ถ้าใช่ , กรุณาบอกชื่อปีที่ท่านใช้ _____

() ไม่ใช่
- ในการเลือกใช้กาวแท่งชนิดติดชั่วคราว (ถ้าผลิตภัณฑ์นี้ได้รับการพัฒนา และมีจำหน่ายในท้องตลาด ท่านคิดว่าลักษณะต่อไปนี้มีความสำคัญต่อการตัดสินใจของท่านอย่างไร กรุณาให้คะแนนตั้งแต่ 1 ถึง 5 ในช่อง [] ที่กำหนดให้

- | | | |
|---|---|------------------|
| 1 | = | ไม่สำคัญ |
| 2 | = | ค่อนข้างไม่สำคัญ |
| 3 | = | สำคัญปานกลาง |
| 4 | = | ค่อนข้างสำคัญ |
| 5 | = | สำคัญมาก |

คะแนน

- [] ความสามารถในการติดกระดาษ
- [] ความสามารถในการติดซ้ำได้อีกหลายครั้ง
- [] แรงที่ต้องใช้ในการดึงกระดาษออกจากพื้นผิวที่นำกระดาษไปติด
- [] ความเสียหายที่เกิดขึ้นบนผนังหรือพื้นผิวของวัตถุหลังจากดึงกระดาษออก
- [] ความสะดวกในการใช้
- [] ความสามารถในการใช้กับวัสดุหลายชนิด

ถ้าคิดว่ามีลักษณะอื่น ๆ ที่สำคัญ โปรดระบุพร้อมกับให้คะแนนความสำคัญของแต่ละลักษณะ

คะแนน

- [] _____
- [] _____
- [] _____
- [] _____

- ท่านคิดว่าจะสามารถใช้ผลิตภัณฑ์ ข. เพื่อวัตถุประสงค์อะไรได้บ้าง (เลือกตอบได้มากกว่า 1 ข้อ)

- () ติดกระดาษโน้ตบนเอกสาร หนังสือ
- () ติดกระดาษโน้ตหรือ การ์ด บนบอร์ดหรือผนัง
- () ติดรูปบนกระดาษ
- () ติดกระดาษเวลาห่อของ
- () ปิดผนึกซองจดหมาย
- () อื่น ๆ (โปรดระบุ) _____

- ถ้าผลิตภัณฑ์ ข. ได้รับการพัฒนาและมีจำหน่ายในท้องตลาด ท่านคิดว่า จะซื้อผลิตภัณฑ์นี้หรือ แนะนำผลิตภัณฑ์นี้ให้กับที่ทำงานของท่านหรือไม่

- () จะซื้อแน่นอน/จะแนะนำแน่นอน
- () อาจจะซื้อ/อาจจะแนะนำ
- () ไม่แน่ใจ
- () อาจจะไม่ซื้อ/อาจจะไม่แนะนำ
- () ไม่ซื้อแน่นอน/ไม่แนะนำแน่นอน

* ถ้าท่านเลือกตอบไม่ซื้อแน่นอน/ไม่แนะนำแน่นอน กรุณาให้เหตุผลแล้วข้ามไป

ตอบคำถามตอนที่ 4

5. ถ้าผลิตภัณฑ์ ข. มีขนาดเท่ากับตัวอย่างที่แจกให้ (น้ำหนักเนื้อขาว 9 กรัม) ท่านคิดว่า จะใช้ได้นานเท่าใด ก่อนที่ท่านต้องซื้อใหม่ หรือเปลี่ยนถังใหม่

- () ประมาณ 1 เดือน
() ประมาณ 2 เดือน
() ประมาณ 3-4 เดือน
() ประมาณ 6 เดือน
() อื่น ๆ (โปรดระบุ) _____

6. ถ้าผลิตภัณฑ์ ข. มีขนาดเท่ากับตัวอย่างที่แจกให้ (น้ำหนักเนื้อขาว 9 กรัม) ท่านคิดว่า ราคาที่เหมาะสมของผลิตภัณฑ์นี้ควรเป็นเท่าใด

- () น้อยกว่า 10 บาท
() 10 บาท
() 12 บาท
() 15 บาท
() 18 บาท
() มากกว่า 18 บาท

7. ท่านคิดว่าความเป็นไปได้ที่ผลิตภัณฑ์ ข. จะถูกนำมาใช้แทนผลิตภัณฑ์ดังกล่าวต่อไปนี้มากแค่ไหน

- ข้อสังเกต 1 = ไม่มีความเป็นไปได้เลย
2 = มีความเป็นไปได้ต่ำ
3 = มีความเป็นไปได้ปานกลาง
4 = มีความเป็นไปได้ค่อนข้างสูง
5 = มีความเป็นไปได้สูงมาก

	1	2	3	4	5
กาวแท่ง	()	()	()	()	()
กาวน้ำ	()	()	()	()	()
แปรงเขียน	()	()	()	()	()
สกอตเทปใส	()	()	()	()	()
กาวลาเทกซ์	()	()	()	()	()
กาวชนิด 2 หน้า	()	()	()	()	()
กระดาษโน้ตมีกาวในตัว	()	()	()	()	()

ตอนที่ 4

กรุณาตอบคำถามข้างล่างนี้ เพื่อประโยชน์ในการติดตามข้อมูลในโอกาสต่อไป

ชื่อ _____ นามสกุล _____

1. เพศ () ชาย () หญิง
2. กลุ่มอายุ () ต่ำกว่า 15 ปี () 15-18 ปี
() 19-25 ปี () 26-40 ปี
() มากกว่า 40 ปี
3. อาชีพ () นักเรียน โรงเรียน _____ ชั้น _____
() นักศึกษา สถาบัน _____
สาขาวิชา _____ ระดับ _____
() ข้าราชการ ที่ทำงาน _____
ตำแหน่ง _____
() พนักงานบริษัทเอกชน ที่ทำงาน _____
ตำแหน่ง _____
() อื่น ๆ โปรดระบุ) _____

APPENDIX 4.2 (continued)

QUESTIONNAIRE (Translation from Thai)

The questionnaire you have received is part of the research project on 'The Development of Glue Stick Product from Thai Tapioca Starch'. This project is conducted by a Ph.D. student in Consumer Technology Department, Massey University, New Zealand. The information on glue product usage and your opinion regarding glue stick products will be used in further development of glue stick products.

The product to be studied are:

- 1) Product A Permanent bonding glue stick made from tapioca flour

This glue product is in stick form and comes in a lip stick like container. The glue can be wound up before using and wound down after finished. The advantages of the glue stick over other glue products are it is easier to use, dries faster, not messy, does not cause wrinkling or curling of paper, easy to carry. The product will be developed to overcome the defect of the existing glue stick and the price will be cheaper because it will be made from raw materials available in Thailand.

- 2) Product B Temporary bonding glue stick made from tapioca flour

Product B is a new type of glue stick which is not available in the market. This glue product will have the general properties similar to those of the conventional glue stick, except that after the glue is used to stick paper together or to other materials, it enables the paper to be peeled off from the receiving surface for a number of times without damaging or leaving glue residues on the receiving surfaces. This glue has the same property as the glue coated on self-adhering note pad such as 3M's 'Post-It' which can be attached to note, table, board or wall. This product can also be used for reports and photocopying etc. in which the paper can be repositioned without any damage.

Your participation in this survey is vital to the decision on the development of these two products which will be very valuable for this project.

Thank you very much for your cooperation.

The questions in this questionnaire are divided into 4 parts:

- | | | |
|---------------|---|---|
| <u>Part 1</u> | - | Relate to glue products usage especially glue sticks as well as important attributes of glue products |
| <u>Part 2</u> | - | Relate to the development and improvement of permanent bonding glue stick product based on tapioca starch |
| <u>Part 3</u> | - | Relate to the development of temporary bonding glue stick product based on tapioca flour |
| <u>Part 4</u> | - | Relate to personal information |

PART I

1. Which of the following products have you ever used to stick paper together or to other materials and how often?

	Frequency (see Note below)
☐ Glue stick	_____
☐ Liquid glue	_____
☐ Latex glue	_____
☐ Paste glue	_____
☐ Cellotape	_____
☐ 2 sided tape	_____
☐ Other glue products (please specify)	_____
_____	_____
_____	_____

Note: Please select frequency from the following choices:

- | | |
|-----------------|---------------------------|
| a) Every day | b) 3 times a week |
| c) Twice a week | d) Once a week |
| e) Once a month | f) Less than once a month |
| g) Not used | |

2. Where did you buy those products?
(If you did not buy the product yourself, please go to Question 3)

- ☐ Stationery shops
☐ Stationery department in department stores
☐ Corner shop or little shop
☐ Supermarkets
☐ Other (please specify)

Go to Question (4)

3. From whom did you get those products?

- ☐ Your office
☐ Other (please specify)

4. When you use a glue to stick pieces of paper together, how important are the following to you:

Note: Please use score from 1 to 5; 1 = not important to 5 = very important

- _____ Odour
- _____ Uniformity of coating
- _____ Amount of glue needed to stick paper together
- _____ Drying time
- _____ Effect on paper after applying the glue
- _____ Stickability
- _____ Cleanliness
- _____ Price
- _____ Ease of use
- _____ Versatility
- _____ Keeping quality

5. Please rate the following products on the attributes provided below:

Note: Please use score from 1 to 5; 1 = unacceptable to 5 = very acceptable

	Glue stick	Liquid glue	PVA glue	Cellotape
Odour	☐	☐	☐	☐
Uniformity of coating	☐	☐	☐	☐
Amount of glue needed to stick paper together	☐	☐	☐	☐
Drying time	☐	☐	☐	☐
Effect on paper after applying the glue	☐	☐	☐	☐
Stickability	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐
Price	☐	☐	☐	☐
Ease of use	☐	☐	☐	☐
Versatility	☐	☐	☐	☐
Keeping quality	☐	☐	☐	☐

6. Do you use a glue stick regularly?

- ☐ Yes If yes, go to Question (7)
☐ No If no, go to Question (10)

7. What brand(s) of glue stick do you use? Please specify:

8. Are you satisfied with current glue stick(s) that you use?

- ☐ Yes. If yes, please go to Part II
☐ No. If no, please go to Question (9)

9. Please specify any reason why you are not satisfied.

Go to Part II

10. If you do not use glue stick, please state reasons.

PART II

Product A: Permanent bonding glue stick based on tapioca flour

The product which you received is a sample of a commercial glue stick available on the market. Please try it now to stick some paper together as you would usually use a glue stick and answer the following questions.

1. The following are attributes of glue stick products. Please rate the importance of these product attributes, use the score from 1 to 5; 1 = Not important to 5 = Very important

SCORE

- _____ Hardness of the stick
- _____ Uniformity of coating
- _____ Thickness of adhesive film left on the paper when applying each coat of glue stick
- _____ Amount of glue needed to stick paper together
- _____ Drying time
- _____ Effect on paper after applying the glue
- _____ Stickability
- _____ Cleanliness of container
- _____ Cleanliness of work

Please specify if there are any other important attributes for glue stick products and also assign score for importance of each attribute.

SCORE

_____	_____
_____	_____
_____	_____
_____	_____

2. What attributes do you think should be improved in this product and specify how you would like those attributes to be improved.

3. Would you buy this product or recommend it to your office if it was improved as suggested?

- ☐ Definitely
- ☐ Probably
- ☐ Might or might not
- ☐ Probably not
- ☐ Definitely not

If not, please state reasons then go to PART III:

4. What is the size of the product that you prefer? (Please see the Figure provided)

- ☐ Size A (8 grams) - as per sample provided.
- ☐ Size B (18 grams)
- ☐ Size C (8 grams)
- ☐ Other (please specify)

5. How often are you going to replace this product, if you use the small size glue stick - 8 grams? (Please estimate)

- ☐ Once a month
- ☐ Once every two months
- ☐ Once every 3-4 months
- ☐ Once every 6 months
- ☐ Other (please specify) _____

6. What do you consider a reasonable price for the small size product (8 grams)?

- ☐ less than 10 baht
- ☐ 10 - 12 baht
- ☐ 13 - 15 baht
- ☐ 16 - 18 baht
- ☐ more than 18 baht

PART III

Product B: Temporary bonding glue stick based on tapioca flour

This product can be used as glue for temporary note, the same purpose as a self-adhering note pad e.g. 'Post-It' note pad, which can be adhered to a receiving surface such as paper, notice board, desk-top etc.

1. Do you use self-adhering note pads e.g. Post-it note pads regularly?

- ☐ Yes If yes, what brand do you use? _____
- ☐ No

2. The following are some attributes of this temporary bonded glue stick product. Please rate the importance of these product attributes, use the score from 1 to 5, 1 = Not important to 5 = Very important.

- | | |
|-------|--|
| _____ | Stickability |
| _____ | Reattachability |
| _____ | Force needed to pull paper from the receiving surface |
| _____ | Damage on the receiving surface after pulling the paper away from that surface |
| _____ | Ease of use |
| _____ | Versatility |

3. Please specify if there are any other important attributes for such a product and also assign score for importance of each of the attributes provided.

SCORE

_____	_____
_____	_____
_____	_____
_____	_____

4. For what purpose would you use this product?

- ☐ To stick note pad on paper or other materials
- ☐ To stick paper or card on notice boards or walls
- ☐ To stick paper to paper
- ☐ To stick paper for parcel wrapping
- ☐ To seal envelope
- ☐ Other (please specify)

5. Would you buy this product or recommend it to your office?

- ☐ Definitely
- ☐ Probably
- ☐ Might or might not
- ☐ Probably not
- ☐ Definitely not

If not, please state the reason then go to PART IV:

6. How often are you going to replace this product, if you use the small size glue stick - 8 grams? (Please estimate)

- ☐ Once a month
- ☐ Once every two months
- ☐ Once every 3-4 months
- ☐ Once every 6 months
- ☐ Other (please specify) _____

7. What do you consider a reasonable price for the small size product (8 grams)?

- ☐ less than 10 baht
- ☐ 10 - 12 baht
- ☐ 13 - 15 baht
- ☐ 16 - 18 baht
- ☐ more than 18 baht

8. What do you think of the possibility that this product will replace the following products:

NOTE

- 1 = No possibility
- 2 = Low possibility
- 3 = Moderate possibility
- 4 = High possibility
- 5 = Very high possibility

	1	2	3	4	5
Glue stick	☐	☐	☐	☐	☐
Liquid glue	☐	☐	☐	☐	☐
PVA glue	☐	☐	☐	☐	☐
Paste glue	☐	☐	☐	☐	☐
Cellotape	☐	☐	☐	☐	☐
2 sided tape	☐	☐	☐	☐	☐
Self-adhering note pads	☐	☐	☐	☐	☐

PART IV

Sex ☐ Male ☐ Female

Age group ☐ 15-18 years ☐ 19-25 years
☐ 26-40 years ☐ more than 40 years

Occupation ☐ Undergraduate Student
☐ Post-graduate Student
☐ Government officer

Thank you very much for your cooperation

APPENDIX 5.1

Correlations between Ingredients and Physical Attributes of Glue Stick from Dextrin Experiment

Attributes	Ingredient	r
Hardness	Starch	0.227
	PVP	-0.546
	Dextrin	0.391
Peel strength	Starch	0.450
	PVP	0.293
	Dextrin	-0.910*

Note: * - Significant at $p < 0.05$

APPENDIX 5.3

Correlation between ingredients and physical and sensory attributes of glue stick from casein experiment

Ingredients	Output Variable	r
Glycerin	Perceived hardness	-0.834**
	Adjustability	0.737
	%Moisture	-0.731*
	Delamination	0.730*
Sorbitol	Perceived hardness	0.834**
	Adjustability	-0.737
	%Moisture	0.731*
	Delamination	-0.730*

Note: * - Significant at $0.10 \geq p \geq 0.05$
 ** - Significant at $p < 0.05$

APPENDIX 5.2

Physical attributes of glue sticks from casein experiment

Sample	Wet glue per area (g/m ²)	Dry glue per area (g/m ²)	%Moisture	Hardness (Newton)	Open time (minutes)	Peel strength (Newton)
C1	39.5	21.2	44.6	5.6	5.5	3.5
C2	36.8	20.7	40.5	6.2	5.5	3.2
C3	26.2	15.3	45.8	6.7	5.3	3.8
C4	38.9	20.9	46.0	6.4	2.3	3.7
C5	39.8	21.6	44.0	5.6	3.8	3.0
C6	37.0	19.8	45.5	4.6	3.5	3.5

Sensory Attributes Mean Scores of the Glue Stick Samples from Casein Experiment (Scores Varied from 0-15)

Sample	Cover	Thick	Visible	Smooth	Clean	Adjust	Bond strength1	Slip	Hard	Deform	Disintegr.Bond strength2	Delamination strength3	
CA 1	10.0 (1.9)	10.1 (1.7)	10.9 (2.2)	10.7 (1.8)	11.4 (1.4)	8.3 (2.0)	6.6 (2.1)	3.7 (2.0)	7.7 (2.4)	10.5 (1.8)	10.0 (2.3)	7.7 (1.9)	4.6 (2.2)
CA 2	5.9 (2.4)	10.3 (1.7)	10.5 (1.9)	10.5 (2.0)	11.1 (2.4)	8.2 (1.9)	5.3 (1.2)	2.5 (1.5)	6.6 (2.3)	11.0 (0.7)	11.4 (1.4)	6.4 (2.4)	3.4 (1.7)
CA 3	6.9 (2.1)	8.1 (2.5)	8.5 (1.9)	10.8 (2.2)	11.8 (0.7)	7.4 (2.2)	5.1 (2.2)	5.4 (2.1)	9.1 (2.2)	9.5 (1.8)	8.9 (1.6)	5.2 (2.2)	2.7 (1.6)
CA 4	7.2 (2.3)	9.7 (1.5)	9.8 (2.4)	10.2 (2.1)	11.4 (1.7)	4.8 (2.3)	8.3 (2.2)	3.5 (1.6)	9.2 (1.5)	10.3 (1.9)	10.3 (1.7)	5.7 (1.9)	2.8 (1.6)
CA 5.1	9.2 (2.4)	8.4 (1.4)	8.9 (2.1)	11.0 (1.5)	11.6 (1.4)	7.7 (1.3)	5.9 (2.3)	4.3 (1.8)	8.7 (2.2)	9.4 (2.2)	9.6 (2.2)	5.3 (2.3)	3.4 (2.1)
CA 5.2	8.1 (1.8)	8.3 (1.1)	8.2 (1.6)	10.7 (1.9)	11.2 (1.9)	6.7 (2.4)	5.7 (1.7)	3.5 (1.7)	9.3 (1.8)	8.0 (2.0)	7.3 (1.9)	5.0 (2.4)	2.5 (1.7)

Note: The numbers in the parentheses are standard deviations

APPENDIX 5.4

Commercial Glue Sticks

PELIFIX Blue glue stick (9g)	Pelikan, Germany
BOSTIK Glu-stik (8g)	Bostik Pty Ltd., Korea
AMOS Glue stick (8g)	Amos, Korea
UHU Stic (8g)	UHU GmbH, Germany
PRITT (9g)	Henkel, Germany
ESSELTE (8g)	Esselte, Spain



APPENDIX 6.1 Questionnaire for Glue Stick Testing by Consumer Panel

แบบทดสอบผลิตภัณฑ์กาวแห้ง

ชื่อผู้ทดสอบ..... วันที่.....

คำแนะนำ

ท่านจะได้รับตัวอย่างกาวแห้ง_____ตัวอย่าง พร้อมกระดาษสำหรับทดสอบ กรุณาทดสอบตัวอย่าง
ตามลำดับต่อไปนี้จากซ้ายไปขวา

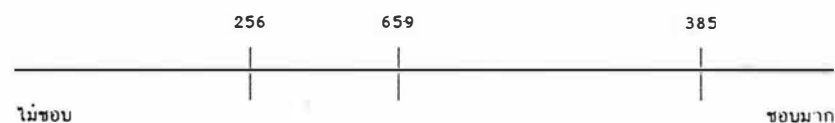
รหัสตัวอย่าง _____

วิธีทดสอบ

1. หมุนกาวให้ไหลขึ้นมาจากขอบภาชนะบรรจุประมาณ 3 มิลลิเมตร ก่อนทดสอบควรทดสอบทาการบนกระดาษที่แจกให้ เพื่อปรับให้พื้นที่หน้าตัดของแท่งกาวเรียบเสมอกัน
2. ทดลองใช้กาวโดยทาการบนกระดาษแผ่นเล็กให้ทั่วบริเวณที่ต้องการ แล้วนำไปติดบนกระดาษแผ่นใหญ่ในช่องที่กำหนดให้
3. ประเมินผลลักษณะตามลักษณะที่กำหนดให้ โดยขีดเส้นตรง () ติดกับเส้นแสดงลักษณะที่กำหนด แล้วตำแหน่งที่ตรงกับความรู้สึกของท่าน พร้อมทั้งให้ตัวอย่าง

ตัวอย่าง

ความชอบผลิตภัณฑ์



แบบทดสอบส่วนที่ 1

- ## 1. การยอมรับ

ไม่ยอมรับ

ยอมรับ

2. ความตั้งใจซื้อ / แนะนำให้ที่ทำงานของท่านซื้อ

ไม่ซื้อ

ชบแนนน

3. ราคาที่จะซื้อ (บาท)



แบบทดสอบส่วนที่ 2

กรุณาทดสอบผลิตภัณฑ์กาวแห้ง เช่นเดียวกับในตอนแรก แล้วประเมินคุณลักษณะต่าง ๆ ของผลิตภัณฑ์ดังต่อไปนี้

1. ความลื่นมือในการทา

ลื่น

2. การรอหรือการหัก, หลุดเป็นชิ้นเล็ก ๆ ของแท่งกาว

น้อย

3. การเปลี่ยนของเนื้อกาวบนกระดาษหลังการทาทั่วเพียง 1 ชิ้น

ไม่ติดเลย

4. การปรับเปลี่ยนกระดาษที่ทาแล้วให้เข้าที่ตามต้องการ

ปรับยาก

5. ความเรียบของกระดาษหลังการปะกบติดกันด้วยกาว

ไม่เรียบ

* เมื่อท่านทดสอบตัวอย่างครบทุกตัวอย่างแล้ว กรุณาทำเครื่องหมาย "I" ๗ ตำแหน่งซึ่งแสดงลักษณะของกาวแห้งที่ท่านต้องการจะซื้อ บนเส้นแสดงลักษณะผลิตภัณฑ์ทุกข้อ

แบบทดสอบส่วนที่ 3

กรุณาทดสอบกระดาษที่ทาแล้วและทิ้งให้กาวแห้งแล้วที่เตรียมไว้ โดยการลอกกระดาษทั้งสองแผ่นออกจากกัน

6. การติดแน่นของกาว

หลุดง่าย

* เมื่อท่านทดสอบตัวอย่างครบทุกตัวอย่างแล้ว กรุณาทำเครื่องหมาย "I" ๗ ตำแหน่ง ซึ่งแสดงลักษณะของกาวแห้งที่ท่านต้องการจะซื้อ บนเส้นแสดงลักษณะผลิตภัณฑ์

APPENDIX 6.1 (continued)

Questionnaire for Glue Stick Testing by Consumer Panel (Translation from Thai)

QUESTIONNAIRE FOR GLUE STICK TESTING

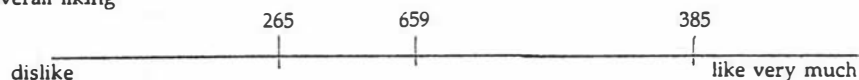
Name _____ Date _____

Method of testing

1. Wind up the stick about 5mm above the top edge of the container. Try rubbing glue stick on the paper before testing in order to smooth the glue stick surface.
2. Rub the glue stick along the surface of the small paper then stick this paper on the big paper at the specified position.
3. Evaluate the samples according to the given attributes and rate the sample by marking on the scale at the point represent your perception of the attribute.

Example

Overall liking



Part I

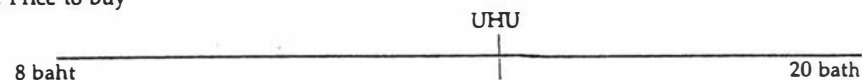
1. Acceptability

not acceptable _____ very acceptable

2. Purchase intention

never buy _____ certainly buy

3. Price to buy



Part II

Please test the glue stick samples then rate the product on the following attributes.

1. Slipperiness

_____ drags _____ slips

2. Deformation

low _____ high

3. Degree of coverage after one coating

none _____ total

4. Adjustability of coated paper to the specified position

very difficult _____ very easy

5. Smoothness of paper after sticking the two piece of paper together

very wrinkled _____ very smooth

After testing every sample, please mark 'I' at the position represent your ideal product on the scale for every attribute.

Part III

Please test the prepared bonded paper by peeling the paper apart.

6. Stickability

easy to peel _____ stick very strongly

After testing every sample, please mark 'I' at the position represent your ideal product on the scale.

Thank you very much.

APPENDIX 6.2

Sensory Attributes Scores of the Prototypes Obtained from Consumer Testing

Note: 742 - RUN 1
557 - RUN 4
428 - RUN 7

243 - RUN 2
181 - RUN 5

314 - RUN 3
887 - RUN 6

Accept Slip Adjust - Acceptability
- Slipperiness
- Adjustability

Purchase Disintegr Smooth - Purchase Intention
- Disintegration
- Smoothness

Price Coverage Stick - Price to Buy
- Degree of Coverage
- Stickability

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SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
742	1	2.2	.8	2.4	1.7	14.0	.9	12.9	1.4	9.6	314	1	0.0	0.0	0.0	.2	14.8	8.4	.1	.1	11.9
742	2	2.5	3.2	.1	1.2	13.0	10.9	12.8	11.8	11.6	314	2	6.1	4.4	0.0	1.2	14.1	10.6	12.8	10.3	2.8
742	3	2.8	.8	0.0	7.5	12.3	8.4	10.7	10.1	12.2	314	3	1.2	.8	0.0	.5	13.5	2.4	4.0	3.4	11.1
742	4	7.2	2.4	0.0	4.6	8.8	7.4	9.8	2.0	6.6	314	4	1.2	1.0	0.0	1.3	15.0	2.6	3.9	9.5	2.0
742	5	11.9	11.0	5.1	12.8	11.4	13.1	12.9	11.3	4.2	314	5	1.8	1.6	0.0	1.9	2.4	6.7	4.5	7.7	2.2
742	6	8.2	6.4	4.0	9.8	4.8	8.9	8.9	12.3	14.5	314	6	4.4	2.5	0.0	5.5	12.2	8.6	6.0	11.2	9.0
742	7	2.1	1.8	0.0	2.3	13.0	2.8	5.4	2.1	9.6	314	7	0.0	0.0	0.0	.7	13.7	2.2	6.0	.7	4.0
742	8	1.3	1.1	0.0	.3	12.4	2.9	1.1	.5	2.9	314	8	.3	.3	0.0	.3	14.6	1.7	1.1	1.5	1.0
742	9	1.8	.5	.4	7.0	6.8	12.3	3.5	4.6	11.6	314	9	0.0	0.0	0.0	.8	14.1	6.2	3.5	4.6	1.2
742	10	9.1	9.6	6.2	6.8	8.1	3.6	11.4	9.9	12.7	314	10	1.1	1.4	.3	3.3	14.5	2.4	10.9	4.7	1.3
742	11	8.4	6.2	4.7	8.5	4.1	8.9	12.6	11.2	14.3	314	11	7.0	3.9	.4	4.7	6.4	9.9	10.6	10.7	10.7
742	12	6.7	5.9	4.8	3.5	8.6	8.9	9.9	10.4	7.3	314	12	2.7	2.7	2.3	1.2	4.0	8.4	4.8	10.0	10.5
742	13	4.7	3.3	1.2	3.8	6.8	6.8	4.2	8.8	12.7	314	13	0.0	0.0	0.0	.1	15.0	.1	7.7	13.1	11.0
742	14	10.4	9.9	5.0	10.4	3.8	9.7	12.5	11.1	13.7	314	14	1.3	1.1	0.0	1.2	12.6	1.4	14.5	8.0	7.9
742	15	10.5	11.1	8.5	9.5	2.2	9.8	13.1	13.3	9.3	314	15	.3	0.0	0.0	2.5	15.0	6.7	14.0	7.9	8.7
742	16	5.4	6.2	3.3	2.7	11.9	11.3	7.4	3.8	13.8	314	16	3.0	2.0	1.5	1.5	12.5	3.2	8.6	1.3	12.0
742	17	6.8	6.8	3.4	9.3	9.1	6.7	7.9	9.8	11.5	314	17	.2	.2	.2	2.2	13.5	1.7	2.9	1.1	11.5
742	18	11.9	7.2	2.4	9.3	14.0	8.1	2.3	15.0	4.9	314	18	0.0	0.0	0.0	.9	15.0	.8	.1	.1	6.9
742	19	8.6	10.1	4.9	2.7	8.8	10.4	8.1	13.7	9.6	314	19	.5	.3	0.0	.8	14.2	4.2	1.2	12.6	9.9
742	20	2.4	2.7	0.0	3.9	8.5	10.7	11.3	12.6	10.6	314	20	.1	0.0	0.0	.1	15.0	.5	13.4	12.6	7.8
742	21	8.1	7.8	2.4	2.9	6.0	6.4	2.3	7.4	13.1	314	21	2	0.0	0.0	.6	13.6	2.2	6.8	5.7	3.0
742	22	5.0	3.0	.9	10.2	6.4	8.5	7.1	11.8	10.4	314	22	3.7	1.7	0.0	.6	12.5	.5	5.1	1.3	6.7
742	23	2.2	.7	3.5	5.1	4.4	5.3	2.1	8.7	10.0	314	23	.1	0.0	3.5	.1	15.0	3.8	12.1	.2	.5
742	24	5.8	6.2	4.9	1.8	12.7	1.3	1.4	1.3	7.6	314	24	.8	.6	0.0	.2	14.8	.3	.3	.2	8.6
742	25	4.5	2.8	0.0	3.3	5.3	4.4	9.8	7.9	12.5	314	25	.5	.4	0.0	.1	12.3	3.2	12.0	1.4	4.0
742	26	.2	.1	0.0	.8	13.5	3.2	12.3	.3	13.2	314	26	0.0	0.0	0.0	.1	15.0	1.4	15.0	.1	.2
742	27	1.5	1.7	0.0	.9	13.0	2.9	1.8	4.0	11.6	314	27	0.0	0.0	0.0	10.0	13.0	.1	15.0	10.8	1.5
742	28	3.8	3.0	0.0	1.3	13.1	3.3	9.3	3.1	9.7	314	28	0.0	0.0	0.0	.1	12.1	.1	15.0	15.0	7.4
742	29	1.8	.8	.1	2.0	13.3	3.3	9.2	10.5	10.5	314	29	.8	0.0	0.0	.1	14.7	.1	15.0	15.0	.2
742	30	7.5	4.1	2.3	6.2	8.9	13.4	4.7	8.3	12.8	314	30	.5	.2	.1	.3	13.9	.8	1.0	.7	5.8
MEAN		5.51	4.57	2.35	5.07	9.30	7.15	7.96	7.92	10.49	MEAN		1.26	.84	.28	1.44	12.97	3.37	7.60	6.05	6.04
SD		3.42	3.45	2.38	3.57	3.61	3.62	4.08	4.44	2.99	SD		1.85	1.21	.78	2.10	3.15	3.24	5.31	5.18	4.10
SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
243	1	5.6	2.6	4.9	5.0	7.8	4.1	.5	7.7	10.8	557	1	13.9	14.2	10.0	14.2	.9	14.7	.1	12.9	10.4
243	2	9.3	11.5	2.4	10.8	13.8	8.5	12.2	11.0	8.9	557	2	1.4	1.3	.1	13.8	1.0	11.1	14.0	10.6	10.6
243	3	13.1	10.6	4.9	10.2	8.2	9.4	5.3	6.1	13.3	557	3	4.5	2.0	0.0	12.6	2.0	12.5	12.1	12.7	10.0
243	4	2.1	1.4	0.0	8.4	1.7	6.5	8.5	10.2	4.3	557	4	7.9	6.2	3.7	11.8	1.1	.2	13.6	12.5	1.6
243	5	13.3	12.7	7.2	12.2	11.9	12.7	12.9	11.0	4.5	557	5	13.0	12.5	7.2	13.5	10.8	13.3	12.9	10.5	4.8
243	6	10.7	10.9	6.4	10.2	7.8	8.6	9.4	13.5	13.6	557	6	13.4	14.0	7.7	12.2	1.9	12.2	11.0	13.6	10.0
243	7	2.5	2.2	0.0	3.2	10.5	3.7	2.4	3.1	11.7	557	7	5.5	5.4	2.5	10.1	8.6	10.3	9.7	10.6	10.6
243	8	9.1	9.1	7.4	9.7	13.8	9.8	11.2	5.9	4.9	557	8	12.2	12.8	8.8	12.7	.7	14.3	12.8	12.4	10.6
243	9	3.6	1.6	1.7	10.2	4.8	12.8	3.7	5.3	11.3	557	9	11.8	11.8	8.4	13.1	.6	13.7	3.8	13.7	11.6
243	10	6.8	6.9	6.8	12.9	10.7	6.5	7.1	9.3	12.0	557	10	13.3	10.9	8.7	11.7	6.2	12.2	12.1	11.4	12.3
243	11	4.5	3.3	2.6	6.3	4.7	7.5	12.6	10.7	12.0	557	11	5.9	3.9	2.6	10.4	2.1	7.5	13.7	12.5	12.0
243	12	5.7	5.2	4.8	10.3	9.9	9.6	12.7	12.2	9.9	557	12	8.0	7.7	7.5	10.9	2.7	11.3	13.2	12.2	6.6
243	13	3.4	2.3	1.2	5.7	9.4	5.7	3.2	12.0	13.7	557	13	12.3	10.9	10.1	13.5	3.7	11.6	5.6	12.7	11.2
243	14	6.1	4.5	2.4	5.4	13.5	8.3	12.5	4.6	11.3	557	14	12.1	12.0	8.8	12.1	2.0	12.9	12.5	13.3	11.3
243	15	7.3	6.8	6.2	11.0	2.0	10.5	12.1	13.3	9.0	557	15	9.4	9.9	8.2	12.5	3.0	9.1	11.9	13.3	10.2
243	16	6.2	10.1	5.3	3.0	13.6	3.9	11.2	2.6	13.1	557	16	10.3	10.6	7.9	12.5	1.8	13.1	7.7	12.7	14.1
243	17	3.5	1.7	.8	4.3	11.5	5.1	7.9	9.8	11.5	557	17	11.4	11.6	4.9	10.6	3.2	9.7	10.1	11.9	11.5
243	18	12.6	13.8	4.8	10.3	14.9	5.8	11.1	13.9	6.9	557	18	12.3	12.4	4.8	10.3	1.1	9.6	2.3	15.0	6.2
243	19	12.9	10.7	5.6	6.2	13.6	2.8	5.1	14.5	11.5	557	19	14.0	13.8	8.8	13.0	11.4	3.3	10.5	13.1	8.6
243	20	1.0	1.0	0.0	1.6	11.9	3.0	11.3	12.6	8.4	557	20	9.3	10.1	4.8	15.0	.5	15.0	11.3	12.6	10.6
243	21	12.5	11.9	7.5	12.1	1.2	13.9	9.7	14.2	7.9	557	21	4.1	.7	.3	14.4	.1	14.7	13.4	15.0	5.8
243	22	6.3	3.8	1.6	8.6	9.6	6.0	8.1	3.4	7.8	557	22	11.1	12.9	7.4	14.1	1.9	10.2	10.5	13.6	6.7
243	23	6.9	7.0	4.9	11.5	12.9	7.1	10.4	13.3	1.5	557	23	13.8	14.1	11.0	14.4	.1	1.3	4.6	11.8	14.3
243	24	5.1	5.1	4.9	7.4	9.6	8.8	9.6	9.7	4.5	557	24	6.8	7.1	4.9	9.3	2.4	10.5	11.4	11.0	5.5
243	25	3.1	1.2	0.0	7.3	13.2	5.7	10.8	3.2	9.7	557	25	5.4	3.8	0.0	1.9	11.4	11.9	8.1	9.9	6.6
243	26	1.4	1.3	0.0	9.1	12.1	9.1	9.0	8.6	6.4	557	26	13.6	14.0	2.3	12.9	.2	14.8	.7	15.0	4.3
243	27	4.1	4.7	2.5	8.9	14.7	4.5	11.6	1.3	9.0	557	27	1.7	1.5	2.5	14.2	.1	14.4	4.8	12.8	6.8
243	28	5.5	4.2	0.0	8.1	12.2	9.2	5.6	14.0	11.0	557	28	11.8	9.3	2.3	11.3	2.1	4.4	8.5	8.3	11.9
243	29	4.5	3.1	.1	9.3	14.9	2.2	13.6	2.8	7.8	557	29	13.1	13.1	4.8	13.8	1.7	15.0	2.1	14.2	14.9
243	30	11.6	5.9	2.3	6.8	10.5	5.9	5.7	10.2	7.0	557	30	12.6	10.7	2.3	11.2	3.7	4.2	9.5	12.5	8.9
MEAN		6.68	5.90	3.31	8.20	10.23	7.24	8.90	9.00	9.17	MEAN		9.86	9.37	5.44	12.13	2.97	10.63	9.15	12.59	9.35
SD		3.76	4.00	2.62	2.94	3.95	3.03	3.53	4.16	3.16	SD		3.81	4.33	3.38	2.44	3.32	4.15	4.21	1.51	3.21

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SAMPLE	PANEL	ACCEPT	PURCHASE PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
181	1	14.4	14.2	10.0	13.5	.3	13.9	.1	14.0
181	2	14.0	13.8	7.3	12.1	2.0	11.6	2.6	14.0
181	3	11.2	9.6	2.3	11.3	9.4	11.6	4.1	11.0
181	4	12.9	10.0	6.2	10.1	3.0	8.3	1.4	7.3
181	5	12.7	12.3	7.0	11.3	13.0	12.1	9.2	9.5
181	6	13.8	14.3	8.2	10.7	4.8	10.7	9.8	13.2
181	7	4.4	4.1	2.5	7.1	5.7	6.8	9.3	9.2
181	8	7.8	3.9	4.8	11.3	1.5	13.3	9.7	13.0
181	9	5.1	2.3	2.4	12.2	.9	13.1	4.1	13.1
181	10	12.0	10.4	7.8	10.5	8.1	10.7	9.9	10.9
181	11	9.2	9.1	6.7	10.4	2.1	8.9	10.6	12.5
181	12	11.1	10.9	8.8	10.9	2.4	11.3	13.2	11.4
181	13	11.9	10.3	10.1	12.8	.7	12.2	11.7	13.1
181	14	11.2	11.0	6.2	12.1	3.8	12.3	11.7	13.3
181	15	9.9	10.0	8.2	8.5	2.5	9.4	13.3	13.3
181	16	11.9	12.3	8.8	12.9	1.4	13.8	3.9	13.2
181	17	11.4	11.6	5.9	10.6	3.2	10.4	10.1	11.9
181	18	13.3	15.0	8.8	10.3	10.5	11.5	13.2	3.4
181	19	12.9	13.0	7.5	11.5	3.1	11.4	12.5	14.2
181	20	7.4	7.6	2.3	11.0	2.9	12.0	11.3	12.6
181	21	14.4	14.3	11.2	10.9	1.2	13.0	5.1	13.6
181	22	9.0	10.9	6.1	14.1	.9	11.0	9.0	13.6
181	23	14.8	15.0	12.5	13.1	1.8	4.4	3.2	14.8
181	24	7.5	7.9	7.6	10.1	1.6	11.6	12.1	12.2
181	25	6.9	7.1	2.3	10.6	4.5	12.6	6.1	11.9
181	26	13.6	14.0	2.3	11.8	8.5	14.8	.7	14.3
181	27	12.2	12.2	6.2	11.8	1.7	10.8	.1	14.7
181	28	13.3	10.7	4.7	9.8	.5	13.8	3.8	12.8
181	29	11.3	12.3	2.5	11.8	.3	13.8	.1	15.0
181	30	13.7	13.0	6.2	10.7	7.1	12.1	8.5	12.0
MEAN		11.17	10.77	6.45	11.19	3.65	11.44	7.46	12.29
SD		2.83	3.28	2.85	1.42	3.33	2.20	4.58	2.42

SAMPLE	PANEL	ACCEPT	PURCHASE PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
847	1	12.2	12.9	7.5	10.9	4.3	9.8	.5	5.2
847	2	13.2	13.0	7.3	5.5	9.0	11.1	3.4	12.8
847	3	6.7	3.1	0.0	6.0	4.6	6.5	2.6	11.6
847	4	3.1	1.9	0.0	2.2	10.8	11.8	.6	3.4
847	5	11.6	10.7	4.6	11.9	12.5	12.4	12.7	9.6
847	6	8.7	7.1	4.6	9.8	9.1	8.3	12.1	13.1
847	7	3.0	2.8	0.0	6.2	11.5	5.8	3.0	3.7
847	8	2.3	1.9	2.2	8.4	4.6	11.3	11.2	8.1
847	9	4.9	2.2	2.2	10.8	3.2	12.8	4.1	6.5
847	10	4.2	3.3	4.8	4.0	5.1	5.0	9.2	8.6
847	11	9.2	7.4	6.7	14.3	8.5	4.1	10.5	10.6
847	12	7.6	7.2	7.5	8.8	5.0	10.1	12.0	10.8
847	13	5.9	4.4	2.9	4.6	6.8	6.8	1.9	6.0
847	14	5.4	3.8	2.4	10.4	10.2	12.3	12.5	11.1
847	15	8.8	7.5	7.0	9.7	4.1	9.6	12.9	13.3
847	16	11.7	11.9	8.4	11.9	2.9	12.3	4.4	12.5
847	17	7.7	6.8	3.4	9.3	5.1	8.1	7.9	9.8
847	18	12.3	12.4	4.8	9.9	14.0	5.3	12.1	13.4
847	19	10.5	11.1	6.2	8.6	10.9	4.8	11.0	12.6
847	20	2.4	2.7	0.0	3.9	8.5	10.7	11.3	12.6
847	21	6.2	3.4	1.1	6.8	7.9	12.3	3.9	12.9
847	22	8.2	6.2	3.5	7.7	7.5	6.8	6.2	11.0
847	23	1.0	.3	3.5	6.8	14.0	12.3	8.3	2.5
847	24	2.1	2.3	2.4	9.9	6.9	7.5	7.7	7.7
847	25	10.4	10.3	6.2	9.5	3.8	11.2	7.6	10.8
847	26	12.4	9.9	.1	8.2	7.0	10.0	8.1	13.6
847	27	13.8	13.6	7.4	6.2	11.5	9.0	6.9	3.0
847	28	2.2	1.4	0.0	2.7	10.9	5.4	7.7	4.9
847	29	3.6	2.3	.1	3.0	11.4	8.0	5.0	12.2
847	30	5.5	2.5	1.2	5.4	11.8	11.1	7.1	9.6
MEAN		7.23	6.21	3.60	7.48	8.11	9.08	7.48	9.45
SD		3.88	4.20	2.82	3.26	3.34	2.74	3.85	3.52

SAMPLE	PANEL	ACCEPT	PURCHASE PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
428	1	.8	.4	2.4	.5	14.6	.1	13.8	.4
428	2	7.4	11.5	2.4	8.1	10.8	9.4	10.4	12.4
428	3	9.0	4.2	0.0	9.0	10.9	10.3	11.3	8.7
428	4	.2	.6	0.0	6.7	4.2	5.5	5.2	7.6
428	5	11.6	10.9	4.8	11.0	13.5	11.8	12.7	10.2
428	6	9.2	7.9	4.6	11.2	3.4	10.1	11.8	13.2
428	7	3.6	3.4	2.5	6.4	9.8	6.2	8.7	8.2
428	8	6.3	2.8	2.2	1.3	9.4	5.2	5.9	3.7
428	9	5.1	2.6	2.8	11.7	.9	13.1	4.1	5.3
428	10	1.9	2.3	2.4	4.6	9.2	1.1	12.8	7.3
428	11	8.4	7.4	4.7	7.3	4.7	10.5	11.2	8.0
428	12	7.6	7.2	7.5	9.4	2.7	10.7	12.2	11.4
428	13	11.0	9.4	6.1	10.4	1.5	11.0	10.1	7.2
428	14	11.2	11.0	6.2	10.4	10.2	9.7	12.5	13.3
428	15	8.2	7.0	6.6	10.0	10.7	10.1	12.2	13.3
428	16	9.8	10.3	6.3	8.9	4.5	10.9	8.1	11.5
428	17	6.8	6.8	3.4	6.2	9.1	5.8	7.9	9.8
428	18	13.7	15.0	8.8	10.1	.6	8.1	11.1	15.0
428	19	8.6	10.1	4.9	3.8	7.2	11.9	12.5	14.5
428	20	7.4	7.6	2.3	11.0	2.9	12.0	11.3	12.6
428	21	4.7	1.5	1.8	2.9	10.2	10.7	11.9	12.2
428	22	6.9	4.3	2.4	12.3	5.4	7.6	9.0	12.5
428	23	12.2	11.0	9.8	3.0	5.4	14.7	6.2	10.5
428	24	8.3	9.1	7.6	3.2	13.6	2.4	2.6	1.9
428	25	3.8	2.0	0.0	2.0	8.1	5.0	8.6	6.5
428	26	2.2	2.4	0.0	1.5	10.4	7.1	9.8	7.8
428	27	2.7	2.4	2.5	3.5	6.2	11.9	1.8	7.8
428	28	10.0	8.1	1.2	4.4	9.3	7.0	10.9	11.3
428	29	2.6	1.4	.1	7.2	6.4	6.7	4.0	8.2
428	30	3.2	1.8	1.2	3.8	11.8	10.2	2.0	3.5
MEAN		6.81	6.08	3.58	6.73	7.59	8.56	9.09	9.21
SD		3.61	4.01	2.77	3.61	3.91	3.53	3.54	3.70

SAMPLE	PANEL	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
IDEAL	1	14.2	.3	14.7	.1	14.0	11.0
IDEAL	2	12.9	1.0	12.6	7.9	14.0	13.9
IDEAL	3	13.9	1.0	13.7	7.1	13.8	9.5
IDEAL	4	10.8	1.1	13.4	9.2	13.6	12.8
IDEAL	5	12.5	11.0	12.6	13.1	9.8	6.5
IDEAL	6	12.5	.8	13.3	12.7	15.0	15.0
IDEAL	7	10.9	1.7	12.8	12.5	12.7	11.3
IDEAL	8	12.0	.3	15.0	12.2	15.0	9.1
IDEAL	9	13.1	.6	13.7	12.1	13.7	11.8
IDEAL	10	11.2	.3	13.2	13.5	13.2	12.5
IDEAL	11	10.4	2.1	11.3	11.2	12.5	12.2
IDEAL	12	10.9	1.6	11.7	13.2	12.2	11.3
IDEAL	13	12.8	.7	13.0	12.4	13.5	10.9
IDEAL	14	12.1	2.0	12.9	12.5	13.3	12.7
IDEAL	15	11.7	1.3	12.8	12.6	13.9	12.5
IDEAL	16	12.7	4.0	13.4	6.2	12.9	12.8
IDEAL	17	11.6	2.0	11.3	11.2	11.9	11.5
IDEAL	18	10.3	.1	11.5	13.2	15.0	4.7
IDEAL	19	13.3	2.6	12.3	12.0	14.5	12.0
IDEAL	20	15.0	.1	15.0	15.0	15.0	7.4
IDEAL	21	9.9	.5	9.2	10.7	11.3	10.9
IDEAL	22	11.3	4.3	9.3	9.7	10.0	7.2
IDEAL	23	14.4	.1	13.4	15.0	14.0	11.3
IDEAL	24	10.1	.6	13.6	13.7	12.2	11.4
IDEAL	25	11.9	3.8	12.6	13.4	13.7	8.3
IDEAL	26	12.9	.2	14.8	3.4	15.0	13.7
IDEAL	27	14.2	1.7	10.8	.1	14.7	14.7
IDEAL	28	9.8	.5	13.8	3.8	12.8	12.9
IDEAL	29	13.8	.1	15.0	3.4	15.0	14.9
IDEAL	30	10.7	2.2	14.5	9.5	13.5	11.5
MEAN		12.13	1.62	12.91	10.09	13.39	11.27
SD		1.46	2.13	1.51	4.22	1.39	2.49

Office workers

SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
742	1	1.7	1.6	0.0	.8	7.6	7.6	5.6	3.7	14.1	557	1	12.8	12.8	7.4	14.2	1.0	13.3	12.7	13.8	5.8
742	2	8.9	10.0	4.8	9.0	10.8	7.4	8.4	8.1	10.7	557	2	12.2	11.7	8.8	10.4	4.8	10.3	10.0	10.8	10.7
742	3	0.0	0.0	0.0	3.9	13.8	7.1	3.8	2.6	10.5	557	3	12.5	0.0	0.0	13.3	3.2	15.0	15.0	15.0	12.1
742	4	11.2	7.6	4.8	2.1	11.4	11.2	14.2	14.2	2.3	557	4	2.9	7.6	4.8	13.6	.9	2.8	14.2	14.2	.7
742	5	3.1	.7	0.0	6.0	11.0	10.5	7.2	13.3	12.1	557	5	10.5	9.6	4.9	13.1	1.3	9.7	9.0	13.3	11.6
742	6	2.7	2.0	.1	14.2	4.5	8.8	5.2	6.0	14.2	557	6	11.7	13.5	8.8	13.6	.3	13.0	3.7	14.0	13.5
742	7	.2	0.0	0.0	1.2	1.9	13.5	.7	2.7	15.0	557	7	3.3	0.0	0.0	14.0	13.3	3.3	14.7	4.6	6.9
742	8	.6	1.8	0.0	.9	7.2	6.4	6.3	6.1	9.2	557	8	8.8	11.8	12.5	11.0	3.9	11.2	11.1	11.0	10.5
742	9	1.0	.6	0.0	2.1	13.9	7.1	1.3	.9	10.0	557	9	12.6	10.7	4.8	12.8	2.1	10.2	13.1	13.4	3.1
742	10	8.5	5.3	0.0	5.6	5.8	12.9	9.9	6.1	13.0	557	10	10.2	7.4	0.0	12.8	6.1	5.3	11.1	11.8	10.3
742	11	5.3	3.2	6.1	3.3	4.3	4.1	6.2	7.3	5.0	557	11	10.2	4.7	7.3	13.1	6.3	10.8	10.9	10.9	7.3
742	12	.2	0.0	0.0	.2	14.7	2.1	.9	.7	6.5	557	12	9.9	7.9	7.4	10.9	2.5	8.9	10.9	9.9	7.9
742	13	3.1	3.1	5.0	3.4	10.5	6.1	5.8	6.4	7.3	557	13	9.7	8.8	7.6	8.3	7.0	3.2	9.7	8.0	4.7
742	14	7.0	2.5	4.8	4.8	9.1	8.2	5.0	8.2	7.0	557	14	9.3	3.3	4.8	10.4	3.4	9.3	6.2	8.1	11.0
742	15	7.8	7.8	8.8	1.9	7.0	.7	14.1	14.2	9.9	557	15	5.8	6.0	7.4	13.3	.3	4.3	10.0	12.5	11.0
742	16	10.9	13.0	10.0	3.7	11.4	12.4	6.9	7.2	.4	557	16	6.7	.1	.2	12.9	1.8	7.2	2.9	1.7	1.6
742	17	1.2	2.6	.3	1.0	12.3	12.2	4.6	1.7	5.9	557	17	13.2	10.8	12.5	13.5	1.8	6.5	13.7	10.2	2.7
742	18	12.5	10.2	7.5	7.5	9.3	5.3	7.9	13.0	5.8	557	18	6.9	6.1	5.0	12.6	2.2	7.4	9.5	5.6	9.9
742	19	.7	.5	.2	.8	12.4	3.3	10.5	.9	12.8	557	19	12.3	10.8	8.8	14.5	2.0	14.0	4.7	14.0	14.1
742	20	5.1	4.1	2.3	7.4	6.8	8.7	6.4	7.2	11.2	557	20	7.7	6.6	4.9	4.9	9.4	4.1	8.7	9.9	.7
742	21	8.1	8.3	4.7	6.1	7.6	11.5	1.6	7.6	2.9	557	21	12.3	12.2	4.7	12.3	2.2	13.8	7.7	14.3	6.9
742	22	3.5	0.0	0.0	6.4	3.4	3.4	3.3	3.6	13.5	557	22	10.0	0.0	0.0	12.2	10.4	9.6	12.8	11.7	10.0
742	23	3.9	0.0	0.0	9.7	8.4	4.7	12.2	8.6	10.2	557	23	1.7	0.0	0.0	12.4	7.4	8.5	11.1	12.0	8.4
742	24	14.1	14.4	5.5	.1	15.0	7.1	9.6	9.6	10.0	557	24	11.8	12.1	6.9	8.9	.3	9.0	12.0	12.5	12.4
742	25	12.6	.3	0.0	2.3	14.5	6.6	.6	12.1	14.6	557	25	6.5	.3	0.0	14.6	.3	7.3	5.4	14.5	14.6
742	26	8.6	10.8	4.8	10.5	6.2	12.0	11.1	9.0	13.4	557	26	11.0	13.7	8.8	14.4	.1	14.6	11.1	15.0	13.4
742	27	.5	.6	0.0	.1	.1	.3	.6	.8	3.3	557	27	2.9	.6	0.0	13.2	13.2	9.7	8.7	8.8	2.1
742	28	0.0	0.0	2.3	10.7	12.5	4.8	6.2	1.4	12.2	557	28	14.9	13.3	2.3	12.6	10.1	11.8	10.4	7.0	14.7
742	29	2.2	5.3	.2	1.8	10.2	3.8	1.4	3.9	13.3	557	29	9.8	13.8	4.9	13.5	1.4	11.7	13.3	13.6	7.0
742	30	8.4	3.5	0.0	3.2	4.4	8.1	8.9	7.9	7.0	557	30	13.3	14.1	4.9	14.7	1.9	2.3	14.4	14.6	4.0
MEAN		5.12	3.99	2.41	4.36	8.93	7.26	6.21	6.50	9.44	MEAN		9.45	7.68	5.01	12.40	4.03	8.94	10.29	11.22	8.32
SD		4.40	4.30	3.09	3.71	3.99	3.64	3.96	4.15	4.06	SD		3.48	5.07	3.75	2.13	3.91	3.72	3.24	3.35	4.34

SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
243	1	12.2	12.2	7.4	2.4	14.9	1.6	1.2	2.7	1.7	181	1	8.5	8.4	4.8	8.7	6.8	7.0	7.3	11.1	3.6
243	2	8.9	10.0	4.8	9.3	10.8	7.4	7.8	8.1	5.4	181	2	12.7	12.7	8.8	12.6	3.5	11.3	10.7	11.5	10.7
243	3	3.5	0.0	0.0	6.3	11.9	10.3	9.0	5.6	7.9	181	3	14.0	0.0	0.0	11.1	8.6	12.0	10.8	9.0	7.9
243	4	8.2	7.6	4.8	3.4	11.4	11.2	14.2	14.2	13.7	181	4	11.2	7.6	4.8	10.2	4.2	11.2	14.2	14.2	13.7
243	5	3.1	.7	0.0	6.0	13.4	10.5	7.2	13.3	12.1	181	5	7.3	6.2	2.3	6.0	11.0	10.5	7.2	13.3	12.1
243	6	10.1	8.6	4.9	6.5	12.6	13.0	6.0	3.3	13.7	181	6	11.4	12.2	7.4	8.4	3.0	7.0	6.0	13.2	14.5
243	7	11.6	10.1	5.9	6.9	6.7	9.6	7.1	12.2	9.6	181	7	6.1	10.1	5.9	9.4	9.0	5.9	12.8	14.2	11.5
243	8	4.5	7.6	2.5	7.5	8.7	7.7	8.2	12.8	7.8	181	8	13.3	14.2	12.5	12.6	.9	12.5	12.7	12.4	13.0
243	9	5.4	.6	0.0	7.5	11.1	7.8	4.1	1.8	2.2	181	9	12.0	9.9	2.4	8.0	3.0	9.5	11.1	12.1	3.8
243	10	5.6	3.5	0.0	4.9	11.7	12.4	10.3	5.3	14.0	181	10	10.8	9.5	4.9	12.1	2.3	11.4	10.7	12.4	13.8
243	11	3.3	1.5	2.3	1.7	12.7	3.5	4.9	12.2	9.8	181	11	12.3	9.7	12.4	11.7	7.1	12.3	12.5	13.0	10.9
243	12	10.7	8.4	7.4	7.1	2.9	8.3	8.7	8.7	12.1	181	12	11.7	9.5	9.9	12.2	2.1	9.7	10.2	9.9	12.1
243	13	4.9	4.2	5.0	4.7	9.5	1.9	3.8	5.4	3.9	181	13	10.6	9.8	10.1	9.3	6.0	8.0	8.1	9.3	8.7
243	14	1.8	.9	3.7	1.8	11.5	2.6	2.3	8.6	6.5	181	14	7.0	1.6	4.8	4.2	7.1	8.7	3.5	8.8	12.8
243	15	2.1	2.3	4.8	7.2	3.8	8.1	7.1	8.9	13.9	181	15	4.2	4.8	4.8	14.8	.3	5.4	7.1	8.9	8.5
243	16	.7	1.9	.2	.9	14.3	8.4	5.0	3.7	3.4	181	16	13.9	14.7	2.4	14.6	.8	13.8	14.3	14.1	13.4
243	17	7.5	6.7	9.9	9.4	13.5	5.1	12.3	9.0	10.2	181	17	3.3	4.7	2.3	4.0	4.1	9.8	8.7	3.7	7.3
243	18	.4	.6	.5	.4	11.7	9.1	11.1	4.1	3.5	181	18	8.2	14.1	10.0	14.2	7.5	13.8	15.0	9.4	14.1
243	19	3.2	1.4	1.3	1.7	13.9	6.3	14.0	4.1	6.6	181	19	13.4	12.2	4.1	11.3	.5	12.5	13.0	10.9	11.1
243	20	2.9	1.3	.1	.8	13.8	1.4	13.7	12.1	8.9	181	20	13.1	10.9	7.3	13.9	1.2	13.5	1.2	1.4	13.5
243	21	8.1	8.3	4.7	11.0	3.4	12.4	4.1	7.6	2.9	181	21	13.4	13.3	4.7	11.0	3.4	12.4	10.5	12.1	6.9
243	22	2.4	0.0	0.0	7.7	8.0	6.6	11.2	7.3	12.3	181	22	11.8	5.4	2.3	11.8	1.9	10.3	13.5	12.4	13.5
243	23	.6	0.0	0.0	1.8	9.4	2.0	14.0	10.7	11.3	181	23	3.1	0.0	0.0	11.5	12.6	6.1	8.9	13.0	5.5
243	24	.8	.8	2.3	2.4	11.9	6.0	7.1	10.5	11.2	181	24	13.0	13.3	7.4	11.7	13.4	4.9	12.8	14.0	13.5
243	25	2.1	.3	0.0	.2	14.5	3.6	2.6	12.1	14.6	181	25	14.2	14.1	9.8	13.5	.3	7.3	14.4	7.0	14.6
243	26	8.2	9.9	2.2	9.0	9.9	14.0	4.4	14.1	14.9	181	26	10.6	12.7	8.8	13.6	1.8	14.6	13.0	15.0	14.5
243	27	7.4	14.4	7.5	.2	1.4	2.6	1.9	2.5	13.9	181	27	10.0	14.4	7.5	10.2	14.2	13.6	13.7	12.5	10.8
243	28	5.5	0.0	2.3	10.7	14.8	8.5	11.5	9.3	12.2	181	28	11.8	9.8	2.3	13.7	8.1	13.6	9.5	13.8	14.0
243	29	.6	12.0	.2	1.8	14.7	3.8	13.3	2.2	11.5	181	29	8.5	7.7	2.3	10.3	7.8	9.9	4.0	13.6	13.3
243	30	12.6	11.3	3.6	4.7	8.2	4.2	6.7	4.5	12.7	181	30	11.8	8.7	2.3	12.7	.7	10.8	12.8	13.4	14.2
MEAN		5.30	4.90	2.94	4.86	10.57	7.00	7.83	7.90	9.48	MEAN		10.44	9.41	5.84	10.98	5.11	10.31	10.34	11.32	11.26
SD		3.78	4.65	2.84	3.37	3.77	3.72	3.99	3.93	4.16	SD		3.19	4.18	3.59	2.80	4.14	2.81	3.54	3.12	3.26

Office workers

SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	
847	1	2.8	2.8	0.0	3.7	6.2	8.5	6.5	5.3	13.6	IDEAL	1	13.2	2.1	12.6	13.9	12.7	9.3	
847	2	10.9	11.1	7.4	11.4	6.3	10.3	9.3	9.8	10.7	IDEAL	2	12.6	4.5	12.0	11.3	11.5	11.1	
847	3	5.4	0.0	0.0	9.4	10.1	14.1	13.6	12.5	7.9	IDEAL	3	13.3	1.0	15.0	15.0	14.5	7.9	
847	4	11.2	7.6	4.8	7.6	4.2	11.2	14.2	14.2	13.7	IDEAL	4	14.1	.2	14.4	14.6	14.6	14.4	
847	5	7.3	6.2	2.3	9.5	6.4	10.5	9.0	13.3	12.1	IDEAL	5	14.4	.7	13.4	12.4	14.3	13.8	
847	6	8.7	5.2	2.5	8.4	5.7	6.2	5.1	10.7	14.0	IDEAL	6	13.8	.1	13.4	10.4	14.4	14.5	
847	7	13.1	10.1	5.9	6.9	6.7	11.3	2.6	10.6	12.8	IDEAL	7	6.9	6.7	11.3	2.6	10.6	12.8	
847	8	6.7	9.9	10.0	2.9	5.7	5.2	4.2	8.2	6.3	IDEAL	8	8.9	1.6	13.3	13.4	13.4	12.3	
847	9	7.7	2.4	0.0	8.9	3.8	10.9	5.5	7.2	6.8	IDEAL	9	12.8	2.1	10.2	13.1	13.4	3.1	
847	10	9.9	8.1	2.3	6.1	5.5	10.8	9.5	10.5	13.3	IDEAL	10	12.3	1.1	12.6	11.5	12.7	12.6	
847	11	4.5	2.3	4.9	10.3	11.5	8.2	7.5	4.6	3.7	IDEAL	11	11.3	3.3	10.1	12.0	14.1	8.9	
847	12	8.0	5.9	7.4	3.0	12.1	4.4	5.3	5.1	9.8	IDEAL	12	12.8	.9	12.3	12.1	12.4	8.9	
847	13	5.7	5.1	5.0	2.2	11.9	9.3	6.9	4.4	9.9	IDEAL	13	13.4	2.9	13.0	12.5	12.8	13.2	
847	14	7.0	2.1	4.8	5.0	8.3	7.5	7.3	8.5	12.8	IDEAL	14	11.9	.1	11.9	9.2	10.5	10.1	
847	15	11.9	11.6	9.9	9.2	3.8	7.0	10.0	11.4	12.2	IDEAL	15	11.0	2.4	13.3	14.7	14.7	14.6	
847	16	12.1	13.8	10.0	4.8	10.4	11.1	11.1	11.3	14.4	IDEAL	16	14.6	.8	11.1	14.3	14.1	14.4	
847	17	4.3	5.7	4.8	7.2	9.0	11.1	10.7	5.4	8.7	IDEAL	17	13.5	4.1	11.1	13.7	9.0	2.7	
847	18	2.8	3.5	2.5	2.7	5.5	10.6	12.5	11.1	12.0	IDEAL	18	14.2	7.5	13.8	15.0	13.0	14.1	
847	19	8.5	7.5	4.9	7.2	10.3	10.6	1.8	2.5	9.1	IDEAL	19	14.5	.5	14.0	14.0	14.0	11.1	
847	20	11.2	8.7	7.3	9.3	11.3	11.1	11.7	14.2	7.1	IDEAL	20	13.9	1.2	13.5	11.7	14.2	13.5	
847	21	6.8	7.1	4.7	6.1	9.6	10.3	10.5	3.1	8.8	IDEAL	21	12.3	2.2	14.6	7.7	14.3	8.8	
847	22	3.5	0.0	0.0	3.8	9.5	7.5	10.0	9.9	4.3	IDEAL	22	10.1	8.4	8.1	11.8	12.8	13.8	
847	23	4.9	0.0	0.0	10.5	11.3	3.5	12.9	9.5	12.3	IDEAL	23	12.4	7.4	6.1	9.7	7.7	13.6	
847	24	15.0	15.0	6.2	10.8	2.3	8.1	10.8	11.5	15.0	IDEAL	24	14.1	.8	13.7	13.1	13.4	13.0	
847	25	14.2	14.1	9.8	13.5	.3	14.4	7.3	14.5	14.6	IDEAL	25	14.6	.3	14.4	14.4	14.5	14.6	
847	26	8.6	10.8	4.8	11.0	8.6	12.0	5.8	11.2	14.0	IDEAL	26	8.1	1.0	15.0	12.1	15.0	12.5	
847	27	11.0	14.4	7.5	2.1	10.5	12.2	12.3	11.2	12.1	IDEAL	27	14.4	.1	14.8	14.4	13.6	14.4	
847	28	8.9	3.5	2.3	5.4	6.0	10.3	8.5	3.0	13.0	IDEAL	28	13.7	8.1	13.6	9.5	13.8	14.0	
847	29	2.2	5.3	.2	3.3	10.2	7.5	11.9	11.2	15.0	IDEAL	29	14.6	.1	15.0	8.3	15.0	9.0	
847	30	9.5	6.4	.7	11.1	3.2	12.7	11.1	11.4	5.6	IDEAL	30	14.7	.1	14.3	14.4	14.6	11.3	
MEAN		8.14	6.87	4.43	7.11	7.54	9.61	8.85	9.24	10.85			MEAN	12.75	2.41	12.73	12.09	13.19	11.61
SD		3.48	4.39	3.29	3.25	3.19	2.66	3.25	3.54	3.31			SD	2.01	2.65	2.08	2.71	1.76	3.16
SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK									
428	1	.80	.70	0.00	.30	14.20	2.20	1.90	1.80	2.50									
428	2	8.90	10.00	4.80	9.60	10.80	7.40	7.80	8.10	10.70									
428	3	2.00	0.00	0.00	6.30	13.80	8.80	8.00	7.50	13.80									
428	4	11.20	7.60	4.80	7.60	10.20	11.20	14.20	14.20	13.70									
428	5	3.10	.70	0.00	9.50	6.40	10.50	9.00	13.30	12.10									
428	6	8.70	5.20	2.50	10.00	3.00	9.00	4.20	6.90	14.00									
428	7	8.50	0.00	0.00	5.30	1.90	7.90	12.80	13.30	8.70									
428	8	2.80	3.40	0.00	9.90	2.50	10.00	9.90	10.00	11.90									
428	9	1.50	.60	0.00	6.50	4.70	11.70	4.60	3.00	5.50									
428	10	8.90	6.60	0.00	7.70	5.20	12.10	10.10	11.30	13.10									
428	11	11.30	8.10	9.90	9.40	5.40	4.90	9.20	6.10	8.00									
428	12	6.00	4.70	2.30	7.80	6.40	5.50	6.20	4.00	7.90									
428	13	11.60	10.90	12.50	10.90	5.30	4.60	2.60	10.50	5.70									
428	14	7.00	2.70	4.80	4.40	7.80	10.50	4.50	8.50	11.70									
428	15	11.90	11.60	9.90	4.50	7.00	2.50	14.10	14.20	13.90									
428	16	1.80	2.40	.20	2.00	12.50	9.70	1.30	.30	11.90									
428	17	7.50	8.10	7.30	7.20	7.20	8.30	7.10	7.50	12.00									
428	18	10.20	8.70	7.50	5.60	3.90	11.80	13.90	7.40	7.80									
428	19	4.20	2.50	2.50	3.20	8.30	8.20	3.20	2.40	13.40									
428	20	13.10	12.70	8.80	12.00	4.00	6.80	3.50	4.90	3.20									
428	21	6.80	7.10	4.70	6.10	10.50	11.50	1.60	12.10	11.80									
428	22	6.10	0.00	0.00	9.30	8.80	8.80	12.40	11.00	11.30									
428	23	11.10	13.00	8.80	8.40	13.70	10.10	9.70	7.70	13.60									
428	24	10.10	10.50	4.80	10.10	14.30	11.10	8.50	8.60	14.30									
428	25	9.10	.30	0.00	1.40	.30	14.40	13.20	14.50	14.60									
428	26	10.20	12.70	8.80	12.90	1.80	12.50	7.20	14.70	14.50									
428	27	9.00	14.40	7.50	1.10	12.00	11.20	10.40	9.80	13.00									
428	28	2.20	0.00	2.30	3.40	3.90	6.60	7.20	.10	14.40									
428	29	2.20	5.30	.20	4.80	12.60	7.50	10.20	3.90	15.00									
428	30	10.40	4.70	1.60	1.90	5.60	14.30	5.00	2.70	11.30									
MEAN		7.27	5.84	3.88	6.64	7.47	9.05	7.78	8.01	11.18									
SD		3.74	4.66	3.89	3.42	4.14	3.09	3.94	4.41	3.46									

School students

SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
742	1	4.2	1.6	.1	3.9	11.2	6.7	6.9	8.8	13.8	557	1	12.1	13.8	12.5	13.7	1.3	9.1	13.5	14.3	12.7
742	2	1.4	.8	1.2	3.0	14.1	7.2	10.8	11.4	14.4	557	2	14.1	12.0	10.1	12.1	3.2	11.4	4.5	10.5	2.4
742	3	3.9	3.0	1.2	1.5	11.9	3.2	2.9	3.1	1.9	557	3	12.5	13.2	7.3	13.1	1.3	13.4	13.4	13.7	11.5
742	4	2.6	1.4	1.9	.4	14.4	10.5	11.0	2.0	9.9	557	4	13.2	12.9	7.3	15.0	.2	15.0	3.7	14.9	.2
742	5	2.8	3.0	.9	3.6	9.7	5.5	2.6	11.5	13.1	557	5	10.2	10.3	1.8	11.9	1.6	13.1	3.1	11.8	5.2
742	6	2.2	1.4	1.7	.5	13.2	.1	.4	3.5	7.4	557	6	4.5	4.9	4.8	13.6	.6	8.6	1.8	7.6	1.6
742	7	5.3	3.8	6.0	3.6	9.7	13.4	5.5	8.8	12.4	557	7	13.1	13.1	7.4	14.0	2.0	11.8	8.2	12.1	9.6
742	8	8.1	5.3	.1	6.5	10.7	11.8	3.8	2.8	12.9	557	8	8.7	12.2	.1	14.4	.5	8.9	5.7	13.1	12.1
742	9	4.0	1.1	.3	.1	12.3	7.3	.4	11.3	12.3	557	9	6.6	2.5	2.4	13.8	13.9	1.9	13.8	9.1	.3
742	10	1.7	0.0	1.2	5.6	12.1	10.0	8.8	4.9	7.8	557	10	4.3	1.9	2.3	13.1	1.1	2.5	13.6	6.3	1.2
742	11	2.2	.1	0.0	1.0	1.7	1.6	4.2	.4	9.9	557	11	11.7	10.5	2.9	12.2	12.3	11.5	2.6	12.7	11.8
742	12	7.1	2.3	0.0	2.6	3.1	12.9	7.3	14.4	11.4	557	12	1.9	0.0	0.0	14.4	1.9	6.0	9.9	14.4	4.2
742	13	7.3	7.1	2.4	3.0	1.7	8.1	4.6	10.1	8.8	557	13	4.6	3.5	0.0	9.4	9.4	1.8	4.6	10.1	7.0
742	14	10.1	10.2	10.4	2.7	7.4	4.7	4.2	4.5	13.2	557	14	5.2	7.8	8.0	11.3	1.5	3.6	9.3	7.9	3.3
742	15	7.1	3.3	6.2	4.6	7.6	6.2	5.6	7.5	13.0	557	15	11.6	9.3	12.4	9.8	2.9	10.9	10.1	12.5	9.0
742	16	.9	0.0	0.0	.1	13.2	14.1	8.3	3.5	3.1	557	16	14.0	15.0	9.9	9.7	.9	4.1	3.1	11.8	.9
742	17	9.9	5.6	12.5	1.2	13.2	13.1	1.8	7.2	15.0	557	17	1.5	0.0	.1	12.8	10.5	8.3	7.7	10.6	8.4
742	18	11.8	9.3	6.2	.8	.8	1.6	1.9	14.0	7.3	557	18	12.3	12.2	7.5	1.9	2.0	3.5	.6	12.6	5.5
742	19	3.7	3.6	4.8	3.8	11.7	5.8	3.5	10.6	10.2	557	19	7.9	10.5	8.8	9.3	14.2	4.9	5.1	7.0	9.3
742	20	8.5	8.7	3.9	4.6	10.0	8.6	3.1	13.9	11.0	557	20	6.1	6.1	1.4	14.8	.6	5.0	8.8	12.5	5.7
742	21	5.7	5.9	3.8	9.7	8.4	9.6	7.1	11.3	9.1	557	21	3.0	1.9	.6	12.1	.4	5.4	4.3	6.1	2.8
742	22	9.5	6.3	3.6	5.4	5.5	10.6	1.6	12.4	11.4	557	22	5.9	2.4	2.4	12.7	11.9	9.2	1.6	10.2	14.1
742	23	13.9	13.7	4.8	.5	12.2	3.1	12.5	9.0	4.0	557	23	13.1	12.8	3.5	2.0	6.4	14.0	8.8	13.8	1.3
742	24	2.4	2.3	0.0	.9	10.7	11.3	1.5	9.5	11.5	557	24	1.7	1.5	0.0	9.8	1.9	6.3	8.5	12.0	6.4
742	25	.7	0.0	0.0	.1	10.4	2.3	3.3	1.0	4.1	557	25	12.5	13.1	7.4	13.6	1.6	15.0	13.7	14.4	9.6
742	26	3.8	2.4	.4	.7	13.0	5.7	10.2	7.2	14.3	557	26	13.1	13.0	7.4	13.9	.8	14.2	13.1	13.2	1.2
742	27	1.4	1.0	1.7	5.7	7.9	6.1	7.2	8.4	3.1	557	27	8.8	8.3	4.9	10.7	1.2	9.5	9.9	12.2	9.2
742	28	.5	2.3	1.1	6.6	8.8	4.6	4.7	7.5	11.9	557	28	9.1	8.2	6.1	11.0	2.7	9.0	7.8	11.8	7.3
742	29	1.8	.3	0.0	.1	14.6	6.9	6.6	7.8	.1	557	29	11.6	15.0	9.9	.1	15.0	1.4	14.5	2.8	2.7
742	30	2.1	2.3	.2	2.0	13.7	5.3	6.0	7.7	11.8	557	30	9.5	10.7	4.7	12.8	2.2	2.4	9.0	11.5	2.2
MEAN		4.89	3.60	2.55	2.83	9.83	7.26	5.28	7.87	9.67	MEAN		8.81	8.62	5.13	11.30	4.35	8.06	7.81	11.12	5.96
SD		3.63	3.43	3.17	2.45	3.92	3.83	3.25	3.94	4.10	SD		4.08	4.87	3.88	3.77	4.81	4.35	4.24	2.91	4.22
SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
243	1	7.0	3.9	3.8	11.3	13.4	5.9	9.5	3.0	5.8	181	1	11.5	12.9	11.2	13.1	2.2	11.0	13.2	14.1	13.6
243	2	.5	.1	.1	4.2	12.6	3.2	8.0	9.3	7.9	181	2	14.9	14.3	11.5	14.1	.7	13.6	12.4	12.2	4.7
243	3	2.4	.7	0.0	5.1	13.3	1.7	1.4	1.6	5.0	181	3	11.6	12.3	6.1	12.2	3.1	11.7	11.6	10.7	13.0
243	4	0.0	0.0	.1	13.1	14.9	9.2	12.1	.5	12.6	181	4	12.7	11.8	5.5	11.2	13.0	11.9	14.8	12.2	14.6
243	5	10.6	12.8	2.2	11.2	10.9	5.0	1.6	8.0	11.7	181	5	2.1	1.6	.5	9.8	.7	13.9	2.4	12.2	5.7
243	6	2.5	2.3	3.4	2.8	15.0	6.5	3.0	11.9	.1	181	6	6.2	7.4	6.2	12.7	1.3	1.1	4.1	1.0	3.0
243	7	10.6	5.9	6.0	11.9	3.8	5.9	9.9	11.1	11.7	181	7	12.8	12.5	7.4	11.1	1.7	11.4	9.0	12.9	13.1
243	8	0.0	.1	.1	7.8	9.3	10.4	1.3	8.7	2.9	181	8	7.6	4.4	.1	9.1	4.4	9.6	6.9	12.9	13.6
243	9	1.5	0.0	0.0	.9	14.9	.5	2.4	10.1	1.4	181	9	12.7	12.9	12.5	11.0	1.0	13.2	11.3	13.5	13.6
243	10	12.3	12.5	8.8	11.6	2.4	10.9	10.5	13.9	5.4	181	10	9.5	7.9	4.8	12.3	2.1	12.0	10.1	13.3	4.4
243	11	3.4	1.2	0.0	12.9	13.6	13.0	3.4	14.5	2.2	181	11	10.5	9.2	2.3	11.2	11.3	10.5	4.6	9.2	11.0
243	12	3.2	.6	0.0	12.2	12.5	11.3	9.1	14.4	3.1	181	12	13.3	10.0	4.9	7.2	7.3	13.9	6.4	14.4	13.6
243	13	6.7	7.1	2.4	8.0	3.9	6.5	9.8	4.7	10.1	181	13	11.0	10.2	3.7	4.4	5.9	4.4	9.8	4.7	12.2
243	14	3.2	0.0	0.0	8.9	15.0	.1	15.0	11.6	11.9	181	14	4.8	7.2	6.6	10.2	11.5	2.7	7.2	3.5	10.1
243	15	5.1	2.6	9.9	5.7	6.5	6.8	6.5	9.2	7.9	181	15	12.4	7.8	11.3	12.0	1.9	12.1	11.2	13.4	7.0
243	16	12.6	14.6	8.3	12.8	7.6	5.8	13.8	14.4	11.2	181	16	8.2	3.4	6.7	6.4	.4	7.6	.9	13.2	5.5
243	17	4.0	2.8	.1	11.6	6.1	1.8	13.5	4.7	15.0	181	17	6.5	6.6	8.8	10.0	3.0	6.7	6.8	8.2	7.2
243	18	2.9	.8	.1	6.4	13.7	5.9	3.4	1.6	13.8	181	18	14.2	14.0	10.1	14.5	10.1	13.1	11.1	9.7	12.7
243	19	1.4	1.2	.1	10.8	4.1	7.1	8.8	11.9	11.9	181	19	13.0	13.2	12.5	13.3	5.6	11.1	9.9	9.6	8.3
243	20	2.7	3.7	1.1	6.6	6.8	5.0	7.8	11.1	5.7	181	20	6.8	6.7	1.4	12.1	3.0	8.6	8.8	13.9	14.3
243	21	4.0	3.2	1.6	11.5	14.8	8.0	8.6	10.8	3.5	181	21	7.3	7.3	6.0	10.6	5.4	6.2	.9	12.2	6.6
243	22	12.3	10.5	7.4	11.5	12.8	5.3	3.7	13.3	13.4	181	22	13.2	12.0	8.8	8.8	1.6	6.5	5.2	13.3	15.0
243	23	4.2	3.9	0.0	2.9	10.6	12.0	10.6	9.8	11.9	181	23	4.2	2.4	0.0	1.2	5.3	14.6	13.8	.9	12.8
243	24	5.3	6.8	3.9	4.0	10.5	10.8	12.9	5.0	9.3	181	24	10.7	10.6	8.0	7.5	7.0	9.6	3.2	10.8	11.0
243	25	5.2	2.4	0.0	3.1	13.1	4.3	7.5	5.0	2.4	181	25	9.6	9.7	4.8	12.5	2.6	2.9	12.1	10.9	10.8
243	26	11.1	11.7	6.0	12.1	4.7	3.7	14.3	11.1	.2	181	26	7.4	7.4	1.6	2.8	8.2	12.5	4.3	5.7	12.6
243	27	7.6	7.1	2.4	7.0	4.9	8.6	7.2	11.6	5.8	181	27	12.0	11.9	8.8	10.7	.8	10.0	9.2	12.2	11.2
243	28	0.0	0.0	0.0	8.4	14.5	2.5	2.5	.1	10.8	181	28	12.5	10.6	8.8	13.5	.3	14.2	13.0	14.0	13.3
243	29	3.2	1.1	0.0	13.9	.4	13.2	10.1	13.4	1.5	181	29	6.9	13.9	7.4	12.4	.1	14.3	4.1	12.0	5.6
243	30	11.1	11.7	5.4	9.5	12.5	3.3	11.6	7.7	3.6	181	30	13.7	12.7	7.4	11.0	4.0	7.7	6.0	4.7	6.7
MEAN		5.22	4.38	2.44	8.66	9.97	6.47	7.99	8.80	7.32	MEAN		9.99	9.49	6.52	10.30	4.18	9.95	8.14	10.38	10.23
SD		4.03	4.59	3.12	3.73	4.50	3.65	4.21	4.42	4.59	SD		3.34	3.54	3.65	3.23	3.67	3.77	3.96	3.94	3.64

School students

SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
847	1	8.5	6.4	7.2	5.7	8.8	10.1	7.9	13.1	8.4	IDEAL	1	14.0	1.1	13.8	13.8	14.4	8.7
847	2	11.0	8.5	6.1	8.3	4.6	5.5	9.6	7.9	10.8	IDEAL	2	13.5	1.2	14.1	10.8	13.6	7.2
847	3	9.1	9.5	4.8	8.4	4.9	7.1	8.0	7.1	6.1	IDEAL	3	12.2	1.3	13.4	11.6	13.7	13.0
847	4	9.3	8.3	3.8	12.0	1.5	13.4	13.6	13.7	8.4	IDEAL	4	15.0	.2	15.0	14.8	14.9	14.6
847	5	4.1	5.2	1.3	10.5	2.8	6.0	2.9	10.8	13.9	IDEAL	5	14.8	.1	14.9	14.1	14.8	14.6
847	6	7.6	8.6	7.3	6.8	3.8	12.0	7.1	4.8	12.9	IDEAL	6	7.2	1.3	12.2	13.2	13.8	7.8
847	7	12.0	10.0	6.0	8.1	5.2	7.7	6.0	13.2	14.2	IDEAL	7	13.0	1.2	8.8	9.5	14.0	12.8
847	8	.3	.6	.1	9.6	6.6	10.0	4.6	10.4	8.4	IDEAL	8	14.4	.1	13.1	8.3	14.9	14.8
847	9	8.4	3.9	4.8	10.2	3.0	2.9	10.1	13.9	2.9	IDEAL	9	14.7	.1	14.9	14.8	14.9	14.9
847	10	7.4	7.9	4.8	6.1	9.0	10.3	9.4	7.9	7.4	IDEAL	10	12.7	.3	14.2	14.1	15.0	4.2
847	11	7.0	4.1	0.0	1.6	3.6	4.8	5.0	2.4	12.6	IDEAL	11	14.6	.5	14.7	14.8	14.5	14.9
847	12	4.6	1.2	0.0	9.1	9.5	12.0	11.0	11.6	12.5	IDEAL	12	7.2	7.3	13.9	7.3	14.4	13.6
847	13	5.7	3.5	0.0	8.7	2.6	9.6	4.6	10.1	11.0	IDEAL	13	9.0	2.6	7.8	11.3	11.3	12.2
847	14	11.1	11.2	12.2	8.2	10.5	8.5	3.6	13.1	4.0	IDEAL	14	10.5	.9	13.4	9.9	14.4	11.1
847	15	9.1	5.9	8.8	8.3	5.8	8.9	7.3	11.4	11.9	IDEAL	15	12.2	2.9	13.9	9.4	14.6	12.6
847	16	3.6	.9	2.3	2.4	14.4	10.7	5.1	1.1	13.0	IDEAL	16	12.0	2.0	13.1	13.3	13.9	10.7
847	17	12.5	12.1	11.8	6.0	8.8	11.3	4.1	4.4	12.9	IDEAL	17	5.3	1.6	15.0	7.3	15.0	7.8
847	18	3.6	1.6	.8	7.4	4.4	9.0	12.0	4.4	14.5	IDEAL	18	14.5	.8	14.4	12.0	15.0	15.0
847	19	9.5	8.6	7.4	14.2	13.5	9.9	1.8	1.2	6.4	IDEAL	19	14.2	.7	13.9	13.5	13.1	8.3
847	20	9.9	9.9	3.9	4.6	8.5	7.0	3.9	13.9	7.0	IDEAL	20	14.8	.1	11.7	10.5	13.9	14.3
847	21	10.7	10.8	8.5	8.1	5.8	7.2	4.9	10.0	11.4	IDEAL	21	9.3	4.2	9.2	8.2	11.2	11.8
847	22	8.8	5.6	4.2	1.8	13.6	7.7	1.6	11.8	14.1	IDEAL	22	14.5	.2	14.7	10.4	14.9	15.0
847	23	2.6	.1	0.0	7.0	13.3	12.8	.7	12.8	2.6	IDEAL	23	14.3	.6	14.9	.3	14.7	14.9
847	24	7.3	8.3	6.2	8.6	6.4	7.2	11.1	11.4	7.4	IDEAL	24	7.0	8.1	7.8	10.2	10.1	8.3
847	25	8.0	8.1	2.3	8.9	2.1	3.2	9.1	12.2	5.1	IDEAL	25	14.5	.1	15.5	14.3	15.0	12.5
847	26	9.5	9.5	4.7	4.7	2.9	10.7	8.0	9.5	10.8	IDEAL	26	14.5	.3	13.6	14.9	14.2	8.7
847	27	2.8	2.4	2.4	7.0	4.9	7.6	7.9	11.6	6.5	IDEAL	27	10.7	.8	10.0	9.2	12.2	11.2
847	28	1.5	3.2	1.1	9.5	5.7	6.3	9.8	5.9	8.4	IDEAL	28	13.5	.3	14.2	13.0	14.0	13.3
847	29	.3	0.0	0.0	6.6	6.7	9.2	1.7	10.5	9.7	IDEAL	29	14.9	.1	15.0	10.1	14.3	.1
847	30	3.6	3.6	.8	6.0	8.9	4.3	6.0	11.5	10.2	IDEAL	30	10.0	2.2	7.7	9.0	11.5	13.1
MEAN		6.98	5.98	4.12	7.48	6.74	8.43	6.61	9.45	9.51	MEAN		12.30	1.44	12.96	11.13	13.87	11.40
SD		3.49	3.67	3.52	2.76	3.66	2.74	3.38	3.86	3.46	SD		2.85	1.96	2.42	3.16	1.31	3.62
SAMPLE	PANEL	ACCEPT	PURCHASE	PRICE	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	SLIP	DISINTEGR	COVERAGE	ADJUST	SMOOTH	STICK
428	1	6.2	2.4	1.3	1.5	12.5	13.5	5.6	7.0	12.3	428	1	6.2	2.4	1.3	1.5	12.5	13.5
428	2	2.4	2.1	2.1	5.7	11.4	9.2	3.6	7.1	12.6	428	2	2.4	2.1	2.1	5.7	11.4	9.2
428	3	5.4	5.2	2.3	3.2	10.9	4.5	4.4	5.1	3.9	428	3	5.4	5.2	2.3	3.2	10.9	4.5
428	4	1.6	.7	.9	1.8	13.8	12.7	13.0	9.5	11.3	428	4	1.6	.7	.9	1.8	13.8	12.7
428	5	1.4	.3	0.0	2.6	6.8	6.7	2.0	9.5	6.3	428	5	1.4	.3	0.0	2.6	6.8	6.7
428	6	8.9	9.5	9.9	4.4	2.0	3.1	12.8	13.5	11.9	428	6	8.9	9.5	9.9	4.4	2.0	3.1
428	7	11.1	9.0	6.0	9.6	6.3	10.1	7.4	10.0	9.1	428	7	11.1	9.0	6.0	9.6	6.3	10.1
428	8	7.6	4.4	.1	9.1	4.4	9.6	6.3	12.9	13.6	428	8	7.6	4.4	.1	9.1	4.4	9.6
428	9	11.2	9.6	7.4	12.5	1.9	11.0	12.4	12.3	4.8	428	9	11.2	9.6	7.4	12.5	1.9	11.0
428	10	7.4	7.9	4.8	10.7	6.7	9.4	8.4	12.3	9.3	428	10	7.4	7.9	4.8	10.7	6.7	9.4
428	11	4.4	2.1	0.0	.5	2.5	2.7	1.7	1.0	6.0	428	11	4.4	2.1	0.0	.5	2.5	2.7
428	12	5.9	1.7	0.0	13.3	13.6	14.5	8.2	14.4	12.5	428	12	5.9	1.7	0.0	13.3	13.6	14.5
428	13	6.2	3.5	0.0	7.0	3.2	2.7	9.8	4.7	7.7	428	13	6.2	3.5	0.0	7.0	3.2	2.7
428	14	6.0	9.1	10.0	10.8	2.9	5.8	5.8	5.4	2.5	428	14	6.0	9.1	10.0	10.8	2.9	5.8
428	15	3.1	1.5	5.1	6.7	4.5	7.6	8.4	10.6	10.8	428	15	3.1	1.5	5.1	6.7	4.5	7.6
428	16	6.9	2.2	4.1	4.5	3.5	2.0	12.2	9.1	14.5	428	16	6.9	2.2	4.1	4.5	3.5	2.0
428	17	8.8	7.7	11.2	7.5	7.6	7.4	7.3	7.2	15.0	428	17	8.8	7.7	11.2	7.5	7.6	7.4
428	18	10.6	7.0	2.5	3.5	11.9	14.4	9.7	8.3	9.5	428	18	10.6	7.0	2.5	3.5	11.9	14.4
428	19	11.0	12.3	9.9	8.0	8.7	8.8	6.8	8.8	13.3	428	19	11.0	12.3	9.9	8.0	8.7	8.8
428	20	13.5	12.9	10.0	6.0	6.8	5.6	3.9	12.5	7.0	428	20	13.5	12.9	10.0	6.0	6.8	5.6
428	21	8.5	8.9	7.4	6.2	11.8	8.5	6.1	4.7	12.0	428	21	8.5	8.9	7.4	6.2	11.8	8.5
428	22	10.6	7.2	4.9	3.6	1.6	13.8	5.2	6.5	12.4	428	22	10.6	7.2	4.9	3.6	1.6	13.8
428	23	12.5	11.5	2.3	13.4	1.5	4.7	9.6	10.8	14.0	428	23	12.5	11.5	2.3	13.4	1.5	4.7
428	24	3.0	3.0	.6	8.6	7.4	8.4	9.9	6.6	10.3	428	24	3.0	3.0	.6	8.6	7.4	8.4
428	25	11.2	11.4	6.1	6.7	5.7	13.8	12.8	11.5	7.4	428	25	11.2	11.4	6.1	6.7	5.7	13.8
428	26	8.6	8.5	3.5	8.7	6.0	8.0	1.5	1.9	9.1	428	26	8.6	8.5	3.5	8.7	6.0	8.0
428	27	7.6	6.2	1.7	8.6	3.1	8.6	9.2	11.0	10.4	428	27	7.6	6.2	1.7	8.6	3.1	8.6
428	28	.5	1.2	.1	10.2	4.4	7.6	6.2	9.8	9.5	428	28	.5	1.2	.1	10.2	4.4	7.6
428	29	9.0	14.6	8.8	14.9	.9	15.0	2.6	14.3	15.0	428	29	9.0	14.6	8.8	14.9	.9	15.0
428	30	4.4	4.2	1.5	4.5	6.8	6.6	3.2	11.5	13.1	428	30	4.4	4.2	1.5	4.5	6.8	6.6
MEAN		7.18	6.26	4.15	7.14	6.37	8.54	7.20	8.88	10.24	MEAN		7.18	6.26	4.15	7.14	6.37	8.54
SD		3.51	4.10	3.70	3.77	3.91	3.80	3.49	3.44	3.35	SD		3.51	4.10	3.70	3.77	3.91	3.80

APPENDIX 6.2 (continued)

Analysis of Variance of Sensory Scores Obtained from the Three Groups of Consumers

Attributes		F-ratio	P value
Acceptability	Sample	58.89	0.000
	Group	3.43	0.073
Purchase intention	Sample	54.33	0.000
	Group	4.09	0.050
Price to buy	Sample	47.62	0.000
	Group	0.05	0.949
Slipperiness	Sample	22.84	0.000
	Group	0.80	0.476
Disintegration	Sample	49.44	0.000
	Group	0.56	0.588
Coverage	Sample	16.67	0.000
	Group	3.75	0.061
Adjustability	Sample	2.50	0.102
	Group	3.38	0.076
Smoothness	Sample	31.68	0.000
	Group	6.43	0.016
Stickability	Sample	10.98	0.001
	Group	9.48	0.005

APPENDIX 6.3 Ideal Ratio Scores of the Prototypes' Sensory Attributes (Original Data)

Kasetsart University Students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
742	1	.12	46.67	.06	129.00	.10	.87
742	2	.09	13.00	.87	1.62	.84	.83
742	3	.54	12.30	.61	1.51	.73	1.28
742	4	.43	8.00	.55	1.07	.15	.52
742	5	1.02	1.04	1.04	.98	1.15	.65
742	6	.78	6.00	.67	.70	.82	.97
742	7	.21	7.65	.22	.43	.17	.85
742	8	.03	41.33	.19	.09	.03	.32
742	9	.53	11.33	.90	.29	.34	.98
742	10	.61	27.00	.27	.84	.75	1.02
742	11	.82	1.95	.79	1.13	.90	1.17
742	12	.32	5.38	.76	.75	.85	.65
742	13	.30	9.71	.52	.34	.65	1.17
742	14	.86	1.90	.75	1.00	.83	1.08
742	15	.81	1.69	.77	1.04	.96	.74
742	16	.21	2.98	.84	1.19	.29	1.08
742	17	.80	4.55	.59	.71	.82	1.00
742	18	.90	140.00	.70	.17	1.00	1.04
742	19	.20	3.38	.85	.68	.94	.80
742	20	.26	85.00	.71	.75	.84	1.43
742	21	.29	12.00	.70	.21	.65	1.20
742	22	.90	1.49	.91	.73	1.18	1.44
742	23	.35	44.00	.40	.14	.62	.88
742	24	.18	21.17	.10	.10	.11	.67
742	25	.28	1.39	.35	.73	.58	1.51
742	26	.06	67.50	.22	3.62	.02	.96
742	27	.06	7.65	.27	18.00	.27	.79
742	28	.13	26.20	.24	2.45	.24	.75
742	29	.14	133.00	.22	2.71	.61	.70
742	30	.58	4.05	.92	.49	.61	1.11

MEAN .43 24.98 .57 5.78 .60 .95
SD .31 36.69 .29 23.49 .35 .28

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
243	1	.35	26.00	.28	5.00	.55	.98
243	2	.84	13.80	.67	1.54	.79	.64
243	3	.73	8.20	.69	.75	.44	1.40
243	4	.78	1.55	.49	.92	.75	.34
243	5	.98	1.08	1.01	.98	1.12	.69
243	6	.82	9.75	.65	.74	.90	.91
243	7	.29	6.18	.29	.19	.24	1.04
243	8	.81	46.00	.65	.92	.39	.54
243	9	.78	8.00	.93	.31	.39	.96
243	10	1.15	35.67	.49	.53	.70	.96
243	11	.61	2.24	.66	1.13	.86	.98
243	12	.94	6.19	.82	.96	1.00	.88
243	13	.45	13.43	.44	.26	.89	1.26
243	14	.45	6.75	.64	1.00	.35	.89
243	15	.94	1.54	.82	.96	.96	.72
243	16	.24	3.40	.29	1.81	.20	1.02
243	17	.37	5.75	.45	.71	.82	1.00
243	18	1.00	149.00	.50	.84	.93	1.47
243	19	.47	5.23	.23	.43	1.00	.96
243	20	.11	119.00	.20	.75	.84	1.14
243	21	1.22	2.40	1.51	.91	1.26	.72
243	22	.76	2.23	.65	.84	.34	1.08
243	23	.80	129.00	.53	.69	.95	.13
243	24	.73	16.00	.65	.70	.80	.39
243	25	.61	3.47	.45	.81	.23	1.17
243	26	.71	60.50	.61	2.65	.57	.47
243	27	.63	8.65	.42	116.00	.09	.61
243	28	.83	24.40	.67	1.47	1.09	.85
243	29	.67	149.00	.15	4.00	.19	.52
243	30	.64	4.77	.41	.60	.76	.61

MEAN .69 28.97 .57 4.98 .68 .84
SD .26 45.30 .28 20.99 .32 .31

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
557	1	1.00	3.00	1.00	1.00	.92	.95
557	2	1.07	1.00	.88	1.77	1.00	.76
557	3	.91	2.00	.91	1.70	.92	1.05
557	4	1.09	1.00	.01	1.48	.92	.13
557	5	1.08	.98	1.06	.98	1.07	.74
557	6	.98	2.38	.92	.87	.91	.67
557	7	.93	5.06	.80	.78	.83	.94
557	8	1.06	2.33	.95	1.05	.83	1.16
557	9	1.00	1.00	1.00	.31	1.00	.98
557	10	1.04	20.67	.92	.90	.86	.98
557	11	1.00	1.00	.66	1.22	1.00	.98
557	12	1.00	1.69	.97	1.00	1.00	.58
557	13	1.05	5.29	.89	.45	.94	1.03
557	14	1.00	1.00	1.00	1.00	1.00	.89
557	15	1.07	2.31	.71	.94	.96	.82
557	16	.98	.45	.98	1.24	.98	1.10
557	17	.91	1.60	.86	.90	1.00	1.00
557	18	1.00	11.00	.83	.17	1.00	1.32
557	19	.98	4.38	.27	.88	.90	.72
557	20	1.00	5.00	1.00	.75	.84	1.43
557	21	1.45	.20	1.60	1.25	1.33	.53
557	22	1.25	.44	1.10	1.08	1.36	.93
557	23	1.00	1.00	.10	.31	.84	1.27
557	24	.92	4.00	.77	.83	.90	.48
557	25	.16	3.00	.94	.60	.72	.80
557	26	1.00	1.00	1.00	.21	1.00	.31
557	27	1.00	.06	1.33	48.00	.87	.46
557	28	1.15	4.20	.32	2.24	.65	.92
557	29	1.00	17.00	1.00	.62	.95	1.00
557	30	1.05	1.68	.29	1.00	.93	.77

MEAN 1.00 3.52 .84 2.52 .95 .86
SD .19 4.74 .34 8.60 .14 .29

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
181	1	.95	1.00	.95	1.00	1.00	1.15
181	2	.94	2.00	.92	.33	1.00	1.00
181	3	.81	9.40	.85	.58	.80	1.45
181	4	.94	2.73	.62	.15	.54	.72
181	5	.90	1.18	.96	.97	.94	1.46
181	6	.86	6.00	.80	.77	.88	.82
181	7	.65	3.35	.53	.74	.72	1.15
181	8	.94	5.00	.89	.80	.87	1.42
181	9	.93	1.50	.96	.34	.96	.96
181	10	.94	27.00	.81	.73	.83	.92
181	11	1.00	1.00	.79	.95	1.00	.98
181	12	1.00	1.50	.97	1.00	.93	1.00
181	13	1.00	1.00	.94	.94	.97	1.00
181	14	1.00	1.90	.95	.94	1.00	.89
181	15	.73	1.92	.73	1.06	.96	.97
181	16	1.02	.35	1.03	.63	1.02	1.08
181	17	.91	1.60	.92	.90	1.00	1.00
181	18	1.00	105.00	1.00	1.00	.23	1.23
181	19	.86	1.19	.93	1.04	.98	1.00
181	20	.73	29.00	.80	.75	.84	1.69
181	21	1.10	2.40	1.41	.48	1.20	.88
181	22	1.25	.21	1.18	.93	1.36	1.71
181	23	.91	18.00	.33	.21	1.06	.53
181	24	1.00	2.67	.85	.88	1.00	1.00
181	25	.89	1.18	1.00	.46	.87	1.42
181	26	.91	42.50	1.00	.21	.95	1.09
181	27	.83	1.00	1.00	1.00	1.00	.88
181	28	1.00	1.00	1.00	1.00	1.00	1.00
181	29	.86	3.00	.92	.03	1.00	.93
181	30	1.00	3.23	.83	.89	.89	.88

MEAN .93 9.29 .90 .72 .93 1.07
SD .11 20.65 .19 .31 .19 .27

Kasetsart University Students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK	SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
847	1	.77	14.33	.67	5.00	.37	1.08	314	1	.01	49.33	.57	1.00	.01	1.08
847	2	.43	9.00	.88	.43	.91	1.00	314	2	.09	14.10	.84	1.62	.74	.20
847	3	.43	4.60	.47	.37	.84	1.49	314	3	.04	13.50	.18	.56	.25	1.17
847	4	.20	9.82	.88	.07	.25	.91	314	4	.12	13.64	.19	.42	.70	.16
847	5	.95	1.14	.98	.97	.98	1.51	314	5	.15	.22	.53	.34	.79	.34
847	6	.78	11.38	.62	.95	.87	.95	314	6	.44	15.25	.65	.47	.75	.60
847	7	.57	6.76	.45	.24	.29	1.18	314	7	.06	8.06	.17	.48	.06	.35
847	8	.70	15.33	.75	.92	.54	.21	314	8	.03	48.67	.11	.09	.10	.11
847	9	.82	5.33	.93	.34	.47	1.04	314	9	.06	23.50	.45	.29	.34	.10
847	10	.36	17.00	.38	.68	.65	.52	314	10	.29	48.33	.18	.81	.36	.10
847	11	1.38	4.05	.36	.94	.85	.88	314	11	.45	3.05	.88	.95	.86	.88
847	12	.81	3.13	.86	.91	.89	1.04	314	12	.11	2.50	.72	.36	.82	.93
847	13	.36	9.71	.52	.15	.44	1.17	314	13	.01	21.43	.01	.62	.97	1.01
847	14	.86	5.10	.95	1.00	.83	.94	314	14	.10	6.30	.11	1.16	.60	.62
847	15	.83	3.15	.75	1.02	.96	.76	314	15	.21	11.54	.52	1.11	.57	.70
847	16	.94	.73	.92	.71	.97	.91	314	16	.12	3.13	.24	1.39	.10	.94
847	17	.80	2.55	.72	.71	.82	1.00	314	17	.19	6.75	.15	.26	.09	1.00
847	18	.96	140.00	.46	.52	.89	1.23	314	18	.09	150.00	.07	.01	.01	1.47
847	19	.65	4.19	.39	.92	.87	.76	314	19	.06	5.46	.34	.10	.87	.83
847	20	.26	85.00	.71	.75	.84	1.69	314	20	.01	150.00	.03	.89	.84	1.05
847	21	.69	15.80	1.34	.36	1.14	1.36	314	21	.06	27.20	.24	.64	.50	.28
847	22	.68	1.74	.73	.64	1.10	1.61	314	22	.05	2.91	.05	.53	.13	.93
847	23	.06	140.00	.92	.55	.18	.25	314	23	.01	150.00	.26	.81	.01	.04
847	24	.68	11.50	.55	.56	.63	.60	314	24	.02	24.67	.02	.02	.02	.75
847	25	.80	1.00	.89	.57	.79	1.06	314	25	.01	3.24	.25	.90	.10	.48
847	26	.64	35.00	.68	2.38	.91	1.09	314	26	.01	75.00	.09	4.41	.01	.01
847	27	.44	6.76	.83	69.00	.20	1.00	314	27	.70	7.65	.01	150.00	.73	.10
847	28	.28	21.80	.39	2.03	.38	.69	314	28	.01	24.20	.01	3.95	1.17	.57
847	29	.22	114.00	.53	1.47	.81	.81	314	29	.01	147.00	.01	4.41	1.00	.01
847	30	.50	5.36	.77	.75	.71	1.00	314	30	.03	6.32	.06	.11	.05	.50
MEAN		.63	23.51	.71	3.21	.71	.99	MEAN		.12	35.43	.27	5.96	.45	.58
SD		.29	39.96	.23	12.46	.27	.35	SD		.16	48.57	.26	27.23	.38	.41

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
428	1	.04	48.67	.01	138.00	.03	1.05
428	2	.63	10.80	.75	1.32	.89	.71
428	3	.65	10.90	.75	1.59	.63	1.35
428	4	.62	3.82	.41	.57	.56	.45
428	5	.88	1.23	.94	.97	1.04	.80
428	6	.90	4.25	.76	.93	.88	.95
428	7	.59	5.76	.48	.70	.65	1.06
428	8	.11	31.33	.35	.48	.25	1.42
428	9	.89	1.50	.96	.34	.39	.98
428	10	.41	30.67	.08	.95	.55	.86
428	11	.70	2.24	.93	1.00	.64	1.17
428	12	.86	1.69	.91	.92	.93	1.04
428	13	.81	2.14	.85	.81	.53	1.26
428	14	.86	5.10	.75	1.00	1.00	.89
428	15	.85	8.23	.79	.97	.96	.93
428	16	.70	1.13	.81	1.31	.89	.90
428	17	.53	4.55	.51	.71	.82	1.00
428	18	.98	6.00	.70	.84	1.00	1.04
428	19	.29	2.77	.97	1.04	1.00	.92
428	20	.73	29.00	.80	.75	.84	1.14
428	21	.29	20.40	1.16	1.11	1.08	1.36
428	22	1.09	1.26	.82	.93	1.25	1.33
428	23	.21	54.00	1.10	.41	.75	1.09
428	24	.32	22.67	.18	.19	.20	.17
428	25	.17	2.13	.40	.64	.47	1.63
428	26	.12	52.00	.48	2.88	.52	.91
428	27	.25	3.65	1.10	18.00	.53	.35
428	28	.45	18.60	.51	2.87	.88	.62
428	29	.52	64.00	.45	1.18	.55	.58
428	30	.36	5.36	.70	.21	.26	1.19
MEAN		.56	15.19	.68	6.12	.70	.97
SD		.30	18.31	.30	25.11	.30	.32

OFFICE WORKERS

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
742	1	.06	3.62	.60	.40	.29	1.52
742	2	.71	2.40	.62	.74	.29	.96
742	3	.29	13.80	.47	.25	.18	1.33
742	4	.15	57.00	.78	.97	.97	.16
742	5	.42	15.71	.78	.58	.93	.88
742	6	1.03	45.00	.66	.50	.42	.98
742	7	.17	.28	1.19	.27	.25	1.17
742	8	.10	4.50	.48	.47	.46	.75
742	9	.16	6.62	.70	.10	.07	3.23
742	10	.46	5.27	1.02	.86	.48	1.03
742	11	.29	1.30	.41	.52	.52	.56
742	12	.02	16.33	.17	.07	.06	.73
742	13	.25	3.62	.47	.46	.50	.55
742	14	.40	91.00	.69	.54	.78	.69
742	15	.17	2.92	.05	.96	.97	.68
742	16	.25	14.25	1.12	.48	.51	.03
742	17	.07	3.00	1.10	.34	.19	2.19
742	18	.53	1.24	.38	.53	1.00	.41
742	19	.06	24.80	.24	.75	.06	1.15
742	20	.53	5.67	.64	.55	.51	.83
742	21	.50	3.45	.79	.21	.53	.33
742	22	.63	.40	.42	.28	.28	.98
742	23	.78	1.14	.77	1.26	1.12	.75
742	24	.01	18.75	.52	.73	.72	.77
742	25	.16	48.33	.46	.04	.83	1.00
742	26	1.30	6.20	.80	.92	.60	1.07
742	27	.01	1.00	.02	.04	.06	.23
742	28	.78	1.54	.35	.65	.10	.87
742	29	.12	102.00	.25	.17	.26	1.48
742	30	.22	44.00	.57	.62	.54	.62
MEAN		.35	18.17	.58	.51	.50	.93
SD		.32	26.54	.30	.30	.32	.61

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
243	1	.18	7.10	.13	.09	.21	.18
243	2	.74	2.40	.62	.69	.70	.49
243	3	.47	11.90	.69	.60	.39	1.00
243	4	.24	57.00	.78	.97	.97	.95
243	5	.42	19.14	.78	.58	.93	.88
243	6	.47	126.00	.97	.58	.23	.94
243	7	1.00	1.00	.85	2.73	1.15	.75
243	8	.84	5.44	.58	.61	.96	.63
243	9	.59	5.29	.76	.31	.13	.71
243	10	.40	10.64	.98	.90	.42	1.11
243	11	.15	3.85	.35	.41	.87	1.10
243	12	.55	3.22	.67	.72	.72	1.36
243	13	.35	3.28	.15	.30	.42	.30
243	14	.15	115.00	.22	.25	.82	.64
243	15	.65	1.58	.61	.48	.61	.95
243	16	.06	17.88	.76	.35	.26	.24
243	17	.70	3.29	.46	.90	1.00	3.78
243	18	.03	1.56	.66	.74	.32	.25
243	19	.12	27.80	.45	1.00	.29	.59
243	20	.06	11.50	.10	1.17	.85	.66
243	21	.89	1.55	.85	.53	.53	.33
243	22	.76	.95	.81	.95	.57	.89
243	23	.15	1.27	.33	1.44	1.39	.83
243	24	.17	14.88	.44	.54	.78	.86
243	25	.01	48.33	.25	.18	.83	1.00
243	26	1.11	9.90	.93	.36	.94	1.19
243	27	.01	14.00	.18	.13	.18	.97
243	28	.78	1.83	.63	1.21	.67	.87
243	29	.12	147.00	.25	1.60	.15	1.28
243	30	.32	82.00	.29	.47	.31	1.12
MEAN		.42	25.22	.55	.73	.62	.90
SD		.32	40.03	.27	.53	.33	.63

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
557	1	1.08	.48	1.06	.91	1.09	.62
557	2	.83	1.07	.86	.88	.94	.96
557	3	1.00	3.20	1.00	1.00	1.03	1.53
557	4	.96	4.50	.19	.97	.97	.05
557	5	.91	1.86	.72	.73	.93	.84
557	6	.99	3.00	.97	.36	.97	.93
557	7	2.03	1.99	.29	5.65	.43	.54
557	8	1.24	2.44	.84	.83	.82	.85
557	9	1.00	1.00	1.00	1.00	1.00	1.00
557	10	1.04	5.55	.42	.97	.93	.82
557	11	1.16	1.91	1.07	.91	.77	.82
557	12	.85	2.78	.72	.90	.80	.89
557	13	.62	2.41	.25	.78	.63	.36
557	14	.87	34.00	.78	.67	.77	1.09
557	15	1.21	.13	.32	.68	.85	.75
557	16	.88	2.25	.65	.20	.12	.11
557	17	1.00	.44	.59	1.00	1.13	1.00
557	18	.89	.29	.54	.63	.43	.70
557	19	1.00	4.00	1.00	.34	1.00	1.27
557	20	.35	7.83	.30	.74	.70	.05
557	21	1.00	1.00	.95	1.00	1.00	.78
557	22	1.21	1.24	1.19	1.08	.91	.72
557	23	1.00	1.00	1.39	1.14	1.56	.62
557	24	.63	.38	.66	.92	.93	.95
557	25	1.00	1.00	.51	.38	1.00	1.00
557	26	1.78	.10	.97	.92	1.00	1.07
557	27	.92	132.00	.66	.60	.65	.15
557	28	.92	1.25	.87	1.09	.51	1.05
557	29	.92	14.00	.78	1.60	.91	.78
557	30	1.00	19.00	.16	1.00	1.00	.35
MEAN		1.01	8.40	.72	1.00	.86	.76
SD		.30	24.36	.32	.92	.26	.36

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
181	1	.66	3.24	.56	.53	.87	.39
181	2	1.00	.78	.94	.95	1.00	.96
181	3	.83	8.60	.80	.72	.62	1.00
181	4	.72	21.00	.78	.97	.97	.95
181	5	.42	15.71	.78	.58	.93	.88
181	6	.61	30.00	.52	.58	.92	1.00
181	7	1.36	1.34	.52	4.92	1.34	.90
181	8	1.42	.56	.94	.95	.93	1.06
181	9	.63	1.43	.93	.85	.90	1.23
181	10	.98	2.09	.90	.93	.98	1.10
181	11	1.04	2.15	1.22	1.04	.92	1.22
181	12	.95	2.33	.79	.84	.80	1.36
181	13	.69	2.07	.62	.65	.73	.66
181	14	.35	71.00	.73	.38	.84	1.27
181	15	1.35	.13	.41	.48	.61	.58
181	16	1.00	1.00	1.24	1.00	1.00	.93
181	17	.30	1.00	.88	.64	.41	2.70
181	18	1.00	1.00	1.00	1.00	.72	1.00
181	19	.78	1.00	.89	.93	.76	1.00
181	20	1.00	1.00	1.00	.10	.10	1.00
181	21	.89	1.55	.85	1.36	.85	.78
181	22	1.17	.23	1.27	1.14	.97	.98
181	23	.93	1.70	1.00	.92	1.69	.40
181	24	.83	16.75	.36	.98	1.04	1.04
181	25	.92	1.00	.51	1.00	.48	1.00
181	26	1.68	1.80	.97	1.07	1.00	1.16
181	27	.71	142.00	.92	.95	.92	.75
181	28	1.00	1.00	1.00	1.00	1.00	1.00
181	29	.71	78.00	.66	.48	.91	1.48
181	30	.86	7.00	.76	.89	.92	1.26
MEAN		.89	13.95	.83	.96	.87	1.03
SD		.31	30.79	.23	.79	.27	.40

OFFICE WORKERS

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
847	1	.28	2.95	.67	.47	.42	1.46
847	2	.90	1.40	.86	.82	.85	.96
847	3	.71	10.10	.94	.91	.86	1.00
847	4	.54	21.00	.78	.97	.97	.95
847	5	.66	9.14	.78	.73	.93	.88
847	6	.61	57.00	.46	.49	.74	.97
847	7	1.00	1.00	1.00	1.00	1.00	1.00
847	8	.33	3.56	.39	.31	.61	.51
847	9	.70	1.81	1.07	.42	.54	2.19
847	10	.50	5.00	.86	.83	.83	1.06
847	11	.91	3.48	.81	.63	.33	.42
847	12	.23	13.44	.36	.44	.41	1.10
847	13	.16	4.10	.72	.55	.34	.75
847	14	.42	83.00	.63	.79	.81	1.27
847	15	.84	1.58	.53	.68	.78	.84
847	16	.33	13.00	1.00	.78	.80	1.00
847	17	.53	2.20	1.00	.78	.60	3.22
847	18	.19	.73	.77	.83	.85	.85
847	19	.50	20.60	.76	.13	.18	.82
847	20	.67	9.42	.82	1.00	1.00	.53
847	21	.50	4.36	.71	1.36	.22	1.00
847	22	.38	1.13	.93	.85	.77	.31
847	23	.85	1.53	.57	1.33	1.23	.90
847	24	.77	2.88	.59	.82	.86	1.15
847	25	.92	1.00	1.00	.51	1.00	1.00
847	26	1.36	8.60	.80	.48	.75	1.12
847	27	.15	105.00	.82	.85	.82	.84
847	28	.39	.74	.76	.89	.22	.93
847	29	.23	102.00	.50	1.43	.75	1.67
847	30	.76	32.00	.89	.77	.78	.50

MEAN
SD.58 17.46 .76 .76 .71 1.04
.29 29.44 .19 .30 .27 .55

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
428	1	.02	6.76	.17	.14	.14	.27
428	2	.76	2.40	.62	.69	.70	.96
428	3	.47	13.80	.59	.53	.52	1.75
428	4	.54	51.00	.78	.97	.97	.95
428	5	.66	9.14	.78	.73	.93	.88
428	6	.72	30.00	.67	.40	.48	.97
428	7	.77	1.28	.70	4.92	1.25	.68
428	8	1.11	1.56	.75	.74	.75	.97
428	9	.51	2.24	1.15	.35	.22	1.77
428	10	.63	4.73	.96	.88	.89	1.04
428	11	.83	1.64	.49	.77	.43	.90
428	12	.61	7.11	.45	.51	.32	.89
428	13	.81	1.83	.35	.21	.82	.43
428	14	.37	78.00	.88	.49	.81	1.16
428	15	.41	2.92	.19	.96	.97	.95
428	16	.14	15.63	.87	.09	.02	.83
428	17	.53	1.76	.75	.52	.83	4.44
428	18	.39	.52	.86	.93	.57	.55
428	19	.22	16.60	.59	.23	.17	1.21
428	20	.86	3.33	.50	.30	.35	.24
428	21	.50	4.77	.79	.21	.85	1.34
428	22	.92	1.05	1.09	1.05	.86	.82
428	23	.68	1.85	1.66	1.00	1.00	1.00
428	24	.72	17.88	.81	.65	.64	1.10
428	25	.10	1.00	1.00	.92	1.00	1.00
428	26	1.59	1.80	.83	.60	.98	1.16
428	27	.08	120.00	.76	.72	.72	.90
428	28	.25	.48	.49	.76	.01	1.03
428	29	.33	126.00	.50	1.23	.26	1.67
428	30	.13	56.00	1.00	.35	.18	1.00

MEAN
SD.56 19.40 .73 .76 .62 1.09
.34 33.74 .30 .84 .34 .73

School students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
742	1	.28	10.18	.49	.50	.61	1.59
742	2	.22	11.75	.51	1.00	.84	2.00
742	3	.12	9.15	.24	.25	.23	.15
742	4	.03	72.00	.70	.74	.13	.68
742	5	.24	97.00	.37	.18	.78	.90
742	6	.07	10.15	.01	.03	.25	.95
742	7	.28	8.08	1.52	.58	.63	.97
742	8	.45	107.00	.90	.46	.19	.87
742	9	.01	123.00	.49	.03	.76	.83
742	10	.44	40.33	.70	.62	.33	1.86
742	11	.07	3.40	.11	.28	.03	.66
742	12	.36	.42	.93	1.00	1.00	.84
742	13	.33	.65	1.04	.41	.89	.72
742	14	.26	8.22	.35	.42	.31	1.19
742	15	.38	2.62	1.48	.60	.51	1.03
742	16	.01	6.60	1.08	.62	.25	.29
742	17	.23	8.25	.87	.25	.48	1.92
742	18	.06	1.00	.11	.16	.93	.49
742	19	.27	16.71	.42	.26	.81	1.23
742	20	.31	100.00	.74	.30	1.00	.77
742	21	1.04	2.00	1.04	.87	1.01	.77
742	22	.37	27.50	.72	.15	.83	.76
742	23	.03	20.33	.21	41.67	.61	.27
742	24	.13	1.32	1.45	.15	.94	1.39
742	25	.01	104.00	.15	.23	.07	.33
742	26	.05	43.33	.42	.68	.51	1.64
742	27	.53	9.88	.61	.78	.69	.28
742	28	.49	29.33	.32	.36	.54	.89
742	29	.01	146.00	.46	.65	.55	1.00
742	30	.20	6.23	.69	.67	.67	.90

MEAN
SD.24 34.22 .60 1.83 .58 .94
.22 43.48 .38 7.53 .30 .49

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
243	1	.81	12.18	.43	.69	.21	.67
243	2	.31	10.50	.23	.74	.68	1.10
243	3	.42	10.23	.13	.12	.12	.38
243	4	.87	74.50	.61	.82	.03	.86
243	5	.76	109.00	.34	.11	.54	.80
243	6	.39	11.54	.53	.23	.86	.01
243	7	.92	3.17	.67	1.04	.79	.91
243	8	.54	93.00	.79	.16	.58	.20
243	9	.06	149.00	.03	.16	.68	.09
243	10	.91	8.00	.77	.74	.93	1.29
243	11	.88	27.20	.88	.23	1.00	.15
243	12	1.69	1.71	.81	1.25	1.00	.23
243	13	.89	1.50	.83	.87	.42	.83
243	14	.85	16.67	.01	1.52	.81	1.07
243	15	.47	2.24	.49	.69	.63	.63
243	16	1.07	3.80	.44	1.04	1.04	1.05
243	17	2.19	3.81	.12	1.85	.31	1.92
243	18	.44	17.13	.41	.28	.11	.92
243	19	.76	5.86	.51	.65	.91	1.43
243	20	.45	68.00	.43	.74	.80	.40
243	21	1.24	3.52	.87	1.05	.96	.30
243	22	.79	64.00	.36	.36	.89	.89
243	23	.20	17.67	.81	35.33	.67	.80
243	24	.57	1.30	1.38	1.26	.50	1.12
243	25	.21	131.00	.28	.52	.33	.19
243	26	.83	15.67	.27	.96	.78	.02
243	27	.65	6.13	.86	.78	.95	.52
243	28	.62	48.33	.18	.19	.01	.81
243	29	.93	4.00	.88	1.00	.94	15.00
243	30	.95	5.68	.43	1.29	.67	.27

MEAN
SD.76 30.88 .53 1.89 .64 1.16
.43 41.73 .32 6.33 .31 2.65

School students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
847	1	.41	8.00	.73	.57	.91	.97
847	2	.61	3.83	.39	.89	.58	1.50
847	3	.69	3.77	.53	.69	.52	.47
847	4	.80	7.50	.89	.92	.92	.58
847	5	.71	28.00	.40	.21	.73	.95
847	6	.94	2.92	.98	.54	.35	1.65
847	7	.62	4.33	.88	.63	.94	1.11
847	8	.67	66.00	.76	.55	.70	.57
847	9	.69	30.00	.19	.68	.93	.19
847	10	.48	30.00	.73	.67	.53	1.76
847	11	.11	7.20	.33	.34	.17	.85
847	12	1.26	1.30	.86	1.51	.81	.92
847	13	.97	1.00	1.23	.41	.89	.90
847	14	.78	11.67	.63	.36	.91	.36
847	15	.68	2.00	.64	.78	.78	.94
847	16	.20	7.20	.82	.38	.08	1.21
847	17	1.13	5.50	.75	.56	.29	1.65
847	18	.51	5.50	.63	1.00	.29	.97
847	19	1.00	19.29	.71	.13	.09	.77
847	20	.31	85.00	.60	.37	1.00	.49
847	21	.87	1.38	.78	.60	.89	.97
847	22	.12	68.00	.52	.15	.79	.94
847	23	.49	22.17	.86	2.33	.87	.17
847	24	1.23	.79	.92	1.09	1.13	.89
847	25	.61	21.00	.21	.64	.81	.41
847	26	.32	9.67	.79	.54	.67	1.24
847	27	.65	6.13	.76	.86	.95	.58
847	28	.70	19.00	.44	.75	.42	.63
847	29	.44	67.00	.61	.17	.73	97.00
847	30	.60	4.05	.56	.67	1.00	.78
MEAN		.65	18.31	.67	.67	.69	4.08
SD		.30	23.14	.23	.43	.29	17.55

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
428	1	.11	11.36	.98	.41	.49	1.41
428	2	.42	9.50	.33	.52	.33	1.75
428	3	.26	8.38	.34	.38	.37	.30
428	4	.12	69.00	.85	.88	.64	.77
428	5	.18	68.00	.45	.14	.64	.43
428	6	.61	1.54	.25	.97	.98	1.53
428	7	.74	5.25	1.15	.78	.71	.71
428	8	.63	44.00	.73	.76	.87	.92
428	9	.85	19.00	.74	.84	.83	.32
428	10	.84	22.33	.66	.60	.60	2.21
428	11	.03	5.00	.18	.11	.07	.40
428	12	1.85	1.86	1.04	1.12	1.00	.92
428	13	.78	1.23	.35	.87	.42	.63
428	14	1.03	3.22	.43	.59	.38	.23
428	15	.55	1.55	.55	.89	.73	.86
428	16	.38	1.75	.15	.92	.65	1.36
428	17	1.42	4.75	.49	1.00	.48	1.92
428	18	.24	14.88	1.00	.81	.55	.63
428	19	.56	12.43	.63	.50	.67	1.60
428	20	.41	68.00	.48	.37	.90	.49
428	21	.67	2.81	.92	.74	.42	1.02
428	22	.25	8.00	.94	.50	.44	.83
428	23	.94	2.50	.32	32.00	.73	.94
428	24	1.23	.91	1.08	.97	.65	1.24
428	25	.46	57.00	.89	.90	.77	.59
428	26	.60	20.00	.59	.10	.13	1.05
428	27	.80	3.88	.86	1.00	.90	.93
428	28	.76	14.67	.54	.48	.70	.71
428	29	1.00	9.00	1.00	.26	1.00	150.00
428	30	.45	3.09	.86	.36	1.00	1.00
MEAN		.64	16.50	.67	1.69	.64	5.92
SD		.41	21.54	.29	5.73	.24	27.22

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
557	1	.98	1.18	.66	.98	.99	1.46
557	2	.90	2.67	.81	.42	.77	.33
557	3	1.07	1.00	1.00	1.16	1.00	.88
557	4	1.00	1.00	1.00	.25	1.00	.01
557	5	.80	16.00	.88	.22	.80	.36
557	6	1.89	.46	.70	.14	.55	.21
557	7	1.08	1.67	1.34	.86	.86	.75
557	8	1.00	5.00	.68	.69	.88	.82
557	9	.94	139.00	.13	.93	.61	.02
557	10	1.03	3.67	.18	.96	.42	.29
557	11	.84	24.60	.78	.18	.88	.79
557	12	2.00	.26	.43	1.36	1.00	.31
557	13	1.04	3.62	.23	.41	.89	.57
557	14	1.08	1.67	.27	.94	.55	.30
557	15	.80	1.00	.78	1.07	.86	.71
557	16	.81	.45	.31	.23	.85	.08
557	17	2.42	6.56	.55	1.05	.71	1.08
557	18	.13	2.50	.24	.05	.84	.37
557	19	.65	20.29	.35	.38	.53	1.12
557	20	1.00	6.00	.43	.84	.90	.40
557	21	1.30	1.17	.59	.52	.54	.24
557	22	.88	59.50	.63	.15	.68	.94
557	23	.14	10.67	.94	29.33	.94	.09
557	24	1.40	.23	.81	.83	1.19	.77
557	25	.94	16.00	.97	.96	.96	.77
557	26	.96	2.67	1.04	.88	.93	.14
557	27	1.00	1.50	.95	1.08	1.00	.82
557	28	.81	9.00	.63	.60	.84	.55
557	29	.01	150.00	.09	1.44	.20	27.00
557	30	1.28	1.00	.31	1.00	1.00	.17
MEAN		1.01	16.34	.62	1.66	.81	1.41
SD		.49	36.78	.32	5.24	.21	4.85

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
181	1	.94	2.00	.80	.96	.98	1.56
181	2	1.04	.58	.96	1.15	.90	.65
181	3	1.00	2.38	.87	1.00	.78	1.00
181	4	.75	65.00	.79	1.00	.82	1.00
181	5	.66	7.00	.93	.17	.82	.39
181	6	1.76	1.00	.09	.31	.07	.38
181	7	.85	1.42	1.30	.95	.92	1.02
181	8	.63	44.00	.73	.83	.87	.92
181	9	.75	10.00	.89	.76	.91	.91
181	10	.97	7.00	.85	.72	.89	1.05
181	11	.77	22.60	.71	.31	.63	.74
181	12	1.00	1.00	1.00	.88	1.00	1.00
181	13	.49	2.27	.56	.87	.42	1.00
181	14	.97	12.78	.20	.73	.24	.91
181	15	.98	.66	.87	1.19	.92	.56
181	16	.53	.20	.58	.07	.95	.51
181	17	1.89	1.88	.45	.93	.55	.92
181	18	1.00	12.63	.91	.93	.65	.85
181	19	.94	8.00	.80	.73	.73	1.00
181	20	.82	30.00	.74	.84	1.00	1.00
181	21	1.14	1.29	.67	.11	1.09	.56
181	22	.61	8.00	.44	.50	.89	1.00
181	23	.08	8.83	.98	46.00	.06	.86
181	24	1.07	.86	1.23	.31	1.07	1.33
181	25	.86	26.00	.19	.85	.73	.86
181	26	.19	27.33	.92	.29	.40	1.45
181	27	1.00	1.00	1.00	1.00	1.00	1.00
181	28	1.00	1.00	1.00	1.00	1.00	1.00
181	29	.83	1.00	.95	.41	.84	56.00
181	30	1.10	1.82	1.00	.67	.41	.51
MEAN		.89	10.32	.78	2.21	.75	2.73
SD		.36	15.04	.28	8.28	.28	10.06

APPENDIX 6.4 Log of Ideal Ratio Scores of the Prototypes' Sensory Attributes (Transformed data)

Kasetsart University students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
742	1	-.92	1.67	-1.21	2.11	-1.00	-.06
742	2	-1.03	1.11	-.06	.21	-.07	-.08
742	3	-.27	1.09	-.21	.18	-.14	.11
742	4	-.37	.90	-.26	.03	-.83	-.29
742	5	.01	.02	.02	-.01	.06	-.19
742	6	-.11	.78	-.17	-.15	-.09	-.01
742	7	-.68	.88	-.66	-.36	-.78	-.07
742	8	-1.60	1.62	-.71	-1.04	-1.48	-.50
742	9	-.27	1.05	-.05	-.54	-.47	-.01
742	10	-.22	1.43	-.56	-.07	-.12	.01
742	11	-.09	.29	-.10	.05	-.05	.07
742	12	-.49	.73	-.12	-.12	-.07	-.19
742	13	-.53	.99	-.28	-.47	-.19	.07
742	14	-.07	.28	-.12	.00	-.08	.03
742	15	-.09	.23	-.12	.02	-.02	-.13
742	16	-.67	.47	-.07	.08	-.53	.03
742	17	-.10	.66	-.23	-.15	-.08	.00
742	18	-.04	2.15	-.15	-.76	.00	.02
742	19	-.69	.53	-.07	-.17	-.02	-.10
742	20	-.59	1.93	-.15	-.12	-.08	-.16
742	21	-.53	1.08	-.16	-.67	-.18	.08
742	22	-.04	.17	-.04	-.14	.07	.16
742	23	-.45	1.64	-.40	-.85	-.21	-.05
742	24	-.75	1.33	-1.02	-.99	-.97	-.18
742	25	-.56	.14	-.46	-.14	-.24	.18
742	26	-1.21	1.83	-.67	.56	-1.70	-.02
742	27	-1.20	.88	-.57	1.26	-.57	-.10
742	28	-.88	1.42	-.62	.39	-.62	-.12
742	29	-.84	2.12	-.66	.43	-.21	-.15
742	30	-.24	.61	-.03	-.31	-.21	.05
MEAN		-.52	1.00	-.33	-.06	-.36	-.04
SD		.41	.61	.31	.63	.45	.14

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
243	1	-.45	1.41	-.55	.70	-.26	-.01
243	2	-.08	1.14	-.17	.19	-.10	-.19
243	3	-.13	.91	-.16	-.13	-.35	.15
243	4	-.11	.19	-.31	-.03	-.12	-.47
243	5	-.01	.03	.00	-.01	.05	-.16
243	6	-.09	.99	-.19	-.13	-.05	-.04
243	7	-.53	.79	-.54	-.72	-.61	.02
243	8	-.09	1.66	-.18	-.04	-.41	-.27
243	9	-.11	.90	-.03	-.51	-.41	-.02
243	10	.06	1.55	-.31	-.28	-.15	-.02
243	11	-.22	.35	-.18	.05	-.07	-.01
243	12	-.02	.79	-.09	-.02	.00	-.06
243	13	-.35	1.13	-.36	-.59	-.05	.10
243	14	-.35	.83	-.19	.00	-.46	-.05
243	15	-.03	.19	-.09	-.02	-.02	-.14
243	16	-.63	.53	-.54	.26	-.70	.01
243	17	-.43	.76	-.35	-.15	-.08	.00
243	18	.00	2.17	-.30	-.08	-.03	.17
243	19	-.33	.72	-.64	-.37	.00	-.02
243	20	-.97	2.08	-.70	-.12	-.08	.06
243	21	.09	.38	.18	-.04	.10	-.14
243	22	-.12	.35	-.19	-.08	-.47	.03
243	23	-.10	2.11	-.28	-.16	-.02	-.88
243	24	-.14	1.20	-.19	-.15	-.10	-.40
243	25	-.21	.54	-.34	-.09	-.63	.07
243	26	-.15	1.78	-.21	.42	-.24	-.33
243	27	-.20	.94	-.38	2.06	-1.05	-.21
243	28	-.08	1.39	-.18	.17	.04	-.07
243	29	-.17	2.17	-.83	.60	-.73	-.28
243	30	-.20	.68	-.39	-.22	-.12	-.22
MEAN		-.21	1.02	-.29	.02	-.24	-.11
SD		.22	.62	.22	.49	.28	.21

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
557	1	.00	.48	.00	.00	-.04	-.02
557	2	.03	.00	-.06	.25	.00	-.12
557	3	-.04	.30	-.04	.23	-.04	.02
557	4	.04	.00	-1.83	.17	-.04	-.90
557	5	.03	-.01	.02	-.01	.03	-.13
557	6	-.01	.38	-.04	-.06	-.04	-.18
557	7	-.03	.70	-.09	-.11	-.08	-.03
557	8	.02	.37	-.02	.02	-.08	.07
557	9	.00	.00	.00	-.50	.00	-.01
557	10	.02	1.32	-.03	-.05	-.06	-.01
557	11	.00	.00	-.18	.09	.00	-.01
557	12	.00	.23	-.02	.00	.00	-.23
557	13	.02	.72	-.05	-.35	-.03	.01
557	14	.00	.00	.00	.00	.00	-.05
557	15	.03	.36	-.15	-.02	-.02	-.09
557	16	-.01	-.35	-.01	.09	-.01	.04
557	17	-.04	.20	-.07	-.04	.00	.00
557	18	.00	1.04	-.08	-.76	.00	.12
557	19	-.01	.64	-.57	-.06	-.04	-.14
557	20	.00	.70	.00	-.12	-.08	.16
557	21	.16	-.70	.20	.10	.12	-.27
557	22	.10	-.35	.04	.03	.13	-.03
557	23	.00	.00	-1.01	-.51	-.07	.10
557	24	-.04	.60	-.11	-.08	-.04	-.32
557	25	-.80	.48	-.02	-.22	-.14	-.10
557	26	.00	.00	.00	-.69	.00	-.50
557	27	.00	-1.23	.12	1.68	-.06	-.33
557	28	.06	.62	-.50	.35	-.19	-.04
557	29	.00	1.23	.00	-.21	-.02	.00
557	30	.02	.23	-.54	.00	-.03	-.11
MEAN		-.01	.27	-.17	-.03	-.03	-.10
SD		.15	.53	.40	.41	.06	.21

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
181	1	-.02	.00	-.02	.00	.00	.06
181	2	-.03	.30	-.04	-.48	.00	.00
181	3	-.09	.97	-.07	-.24	-.10	.16
181	4	-.03	.44	-.21	-.82	-.27	-.14
181	5	-.04	.07	-.02	-.01	-.03	.16
181	6	-.07	.78	-.09	-.11	-.06	-.09
181	7	-.19	.53	-.27	-.13	-.14	.06
181	8	-.03	.70	-.05	-.10	-.06	.15
181	9	-.03	.18	-.02	-.47	-.02	-.02
181	10	-.03	1.43	-.09	-.13	-.08	-.04
181	11	.00	.00	-.10	-.02	.00	-.01
181	12	.00	.18	-.02	.00	-.03	.00
181	13	.00	.00	-.03	-.03	-.01	.00
181	14	.00	.28	-.02	-.03	.00	-.05
181	15	-.14	.28	-.13	.02	-.02	-.01
181	16	.01	-.46	.01	-.20	.00	.03
181	17	-.04	.20	-.04	-.04	.00	.00
181	18	.00	2.02	.00	.00	-.64	.09
181	19	-.06	.08	-.03	.02	-.01	.00
181	20	-.13	1.46	-.10	-.12	-.08	.23
181	21	.04	.38	.15	-.32	.08	-.06
181	22	.10	-.68	.07	-.03	.13	.23
181	23	-.04	1.26	-.48	-.67	.02	-.27
181	24	.00	.43	-.07	-.05	.00	.00
181	25	-.05	.07	.00	-.34	-.06	.15
181	26	-.04	1.63	.00	-.69	-.02	.04
181	27	-.08	.00	.00	.00	.00	-.05
181	28	.00	.00	.00	.00	.00	.00
181	29	-.07	.48	-.04	-1.53	.00	-.03
181	30	.00	.51	-.08	-.05	-.05	-.06
MEAN		-.04	.45	-.06	-.22	-.05	.02
SD		.05	.61	.11	.34	.13	.11

Kasetsart University students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
847	1	-.11	1.16	-.18	.70	-.43	.03
847	2	-.37	.95	-.06	-.37	-.04	.00
847	3	-.36	.66	-.32	-.44	-.08	.17
847	4	-.69	.99	-.06	-1.19	-.60	-.04
847	5	-.02	.06	-.01	-.01	-.01	.18
847	6	-.11	1.06	-.20	-.02	-.06	-.02
847	7	-.25	.83	-.34	-.62	-.54	.07
847	8	-.15	1.19	-.12	-.04	-.27	-.68
847	9	-.08	.73	-.03	-.47	-.32	.02
847	10	-.45	1.23	-.42	-.17	-.19	-.28
847	11	.14	.61	-.44	-.03	-.07	-.06
847	12	-.09	.49	-.06	-.04	-.05	.02
847	13	-.44	.99	-.28	-.81	-.35	.07
847	14	-.07	.71	-.02	.00	-.08	-.03
847	15	-.08	.50	-.12	.01	-.02	-.12
847	16	-.03	-.14	-.04	-.15	-.01	-.04
847	17	-.10	.41	-.14	-.15	-.08	.00
847	18	-.02	2.15	-.34	-.04	-.05	.09
847	19	-.19	.62	-.41	-.04	-.06	-.12
847	20	-.59	1.93	-.15	-.12	-.08	.23
847	21	-.16	1.20	.13	-.44	.06	.13
847	22	-.17	.24	-.14	-.19	.04	.21
847	23	-1.26	2.15	-.04	-.26	-.75	-.61
847	24	-.17	1.06	-.26	-.25	-.20	-.22
847	25	-.10	.00	-.05	-.25	-.10	.03
847	26	-.20	1.54	-.17	.38	-.04	.04
847	27	-.36	.83	-.08	1.84	-.69	.00
847	28	-.56	1.34	-.41	.31	-.42	-.16
847	29	-.66	2.06	-.27	.17	-.09	-.09
847	30	-.30	.73	-.12	-.13	-.15	.00

MEAN		-.27	.94	-.17	-.09	-.19	-.04
SD		.28	.60	.15	.51	.22	.20

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
428	1	-1.45	1.69	-2.17	2.14	-1.54	.02
428	2	-.20	1.03	-.13	.12	-.05	-.15
428	3	-.19	1.04	-.12	.20	-.20	.13
428	4	-.21	.58	-.39	-.25	-.25	-.34
428	5	-.06	.09	-.03	-.01	.02	-.10
428	6	-.05	.63	-.12	-.03	-.06	-.02
428	7	-.23	.76	-.31	-.16	-.19	.03
428	8	-.97	1.50	-.46	-.32	-.61	.15
428	9	-.05	.18	-.02	-.47	-.41	-.01
428	10	-.39	1.49	-1.08	-.02	-.26	-.07
428	11	-.15	.35	-.03	.00	-.19	.07
428	12	-.06	.23	-.04	-.03	-.03	.02
428	13	-.09	.33	-.07	-.09	-.27	.10
428	14	-.07	.71	-.12	.00	.00	-.05
428	15	-.07	.92	-.10	-.01	-.02	-.03
428	16	-.15	.05	-.09	.12	-.05	-.05
428	17	-.27	.66	-.29	-.15	-.08	.00
428	18	-.01	.78	-.15	-.08	.00	.02
428	19	-.54	.44	-.01	.02	.00	-.04
428	20	-.13	1.46	-.10	-.12	-.08	.06
428	21	-.53	1.31	.07	.05	.03	.13
428	22	.04	.10	-.09	-.03	.10	.12
428	23	-.68	1.73	.04	-.38	-.12	.04
428	24	-.50	1.36	-.75	-.72	-.69	-.78
428	25	-.77	.33	-.40	-.19	-.32	.21
428	26	-.93	1.72	-.32	.46	-.28	-.04
428	27	-.61	.56	.04	1.26	-.28	-.46
428	28	-.35	1.27	-.29	.46	-.05	-.21
428	29	-.28	1.81	-.35	.07	-.26	-.24
428	30	-.45	.73	-.15	-.68	-.59	.08

MEAN		-.35	.86	-.27	.04	-.22	-.05
SD		.35	.55	.43	.53	.32	.20

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
314	1	-1.85	1.69	-.24	.00	-2.15	.03
314	2	-1.03	1.15	-.08	.21	-.13	-.70
314	3	-1.44	1.13	-.76	-.25	-.61	.07
314	4	-.92	1.13	-.71	-.37	-.16	-.81
314	5	-.82	-.66	-.27	-.46	-.10	-.47
314	6	-.36	1.18	-.19	-.33	-.13	-.22
314	7	-1.19	.91	-.76	-.32	-1.26	-.45
314	8	-1.60	1.69	-.95	-1.04	-1.00	-.96
314	9	-1.21	1.37	-.34	-.54	-.47	-.99
314	10	-.53	1.68	-.74	-.09	-.45	-.98
314	11	-.34	.48	-.06	-.02	-.07	-.06
314	12	-.96	.40	-.14	-.44	-.09	-.03
314	13	-2.11	1.33	-2.11	-.21	-.01	.00
314	14	-1.00	.80	-.96	.06	-.22	-.21
314	15	-.67	1.06	-.28	.05	-.25	-.16
314	16	-.93	.49	-.62	.14	-1.00	-.03
314	17	-.72	.83	-.82	-.59	-1.03	.00
314	18	-1.06	2.18	-1.16	-2.12	-2.18	.17
314	19	-1.22	.74	-.47	-1.00	-.06	-.08
314	20	-2.18	2.18	-1.48	-.05	-.08	.02
314	21	-1.22	1.43	-.62	-.20	-.30	-.56
314	22	-1.27	.46	-1.27	-.28	-.89	-.03
314	23	-2.16	2.18	-.55	-.09	-1.85	-1.35
314	24	-1.70	1.39	-1.66	-1.66	-1.79	-.12
314	25	-2.08	.51	-.60	-.05	-.99	-.32
314	26	-2.11	1.88	-1.02	.64	-2.18	-1.84
314	27	-.15	.88	-2.03	2.18	-.13	-.99
314	28	-1.99	1.38	-2.14	.60	.07	-.24
314	29	-2.14	2.17	-2.18	.64	.00	-1.87
314	30	-1.55	.80	-1.26	-.98	-1.29	-.30

MEAN		-1.28	1.16	-.88	-.22	-.69	-.45
SD		.60	.65	.64	.75	.73	.55

Office workers

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
742	1	-1.22	.56	-.22	-.39	-.54	-.18
742	2	-.15	.38	-.21	-.13	-.15	-.02
742	3	-.53	1.14	-.32	-.60	-.75	-.12
742	4	-.83	1.76	-.11	-.01	-.01	-.80
742	5	-.38	1.20	-.11	-.24	-.03	-.06
742	6	.01	1.65	-.18	-.30	-.38	-.01
742	7	-.76	-.55	.08	-.57	-.59	.07
742	8	-1.00	.65	-.32	-.33	-.34	-.13
742	9	-.78	.82	-.16	-1.00	-1.17	.51
742	10	-.34	.72	.01	-.07	-.32	.01
742	11	-.53	.11	-.39	-.29	-.29	-.25
742	12	-1.81	1.21	-.77	-1.13	-1.25	-.14
742	13	-.60	.56	-.33	-.33	-.30	-.26
742	14	-.39	1.96	-.16	-.26	-.11	-.16
742	15	-.76	.46	-1.28	-.02	-.02	-.17
742	16	-.60	1.15	.05	-.32	-.29	-1.56
742	17	-1.13	.48	.04	-.47	-.72	.34
742	18	-.28	.09	-.42	-.28	.00	-.39
742	19	-1.26	1.39	-.63	-.12	-1.19	.06
742	20	-.27	.75	-.19	-.26	-.29	-.08
742	21	-.30	.54	-.10	-.68	-.27	-.48
742	22	-.20	-.39	-.38	-.55	-.55	-.01
742	23	-.11	.06	-.11	.10	.05	-.12
742	24	-2.15	1.27	-.29	-.14	-.14	-.11
742	25	-.80	1.68	-.34	-1.38	-.08	.00
742	26	.11	.79	-.10	-.04	-.22	.03
742	27	-2.16	.00	-1.69	-1.38	-1.23	-.64
742	28	-.11	.19	-.45	-.19	-.99	-.06
742	29	-.91	2.01	-.60	-.77	-.59	.17
742	30	-.66	1.64	-.25	-.21	-.27	-.21
MEAN		-.70	.81	-.33	-.41	-.43	-.14
SD		.58	.68	.38	.39	.39	.37

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
243	1	-.74	.85	-.90	-1.06	-.67	-.74
243	2	-.13	.38	-.21	-.16	-.15	-.31
243	3	-.32	1.08	-.16	-.22	-.41	.00
243	4	-.62	1.76	-.11	-.01	-.01	-.02
243	5	-.38	1.28	-.11	-.24	-.03	-.06
243	6	-.33	2.10	-.01	-.24	-.64	-.02
243	7	.00	.00	-.07	-.44	.06	-.12
243	8	-.07	.74	-.24	-.21	-.02	-.20
243	9	-.23	.72	-.12	-.50	-.87	-.15
243	10	-.40	1.03	-.01	-.05	-.38	.05
243	11	-.82	.59	-.46	-.39	-.06	.04
243	12	-.26	.51	-.17	-.14	-.15	.13
243	13	-.46	.52	-.84	-.52	-.37	-.53
243	14	-.82	2.06	-.66	-.60	-.09	-.19
243	15	-.18	.20	-.22	-.32	-.22	-.02
243	16	-1.21	1.25	-.12	-.46	-.58	-.63
243	17	-.16	.52	-.34	-.05	.00	.58
243	18	-1.55	.19	-.18	-.13	-.50	-.61
243	19	-.93	1.44	-.35	.00	-.53	-.23
243	20	-1.24	1.06	-.98	.07	-.07	-.18
243	21	-.05	.19	-.07	-.27	-.27	-.48
243	22	-.12	-.02	-.09	-.02	-.24	-.05
243	23	-.84	.10	-.48	.16	.14	-.08
243	24	-.77	1.17	-.36	-.27	-.11	-.06
243	25	-1.86	1.68	-.60	-.74	-.08	.00
243	26	.05	1.00	-.03	-.44	-.03	.08
243	27	-1.86	1.15	-.76	-.88	-.74	-.02
243	28	-.11	.26	-.20	.08	-.17	-.06
243	29	-.91	2.17	-.60	-.20	-.83	.11
243	30	-.50	1.91	-.53	-.33	-.51	.05
MEAN		-.59	.93	-.33	-.24	-.29	-.12
SD		.53	.66	.28	.32	.28	.27

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
557	1	.03	-.32	.02	-.04	.04	-.21
557	2	-.08	.03	-.07	-.05	-.03	-.02
557	3	.00	.51	.00	.00	.01	-.19
557	4	-.02	.65	-.01	-.01	-.01	-1.31
557	5	-.04	.27	-.14	-.14	-.03	-.08
557	6	-.01	.48	-.01	-.45	-.01	-.03
557	7	.31	.30	-.53	.75	-.36	-.27
557	8	.09	.39	-.07	-.08	-.09	-.07
557	9	.00	.00	.00	.00	.00	.00
557	10	.02	.74	-.38	-.02	-.03	-.09
557	11	.06	.28	.03	-.04	-.11	-.09
557	12	-.07	.44	-.14	-.05	-.10	-.05
557	13	-.21	.38	-.61	-.11	-.20	-.45
557	14	-.06	1.53	-.11	-.17	-.11	.04
557	15	.08	-.90	-.49	-.17	-.07	-.12
557	16	-.05	.35	-.19	-.69	-.92	-.95
557	17	.00	-.36	-.23	.00	.05	.00
557	18	-.05	-.53	-.27	-.20	-.37	-.15
557	19	.00	.60	.00	-.47	.00	.10
557	20	-.45	.89	-.52	-.13	-.16	-1.29
557	21	.00	.00	-.02	.00	.00	-.11
557	22	.08	.09	.07	.04	-.04	-.14
557	23	.00	.00	.14	.06	.19	-.21
557	24	-.20	-.43	-.18	-.04	-.03	-.02
557	25	.00	.00	-.30	-.43	.00	.00
557	26	.25	-1.00	-.01	-.04	.00	.03
557	27	-.04	2.12	-.18	-.22	-.19	-.84
557	28	-.04	.10	-.06	.04	-.29	.02
557	29	-.03	1.15	-.11	.20	-.04	-.11
557	30	.00	1.28	-.79	.00	.00	-.45
MEAN		-.01	.30	-.20	-.08	-.10	-.22
SD		.13	.67	.24	.24	.20	.38

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
181	1	-.18	.51	-.26	-.28	-.06	-.41
181	2	.00	-.11	-.03	-.02	.00	-.02
181	3	-.08	.93	-.10	-.14	-.21	.00
181	4	-.14	1.32	-.11	-.01	-.01	-.02
181	5	-.38	1.20	-.11	-.24	-.03	-.06
181	6	-.22	1.48	-.28	-.24	-.04	.00
181	7	.13	.13	-.28	.69	.13	-.05
181	8	.15	-.25	-.03	-.02	-.03	.02
181	9	-.20	.15	-.03	-.07	-.04	.09
181	10	-.01	.32	-.04	-.03	-.01	.04
181	11	.02	.33	.09	.02	-.04	.09
181	12	-.02	.37	-.10	-.07	-.10	.13
181	13	-.16	.32	-.21	-.19	-.14	-.18
181	14	-.45	1.85	-.14	-.42	-.08	.10
181	15	.13	-.90	-.39	-.32	-.22	-.23
181	16	.00	.00	.09	.00	.00	-.03
181	17	-.53	.00	-.05	-.20	-.39	.43
181	18	.00	.00	.00	.00	-.14	.00
181	19	-.11	.00	-.05	-.03	-.11	.00
181	20	.00	.00	.00	-.99	-1.01	.00
181	21	-.05	.19	-.07	.13	-.07	-.11
181	22	.07	-.65	.10	.06	-.01	-.01
181	23	-.03	.23	.00	-.04	.23	-.39
181	24	-.08	1.22	-.45	-.01	.02	.02
181	25	-.03	.00	-.30	.00	-.32	.00
181	26	.23	.26	-.01	.03	.00	.06
181	27	-.15	2.15	-.04	-.02	-.04	-.12
181	28	.00	.00	.00	.00	.00	.00
181	29	-.15	1.89	-.18	-.32	-.04	.17
181	30	-.06	.85	-.12	-.05	-.04	.10
MEAN		-.08	.46	-.10	-.09	-.09	-.01
SD		.17	.74	.14	.26	.21	.16

OFFICE WORKERS

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
847	1	-.55	.47	-.17	-.33	-.38	-.17
847	2	-.04	.15	-.07	-.08	-.07	-.02
847	3	-.15	1.00	-.03	-.04	-.06	-.00
847	4	-.27	1.32	-.11	-.01	-.01	-.02
847	5	-.18	.96	-.11	-.14	-.03	-.06
847	6	-.22	1.76	-.33	-.31	-.13	-.02
847	7	.00	.00	.00	.00	.00	.00
847	8	-.49	.55	-.41	-.50	-.21	-.29
847	9	-.16	.26	.03	-.38	-.27	.34
847	10	-.30	.70	-.07	-.08	-.08	.02
847	11	-.04	.54	-.09	-.20	-.49	-.38
847	12	-.63	1.13	-.45	-.36	-.39	.04
847	13	-.78	.61	-.15	-.26	-.46	-.12
847	14	-.38	1.92	-.20	-.10	-.09	.10
847	15	-.08	.20	-.28	-.17	-.11	-.08
847	16	-.48	1.11	.00	-.11	-.10	.00
847	17	-.27	.34	.00	-.11	-.22	.51
847	18	-.72	-.13	-.11	-.08	-.07	-.07
847	19	-.30	1.31	-.12	-.89	-.75	-.09
847	20	-.17	.97	-.09	.00	.00	-.28
847	21	-.30	.64	-.15	.13	-.66	.00
847	22	-.42	.05	-.03	-.07	-.11	-.51
847	23	-.07	.18	-.24	.12	.09	-.04
847	24	-.12	.46	-.23	-.08	-.07	.06
847	25	-.03	.00	.00	-.30	.00	.00
847	26	.13	.93	-.10	-.32	-.13	.05
847	27	-.84	2.02	-.08	-.07	-.08	-.08
847	28	-.40	-.13	-.12	-.05	-.66	-.03
847	29	-.65	2.01	-.30	.16	-.13	.22
847	30	-.12	1.51	-.05	-.11	-.11	-.30
MEAN		-.30	.76	-.14	-.16	-.19	-.03
SD		.25	.65	.12	.21	.22	.20

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
428	1	-1.64	.83	-.76	-.86	-.85	-.57
428	2	-.12	.38	-.21	-.16	-.15	-.02
428	3	-.32	1.14	-.23	-.27	-.29	.24
428	4	-.27	1.71	-.11	-.01	-.01	-.02
428	5	-.18	.96	-.11	-.14	-.03	-.06
428	6	-.14	1.48	-.17	-.39	-.32	-.02
428	7	-.11	.55	-.16	.69	.10	-.17
428	8	.05	.19	-.12	.13	-.13	-.01
428	9	-.29	.35	.06	-.45	-.65	.25
428	10	-.20	.67	-.02	-.06	-.05	.02
428	11	-.08	.21	-.31	-.12	-.36	-.05
428	12	-.22	.85	-.35	-.29	-.49	-.05
428	13	-.09	.26	-.45	-.68	-.09	-.36
428	14	-.43	1.89	-.05	-.31	-.09	.06
428	15	-.39	.46	-.73	-.02	-.02	-.02
428	16	-.86	1.19	-.06	-1.04	-1.67	-.08
428	17	-.27	.24	-.13	-.29	-.08	.65
428	18	-.40	-.28	-.07	-.03	-.24	-.26
428	19	-.66	1.22	-.23	-.64	-.77	.08
428	20	-.06	.52	-.30	-.52	-.46	-.63
428	21	-.30	.68	-.10	-.68	-.07	.13
428	22	-.04	.02	.04	.02	-.07	-.09
428	23	-.17	.27	.22	.00	.00	.00
428	24	-.14	1.25	-.09	-.19	-.19	.04
428	25	-1.02	.00	.00	-.04	.00	.00
428	26	.20	.26	-.08	-.23	-.01	.06
428	27	-1.12	2.08	-.12	-.14	-.14	-.04
428	28	-.61	-.32	-.31	-.12	-2.14	.01
428	29	-.48	2.10	-.30	.09	-.59	.22
428	30	-.89	1.75	.00	-.46	-.73	.00
MEAN		-.38	.73	-.18	-.25	-.35	-.02
SD		.40	.72	.21	.33	.50	.23

School students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
742	1	-.56	1.01	-.31	-.30	-.21	.20
742	2	-.65	1.07	-.29	.00	-.08	.30
742	3	-.91	.96	-.62	-.60	-.65	-.84
742	4	-1.57	1.86	-.15	-.13	-.87	-.17
742	5	-.61	1.99	-.43	-.73	-.11	-.05
742	6	-1.16	1.01	-2.09	-1.52	-.60	-.02
742	7	-.56	.91	-.18	-.24	-.20	-.01
742	8	-.35	2.03	-.05	-.34	-.73	-.06
742	9	-2.17	2.09	-.31	-1.57	-.12	-.08
742	10	-.36	1.61	-.15	-.20	-.49	.27
742	11	-1.16	.53	-.96	-.55	-1.56	-.18
742	12	-.44	-.37	-.03	.00	.00	-.08
742	13	-.48	-.18	.02	-.39	-.05	-.14
742	14	-.59	.91	-.46	-.37	-.51	.08
742	15	-.42	.42	-.35	-.22	-.29	.01
742	16	-2.08	.82	.03	-.20	-.60	-.54
742	17	-.65	.92	-.06	-.61	-.32	.28
742	18	-1.26	.00	-.95	-.80	-.03	-.31
742	19	-.57	1.22	-.38	-.59	-.09	.09
742	20	-.51	2.00	-.13	-.53	.00	-.11
742	21	.02	.30	.02	-.06	.00	-.11
742	22	-.43	1.44	-.14	-.81	-.08	-.12
742	23	-1.46	1.31	-.68	1.62	-.21	-.57
742	24	-.89	.12	.16	-.83	-.03	.14
742	25	-2.16	2.02	-.83	-.64	-1.18	-.48
742	26	-1.32	1.64	-.38	-.16	-.29	.22
742	27	-.27	.99	-.21	-.11	-.16	-.56
742	28	-.31	1.47	-.49	-.44	-.27	-.05
742	29	-2.17	2.16	-.34	-.18	-.26	.00
742	30	-.70	.79	-.16	-.18	-.17	-.05
MEAN		-.89	1.10	-.35	-.39	-.34	-.10
SD		.62	.71	.44	.54	.37	.27

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
243	1	-.09	1.09	-.37	-.16	-.68	-.18
243	2	-.51	1.02	-.64	-.13	-.17	.04
243	3	-.38	1.01	-.90	-.92	-.93	-.41
243	4	-.06	1.87	-.21	-.09	-1.47	-.06
243	5	-.12	2.04	-.47	-.95	-.27	-.10
243	6	-.41	1.06	-.27	-.64	-.06	-1.89
243	7	-.04	.50	-.17	.02	-.10	-.04
243	8	-.27	1.97	-.10	-.81	-.23	-.71
243	9	-1.21	2.17	-1.47	-.79	-.17	-1.03
243	10	-.04	.90	-.11	-.13	-.03	.11
243	11	-.05	1.43	-.05	-.64	.00	-.83
243	12	.23	.23	-.09	.10	.00	-.64
243	13	-.05	.18	-.08	-.06	-.38	-.08
243	14	-.07	1.22	-2.13	.18	-.09	.03
243	15	-.33	.35	-.31	-.16	-.20	-.20
243	16	.03	.58	-.35	.02	.02	.02
243	17	.34	.58	-.92	.27	-.50	.28
243	18	-.36	1.23	-.39	-.55	-.97	-.04
243	19	-.12	.77	-.29	-.19	-.04	.16
243	20	-.35	1.83	-.37	-.13	-.10	-.40
243	21	.09	.55	-.06	.02	-.02	-.53
243	22	-.10	1.81	-.44	-.45	-.05	-.05
243	23	-.69	1.25	-.09	1.55	-.18	-.10
243	24	-.24	.11	.14	.10	-.31	.05
243	25	-.67	2.12	-.56	-.28	-.48	-.72
243	26	-.08	1.19	-.57	-.02	-.11	-1.64
243	27	-.18	.79	-.07	-.11	-.02	-.29
243	28	-.21	1.68	-.75	-.72	-2.15	-.09
243	29	-.03	.60	-.06	.00	-.03	1.18
243	30	-.02	.75	-.37	.11	-.17	-.56
MEAN		-.20	1.10	-.42	-.18	-.33	-.29
SD		.30	.61	.46	.48	.49	.57

School students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
557	1	-.01	.07	-.18	-.01	-.00	.16
557	2	-.05	.43	-.09	-.11	-.38	-.48
557	3	.03	.00	.00	.06	.00	-.05
557	4	.00	.00	.00	-.60	.00	-1.86
557	5	-.09	1.20	-.06	-.66	-.10	-.45
557	6	.28	-.34	-.15	-.87	-.26	-.69
557	7	.03	.22	.13	-.06	-.06	-.12
557	8	.00	.70	-.17	-.16	-.06	-.09
557	9	-.03	2.14	-.89	-.03	-.21	-1.70
557	10	.01	.56	-.75	-.02	-.38	-.54
557	11	-.08	1.39	-.11	-.76	-.06	-.10
557	12	.30	-.58	-.36	.13	.00	-.51
557	13	.02	.56	-.64	-.39	-.05	-.24
557	14	.03	.22	-.57	-.03	-.26	-.53
557	15	-.10	.00	-.11	.03	-.07	-.15
557	16	-.09	-.35	-.50	-.63	-.07	-1.08
557	17	.38	.82	-.26	.02	-.15	.03
557	18	-.88	.40	-.61	-1.30	-.08	-.44
557	19	-.18	1.31	-.45	-.42	-.27	.05
557	20	.00	.78	-.37	-.08	-.05	-.40
557	21	.11	.07	-.23	-.28	-.26	.62
557	22	-.06	1.77	-.20	-.81	-.16	-.03
557	23	-.85	1.03	-.03	1.47	-.03	-1.06
557	24	.15	-.63	-.09	-.08	.07	-.11
557	25	-.03	1.20	-.01	-.02	-.02	-.11
557	26	-.02	.43	.02	-.06	-.03	-.86
557	27	.00	.18	-.02	.03	.00	-.09
557	28	-.09	.95	-.20	-.22	-.07	-.26
557	29	-2.17	2.18	-1.03	.16	-.71	1.43
557	30	.11	.00	-.51	.00	.00	-.77
MEAN		-.11	.56	-.28	-.20	-.11	-.39
SD		.47	.74	.29	.47	.15	.59

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
181	1	-.03	.30	-.10	-.02	-.01	.19
181	2	.02	-.23	-.02	.06	-.05	-.19
181	3	.00	.38	-.06	.00	-.11	.00
181	4	-.13	1.81	-.10	.00	-.09	.00
181	5	-.18	.85	-.03	-.77	-.08	-.41
181	6	-.25	.00	-1.04	-.51	-1.14	-.41
181	7	-.07	.15	.11	-.02	-.04	.01
181	8	-.20	1.64	-.14	-.08	-.06	-.04
181	9	-.13	1.00	-.05	-.12	-.04	-.04
181	10	-.01	.85	-.07	-.14	-.05	.02
181	11	-.12	1.35	-.15	-.51	-.20	-.13
181	12	.00	.00	.00	-.06	.00	.00
181	13	-.31	.36	-.25	-.06	-.38	.00
181	14	-.01	1.11	-.70	-.14	-.61	-.04
181	15	-.01	-.18	-.06	.08	-.04	-.26
181	16	-.27	-.70	-.24	-1.17	-.02	-.29
181	17	.28	.27	-.35	-.03	-.26	-.03
181	18	.00	1.10	-.04	-.03	-.19	-.07
181	19	-.03	.90	-.10	-.13	-.14	.00
181	20	-.09	1.48	-.13	-.08	.00	.00
181	21	.06	.11	-.17	-.96	.04	-.25
181	22	-.22	.90	-.35	-.30	-.05	.00
181	23	-1.08	.95	-.01	1.66	-1.21	-.07
181	24	.03	-.06	.09	-.50	.03	.12
181	25	-.06	1.41	-.73	-.07	-.14	-.06
181	26	-.71	1.44	-.04	-.54	-.40	.16
181	27	.00	.00	.00	.00	.00	.00
181	28	.00	.00	.00	.00	.00	.00
181	29	-.08	.00	-.02	-.39	-.08	1.75
181	30	.04	.26	.00	-.18	-.39	-.29
MEAN		-.10	.58	-.16	-.17	-.19	-.01
SD		.25	.66	.25	.46	.31	.36

School students

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
847	1	-.39	.90	-.14	-.24	-.04	-.02
847	2	-.21	.58	-.41	-.05	-.24	.18
847	3	-.16	.58	-.28	-.16	-.29	-.33
847	4	-.10	.88	-.05	-.04	-.04	-.24
847	5	-.15	1.45	-.40	-.69	-.14	-.02
847	6	-.02	.47	-.01	-.27	-.46	.22
847	7	-.21	.64	-.06	-.20	-.03	.05
847	8	-.18	1.82	-.12	-.26	-.16	-.25
847	9	-.16	1.48	-.71	-.17	-.03	-.71
847	10	-.32	1.48	-.14	-.18	-.28	.25
847	11	-.96	.86	-.49	-.47	-.78	-.07
847	12	.10	.11	-.06	.18	-.09	-.04
847	13	-.01	.00	.09	-.39	-.05	-.04
847	14	-.11	1.07	-.20	-.44	-.04	-.44
847	15	-.17	.30	-.19	-.11	-.11	-.02
847	16	-.70	.86	-.09	-.42	-1.10	.08
847	17	.05	.74	-.12	-.25	-.53	.22
847	18	-.29	.74	-.20	.00	-.53	-.01
847	19	.00	1.29	-.15	-.88	-1.04	-.11
847	20	-.51	1.93	-.22	-.43	.00	-.31
847	21	-.06	.14	-.11	-.22	-.05	-.01
847	22	-.91	1.83	-.28	-.81	-.10	-.03
847	23	-.31	1.35	-.07	.37	-.06	-.76
847	24	.09	-.10	-.03	.04	.05	-.05
847	25	-.21	1.32	-.69	-.20	-.09	-.39
847	26	-.49	.99	-.10	-.27	-.17	.09
847	27	-.18	.79	-.12	-.07	-.02	-.24
847	28	-.15	1.28	-.35	-.12	-.38	-.20
847	29	-.35	1.83	-.21	-.77	-.13	1.99
847	30	-.22	.61	-.25	-.18	.00	-.11
MEAN		-.24	.94	-.20	-.26	-.23	-.04
SD		.26	.56	.18	.28	.30	.45

SAMPLE	PANEL	SLIP	DEFORM	COATING	ADJUST	SMOOTH	STICK
428	1	-.97	1.06	-.01	-.39	-.31	.15
428	2	-.37	.98	-.19	-.48	-.28	.24
428	3	-.58	.92	-.47	-.42	-.43	-.52
428	4	-.92	1.84	-.07	-.06	-.20	-.11
428	5	-.76	1.83	-.35	-.85	-.19	-.37
428	6	-.21	.19	-.59	-.01	-.01	.18
428	7	-.13	.72	.06	-.11	-.15	-.15
428	8	-.20	1.64	-.14	-.12	-.06	-.04
428	9	-.07	1.28	-.13	-.08	-.08	-.49
428	10	-.07	1.35	-.18	-.22	-.22	.35
428	11	-1.47	.70	-.74	-.94	-1.16	-.40
428	12	.27	.27	.02	.05	.00	-.04
428	13	-.11	.09	-.46	-.06	-.38	-.20
428	14	.01	.51	-.36	-.23	-.43	-.65
428	15	-.26	.19	-.26	-.05	-.14	-.07
428	16	-.43	.24	-.82	-.04	-.18	.13
428	17	-.15	.68	-.31	.00	-.32	.28
428	18	-.62	1.17	.00	-.09	-.26	-.20
428	19	-.25	1.09	-.20	-.30	-.17	.20
428	20	-.39	1.83	-.32	-.43	-.05	-.31
428	21	-.18	.45	-.03	-.13	-.38	.01
428	22	-.61	.90	-.03	-.30	-.36	-.08
428	23	-.03	.40	-.50	1.51	-.13	-.03
428	24	.09	-.04	.03	-.01	-.18	.09
428	25	-.34	1.76	-.05	-.05	-.12	-.23
428	26	-.22	1.30	-.23	-1.00	-.87	.02
428	27	-.09	.59	-.07	.00	-.04	-.03
428	28	-.12	1.17	-.27	-.32	-.15	-.15
428	29	.00	.95	.00	-.59	.00	2.18
428	30	-.35	.49	-.07	-.45	.00	.00
MEAN		-.31	.89	-.22	-.21	-.24	-.01
SD		.37	.56	.23	.43	.25	.48

APPENDIX 9.1

Questionnaire for Final Product Testing

คำอธิบาย ผลผลิตกาวแท่งที่ท่านได้รับนี้เป็นผลผลิตที่ได้มีการพัฒนาขึ้นใหม่ เพื่อผู้บริโภคคนไทยโดยใช้ผลผลิตจากแป้งมันสำปะหลังที่ผลิตได้ในประเทศไทยเป็นวัตถุดิบหลัก ผลที่ได้จากการทดสอบครั้งนี้จะนำไปใช้เป็นแนวทางในการปรับปรุงผลผลิตเพื่อการผลิตและการจำหน่ายในประเทศต่อไป

คำแนะนำ กรุณาทดลองใช้ผลผลิตกาวแท่งที่แจกให้ในลักษณะเดียวกับที่ท่านเคยใช้กาวแท่งความปกติ หลังจากที่ได้ทดลองใช้อย่างน้อย 2-3 ครั้ง กรุณาตอบคำถามในแบบสอบถามที่ได้แนบมาด้วย โดยทำเครื่องหมาย / ลงในวงเล็บ () หน้าคำตอบที่ท่านเห็นว่าเหมาะสมที่สุด หรือกรอกข้อความในช่องว่างโดยให้รายละเอียดให้มากที่สุด

* **หมายเหตุ** กรุณาตอบแบบสอบถามให้เสร็จภายในวันที่ ____ มิถุนายน 2536

ส่วนที่ 1 ข้อมูลเกี่ยวกับการใช้กาวแท่ง

1. ท่านใช้กาวแท่งบ่อยเพียงใด

- () วันละ 3-4 ครั้ง
() วันละ 1 ครั้ง
() สัปดาห์ละ 2-3 ครั้ง
() เดือนละ 2-3 ครั้ง
() น้อยกว่าเดือนละครั้ง
() อื่น ๆ (โปรดระบุ) _____

2. กรุณาบอกที่มาของกาวแท่งที่ท่านใช้ประจำ

- () ซื้อมาใช้เอง
() ที่ทำงานจัดหาให้
() อื่น ๆ (โปรดระบุ) _____

3. ความปกติท่านใช้กาวแท่งยี่ห้ออะไร

- () UHU
() PRITT
() PELIKAN
() อื่น ๆ (โปรดระบุ) _____

4. ท่านใช้กาวแท่งขนาดใด

- () ขนาดเล็ก ประมาณ 8 กรัม (ขนาดเท่ากับกาวที่แจกให้)
() ขนาดใหญ่ ประมาณ 21 กรัม

ส่วนที่ 2 เมื่อท่านได้ทดลองใช้ผลผลิตกาวแท่งที่แจกให้แล้ว กรุณาตอบคำถามต่อไปนี้

* **หมายเหตุ** เนื่องจากทางผู้วิจัยไม่สามารถหาเครื่องบรรจุกาวแท่งที่เหมาะสมสำหรับกาวแท่งได้ กรุณาพิจารณาการยอมรับจากคุณสมบัติของกาวแท่งเท่านั้น ไม่รวมการหมุนขึ้น-ลงของกาว

5. กรุณาอธิบายว่าท่านได้ทดลองใช้ผลผลิตกาวแท่งที่แจกให้อย่างไร (เช่น ติดกระดาษเข้าด้วยกัน ติดรูปบนกระดาษ ติดผ้าบนกระดาษ เป็นต้น)

6. ท่านยอมรับผลิตภัณฑ์นี้หรือไม่

- () บอรับ
() ไม่ยอมรับ ถ้าท่านไม่ยอมรับ กรุณาให้เหตุผล

7. กรุณาเปรียบเทียบผลผลิตกาวแท่งนี้ กับกาวแท่งที่ท่านใช้อยู่ประจำ

- () ดีกว่ามาก
() ดีกว่าเล็กน้อย
() เท่าเทียมกัน
() ค่อนข้างดีกว่าเล็กน้อย
() ค่อนข้างมาก

ถ้าท่านตอบว่าดีกว่าหรือดีกว่า กรุณาให้เหตุผลว่าผลผลิตกาวแท่งนี้ต่างจากกาวแท่งที่ท่านใช้อยู่อย่างไร

8. ท่านคิดว่าจะซื้อหรือแนะนำให้ที่ทำงานของท่านซื้อผลิตภัณฑ์กาวแท่งนี้หรือไม่
 () ซื้อ/แนะนำ
 () ไม่ซื้อ/ไม่แนะนำ
9. ท่านคิดว่าผลิตภัณฑ์กาวแท่งนี้ควรขายในราคาใด (น้ำหนักบรรจุเท่ากับกาวที่ท่านใช้ประจำ)

- () ราคาสูงกว่าผลิตภัณฑ์กาวแท่งที่ท่านใช้ประจำมาก
 () ราคาสูงกว่าผลิตภัณฑ์กาวแท่งที่ท่านใช้ประจำเล็กน้อย
 () ราคาเท่ากับผลิตภัณฑ์กาวแท่งที่ท่านใช้ประจำ
 () ราคาต่ำกว่าผลิตภัณฑ์กาวแท่งที่ท่านใช้ประจำเล็กน้อย
 () ราคาต่ำกว่าผลิตภัณฑ์กาวแท่งที่ท่านใช้ประจำมาก

10. ลักษณะต่อไปนี้ เป็นลักษณะเฉพาะตัวของผลิตภัณฑ์กาวแท่งนี้ ลักษณะข้อใดจะมีส่วนจูงใจให้ท่านซื้อหรือทดลองใช้ผลิตภัณฑ์ ถ้ามีการวางจำหน่ายในท้องตลาด

กรุณาเลือกตอบไม่เกิน 3 ข้อ โดยให้คะแนนดังนี้

- 1 = มีส่วนจูงใจมากที่สุด
 2 = มีส่วนจูงใจเป็นอันดับ 2
 3 = มีส่วนจูงใจเป็นอันดับ 3

- () ผลิตในประเทศไทย
 () ผลิตจากแป้งมันสำปะหลังของไทย
 () ปลอดภัยต่อสิ่งแวดล้อม
 () ปลอดภัยต่อผู้ใช้
 () เป็นผลิตภัณฑ์ที่พัฒนาขึ้นใหม่
 () ราคาถูกกว่ากาวแท่งอื่น ๆ ในท้องตลาด

11. กรุณาให้คำแนะนำที่ท่านคิดว่าจะ เป็นประโยชน์ในการพัฒนาปรับปรุง และส่งเสริมการตลาดของผลิตภัณฑ์กาวแท่งนี้

ขั้นที่ 3

รายละเอียดของผู้ตอบแบบสอบถาม

- เพศ () หญิง () ชาย
 อายุ () 5-15 ปี () 16-20 ปี () 21-30 ปี
 () 31-40 ปี () มากกว่า 40 ปี
 อาชีพ () นักเรียน () นิสิต นักศึกษา
 () ข้าราชการ () พนักงานบริษัทเอกชน

กรุณาให้ความเห็นหรือข้อเสนอแนะ เกี่ยวกับการออกแบบสอบถามครั้งนี้ _____

ขอพระคุณอย่างสูง

ผู้วิจัย

APPENDIX 9.1 (continued)

Questionnaire for Final Product Testing (Translation from Thai)

The sample you have been given is a new glue stick product. This product was developed in Thailand for Thai consumers. It is made from tapioca flour produced in Thailand as the basic ingredient. We should like you to test it now so that it can be developed further for production and marketing in Thailand.

Instruction

Please use the given sample as you would use glue stick normally. Then complete the accompanying questionnaire after you have tried the sample at least three times.

Please place a tick in front of the answer nearest to your answer for the question. Where we have left a space for you to write, please give as detailed an answer as possible.

Note: The questionnaire will be collected by the interviewer by __ June 93.

PART I

1. How often do you use glue stick?

- ☐ 3-4 times a day
☐ Once a day
☐ 2-3 times a week
☐ 2-3 times a month
☐ Less than once a month
☐ Other (please specify) _____

2. Do you buy the glue stick you use or it is provided by the office?

- ☐ Buy the glue stick myself
☐ Provided by the office
☐ Other (please specify) _____

3. What brand of glue stick do you normally use?

- ☐ UHU
☐ PRIT
☐ PELIFIX
☐ Other (please specify) _____

4. What size of glue stick do you normally use?

- ☐ Small 8 grams
☐ Medium 21 grams
☐ Large 40 grams

PART II

Now please answer the following questions after you have tested the new glue stick.

Note: Since a suitable machine for glue stick packing was not available, please evaluate acceptability from glue stick characteristic only, not the turning up and down of the stick

5. Please explain how you tried the glue stick sample (e.g. stick paper together, stick photo onto paper, stick fabric onto paper etc.)

6. Was the new glue stick product acceptable when you used it?

- ☐ Yes
☐ No If not acceptable, please tell us what was wrong with it.

7. How does this product compare to the glue stick you usually use?

- ☐ Very much better
☐ Slightly better
☐ The same
☐ Slightly worse
☐ Very much worse

If better or worse, please tell us how it is different from your present glue stick.

8. Would you purchase or recommend to your company to purchase this new glue stick?

- ☐ Yes
☐ No

9. At what price you think this glue stick should be sold?

- ☐ Very much higher than the one you normally use
☐ Slightly higher than the one you normally use
☐ The same price as the one you normally use
☐ Slightly lower than the one you normally use
☐ Very much lower than the one you normally use

10. If this glue stick was available on the market, which ones of the following would attract you to purchase or try it. Please select three characteristics and give scores

- 1 - Most attractive
2 - Second attractive
3 - Third attractive

- ☐ Made in Thailand
☐ Made from Thai tapioca
☐ Environmentally friendly
☐ Safe
☐ New product
☐ Cheaper than the ones already in the market

11. Please make any other comments that could help us to develop and market this product.

PART IV Personal details

Age ☐ 5 to 15 ☐ 16-20 ☐ 21-30
 ☐ 31-40 ☐ Over 40

Occupation ☐ School student
 ☐ College/University student
 ☐ Government office worker
 ☐ Private sector office worker

APPENDIX 9.2 Summary of Results from Final Product Testing

Question 1: How often do you use glue stick?

Source	3-4 times a day	Once a day	2-3 times a week	2-3 times a month	Once a month	Row total
University		1 (1.8%)	11 (20.0%)	24 (43.6%)	19 (34.5%)	55 (32.0%)
School	1 (1.9%)	2 (3.8%)	27 (50.9%)	18 (34.0%)	5 (9.4%)	53 (30.8%)
Govern.	8 (23.5%)	4 (11.8%)	8 (23.5%)	11 (32.4%)	3 (8.8%)	34 (19.8%)
Private	4 (13.3%)	4 (13.3%)	10 (33.3%)	10 (33.3%)	2 (6.7%)	30 (17.4%)
Col. total	13 (7.6%)	11 (6.4%)	56 (32.6%)	63 (36.6%)	29 (16.9%)	172 (100.0%)

Chi-square = 50.583 df = 12 Significance = 0.000

Comparison	Chi-square	df	Significance
Univ&School	17.063	4	0.002
Govern&Private	1.559	4	0.816
(Govern+Private)&Univ	26.974	4	0.000
(Govern+ Private)&School	14.028	4	0.007

Source	3-4 times a day	Once a day	2-3 times a week	2-3 times a month	Once a month	Row total
Govern+Private	12 (18.8%)	8 (12.5%)	18 (28.1%)	21 (32.8%)	5 (7.8%)	64 (37.2%)
School	1 (1.9%)	2 (3.8%)	27 (50.9%)	18 (34.0%)	5 (9.4%)	53 (30.8%)
University		1 (1.8%)	11 (20.0%)	24 (43.6%)	19 (34.5%)	55 (32.0%)
Column total	13 (7.6%)	11 (6.4%)	56 (32.6%)	63 (36.6%)	29 (16.9%)	172 (100.0%)

Question 2: Do you buy the glue stick you use or it is provided by your office?

Source	Buy	Provided	Others	Row total
University	51 (92.7%)	4 (7.3%)		55 (32.0%)
School	50 (94.3%)	3 (5.7%)	3 (5.7%)	53 (30.8%)
Government	8 (23.5%)	25 (73.5%)	1 (2.9%)	34 (19.8%)
Private	2 (6.7%)	28 (93.3%)		30 (17.4%)
Column total	111 (64.5%)	57 (33.1%)	4 (2.3%)	172 (100.0%)

Chi-square = 121.267 df = 6 Significance = 0.000

Comparison	Chi-square	df	Significance
Univ&School	6.98	2	0.031
Govern&Private	4.54	2	0.103
(Govern+Private)&Univ	70.40	2	0.000
(Govern+Private)&School	80.34	2	0.000

Source	Buy	Provided	Others	Row total
University	51 (92.7%)	4 (7.3%)		55 (32.0%)
School	50 (94.3%)	3 (5.7%)	3 (5.7%)	53 (30.8%)
Govern+Private	10 (15.6%)	53 (82.8%)	1 (1.6%)	64 (37.2%)
Column Total	111 (64.5%)	57 (33.1%)	4 (2.3%)	172 (100.0%)

Question 3: What brand of glue stick do you normally use?

Source	UHU	PRITT	PELIJIX	Others	Row total
University	54 (98.2%)	1 (1.8%)			55 (32.0%)
School	45 (84.9%)	7 (13.2%)		1 (1.9%)	53 (30.8%)
Govern	31 (91.2%)		2 (5.9%)	1 (2.9%)	34 (19.8%)
Private	25 (83.3%)		2 (6.7%)	3 (10.0%)	30 (17.4%)
Col. total	155 (90.1%)	8 (4.7%)	4 (2.3%)	5 (2.9%)	172 (100.0%)

Chi-square = 26.755 df = 1 Significance = 0.002

Comparison	Chi-square	df	Significance
Univ&School	6.28	2	0.043
Govern&Private	1.40	2	0.497
(Govern+Private)&Univ	8.40	3	0.038
(Govern+Private)&School	13.08	3	0.004

Source	UHU	PRITT	PELIJIX	Others	Row total
University	54 (98.2%)	1 (1.8%)			55 (32.0%)
School	45 (84.9%)	7 (13.2%)		1 (1.9%)	53 (30.8%)
Govern+Private	56 (87.5%)		4 (6.3%)	4 (6.3%)	64 (37.2%)
Column total	155 (90.1%)	8 (4.7%)	4 (2.3%)	5 (2.9%)	172 (100.0%)

Question 4: What size of glue stick do you normally use?

Source	Small	Medium	Large	Row total
University	43 (78.2%)	12 (21.8%)		55 (32.0%)
School	38 (71.7%)	15 (28.3%)		53 (30.8%)
Govern	13 (38.2%)	19 (59.9%)	2 (5.9%)	34 (19.8%)
Private	21 (70.0%)	9 (30.0%)		30 (17.4%)
Column total	115 (66.9%)	55 (32.0%)	2 (1.2%)	172 (100.0%)

Chi-square = 21.68 df = 6 Significance = 0.001

Comparison	Chi-square	df	Significance
Univ&School	0.605	1	0.437
Govern&Private	7.23	2	0.027
(Univ+School)&Private	0.034	1	0.581
(Univ+School)&Govern	19.25	2	0.000
(Univ+School+Private)&Govern	28.885	2	0.000

Source	Small	Medium	Large	Row total
Univ+School+Private	102 (73.9%)	36 (26.1%)		138 (80.2%)
Govern	13 (38.2%)	19 (59.9%)	2 (5.9%)	34 (19.8%)
Column total	115 (66.9%)	55 (32.0%)	2 (1.2%)	172 (100%)

Question 6: Was the new glue stick product acceptable?

Source	Acceptable	Not acceptable	Row total
University	39 (70.9%)	16 (29.1%)	55 (32.0%)
School	36 (67.9%)	12 (32.1%)	53 (30.8%)
Govern	23 (67.6%)	11 (32.4%)	34 (19.8%)
Private	19 (63.3%)	11 (36.7%)	30 (17.4%)
Column total	117 (68.0%)	55 (32.0%)	172 (100%)

Chi-square = 0.156 df = 3 Significance = 0.915

Question 7: How does this product compare to the glue stick you usually used?

Source	Very much better	Slightly better	The same	Slightly worse	Very much worse	Row total
University	1 (1.8%)	7 (12.7%)	19 (34.5%)	22 (40.0%)	6 (10.9%)	55 (32.0%)
School	1 (1.9%)	9 (17.0%)	14 (26.4%)	23 (43.4%)	6 (11.3%)	53 (30.8%)
Govern		6 (17.6%)	10 (29.4%)	13 (38.2%)	5 (14.7%)	34 (19.8%)
Private	2 (6.7%)	3 (10.0%)	6 (20.0%)	14 (46.7%)	5 (16.7%)	30 (17.4%)
Column total	4 (2.3%)	25 (14.5%)	49 (28.5%)	72 (41.9%)	22 (12.8%)	172 (100.0%)

Chi-square = 6.196 df = 12 Significance = 0.863

Question 8: Would you purchase or recommend to your office to purchase this new glue stick?

Source	Yes	No	Row total
University	31 (56.4%)	24 (43.6%)	55 (32.0%)
School	30 (56.6%)	23 (43.4%)	53 (30.8%)
Government	22 (64.7%)	12 (35.3%)	34 (19.8%)
Private	15 (50.0%)	15 (50.0%)	30 (17.4%)
Column total	98 (57.0%)	74 (43.0%)	172 (100.0%)

Chi-square = 1.436 df = 7 Significance = 0.697

Question 9: At what price you think this glue stick should be sold?

Source	Slightly higher	The same	Slightly lower	Very much lower	Row total
University		12 (21.8%)	37 (67.3%)	6 (10.9%)	55 (32.0%)
School	3 (5.7%)	4 (7.5%)	38 (72.2%)	8 (15.1%)	53 (30.8%)
Government		6 (17.6%)	24 (70.6%)	4 (11.8%)	34 (19.8%)
Private	1 (3.3%)	5 (16.7%)	18 (60.0%)	6 (20.0%)	30 (17.4%)
Column total	4 (2.3%)	27 (15.7%)	117 (68.0%)	24 (14.0%)	172 (100.0%)

Chi-square = 10.135 df = 9 Significance = 0.340

Question 10: If this glue was available on the market, which ones would attract you to purchase or try it?

Please choose three characteristics and give the score

1 - Most attractive

2 - Second attractive

3 - Third attractive

Made in Thailand

Source	Most attractive	Second attractive	Third attractive	Not attractive	Row total
University	8 (14.5%)	7 (12.7%)	9 (16.4%)	31 (56.4%)	55 (32.0%)
School	4 (7.5%)	17 (32.1%)	4 (7.5%)	28 (52.8%)	53 (30.8%)
Government	4 (11.8%)	10 (29.4%)	5 (14.7%)	15 (44.1%)	34 (19.8%)
Private	8 (26.7%)	6 (20.0%)	4 (13.3%)	12 (40.0%)	30 (17.4%)
Column total	24 (14.0%)	40 (23.3%)	22 (12.8%)	86 (50.0%)	172 (100%)

Chi-square = 13.408 df = 9 Significance = 1.145

Made from Thai Tapioca

Source	Most attractive	Second attractive	Third attractive	Not attractive	Row total
University	12 (21.8%)	12 (21.8%)	6 (10.9%)	25 (45.5%)	55 (32.0%)
School	12 (22.6%)	11 (20.8%)	9 (17.0%)	21 (39.6%)	53 (30.8%)
Government	6 (17.6%)	9 (26.5%)	3 (8.8%)	16 (47.1%)	34 (19.8%)
Private	6 (20.0%)	6 (20.0%)	2 (6.7%)	16 (53.3%)	30 (17.4%)
Column total	36 (20.9%)	38 (22.1%)	20 (11.6%)	78 (45.3%)	172 (100.0%)

Chi-square = 3.704 df = 9 significance = 0.903

Environmental friendly

Source	Most attractive	Second attractive	Third attractive	Not attractive	Row total
University	16 (29.1%)	13 (23.6%)	7 (12.7%)	19 (34.5%)	55 (32.0%)
School	24 (45.3%)	15 (28.3%)	7 (13.2%)	7 (13.2%)	53 (30.8%)
Government	3 (8.8%)	9 (26.5%)	2 (8.8%)	19 (55.9%)	34 (19.8%)
Private	5 (16.7%)	8 (26.7%)	3 (10.0%)	14 (46.7%)	30 (17.4%)
Column total	48 (27.9%)	45 (26.2%)	20 (11.6%)	59 (34.3%)	172 (100.0%)

Chi-square = 25.086 df = 9 Significance = 0.003

Comparisons	Chi-square	df	Significance
Univ&School	7.247	3	0.064
Govern&Private	1.071	3	0.784
(Govern+Private)&School	24.282	3	0.000
(Govern+Private)&Univ	6.402	3	0.094
(Govern+Private+Univ)&School	18.524	3	0.000

Source	Most attractive	Second attractive	Third attractive	Not attractive	Row total
School	24 (45.3%)	15 (28.3%)	7 (13.2%)	7 (13.2%)	53 (30.8%)
Univ+Govern+Private	24 (20.2%)	30 (25.2%)	13 (10.9%)	52 (43.7%)	119 (69.2%)
Column total	48 (27.9%)	45 (26.2%)	20 (11.6%)	59 (34.3%)	172 (100.0%)

Safe

Source	Most attractive	Second attractive	Third attractive	Not attractive	Row total
University	15 (27.3%)	14 (25.5%)	3 (5.5%)	23 (41.8%)	55 (32.0%)
School	23 (43.4%)	8 (15.1%)	8 (15.1%)	14 (26.4%)	53 (30.8%)
Government	9 (26.5%)	8 (23.5%)	1 (2.9%)	16 (47.1%)	34 (19.8%)
Private	10 (33.3%)	7 (23.3%)	3 (10.0%)	10 (33.3%)	30 (17.4%)
Column total	57 (33.1%)	37 (21.5%)	15 (8.7%)	63 (36.6%)	172 (100%)

Chi-square = 11.746 df = 9 Significance = 0.228

New Product

Source	Most attractive	Second attractive	Third attractive	Not attractive	Row total
University	6 (10.9%)	5 (9.1%)	10 (18.2%)	34 (61.8%)	55 (32.0%)
School	8 (15.1%)	8 (15.1%)	6 (11.3%)	31 (58.5%)	53 (30.8%)
Government	4 (11.8%)	8 (23.5%)	1 (2.9%)	21 (61.8%)	34 (19.8%)
Private	5 (16.7%)	6 (20.0%)	7 (23.3%)	12 (40.0%)	30 (17.4%)
Column total	23 (13.4%)	27 (15.7%)	24 (14.0%)	98 (57.0%)	172 (100%)

Chi-square = 11.617 df = 9 Significance = 0.256

Cheaper than the ones already in the market

Source	Most attractive	Second attractive	Third attractive	Not attractive	Row total
University	8 (14.5%)	8 (14.5%)	9 (16.4%)	30 (54.5%)	55 (32.0%)
School	11 (20.8%)	11 (20.8%)	12 (22.6%)	19 (35.8%)	53 (30.8%)
Government	2 (5.9%)	10 (29.4%)	5 (14.7%)	17 (50.0%)	34 (19.8%)
Private	9 (30.0%)	2 (6.7%)	2 (6.7%)	17 (56.7%)	30 (17.4%)
Column total	30 (17.4%)	31 (18.0%)	28 (16.3%)	83 (48.3%)	172 (100.0%)

Chi-Square = 16.773 df = 9 Significance = 0.052

APPENDIX 9.3

Cross-tabulation of 'Reason Consumers Thought that the Developed Glue Stick was Better or Worse than their Glue Stick' by 'Acceptability'

Reason	Accept	Not accept	Row total
Weaker bond	50 (65.8%)	44 (86.3%)	94 (74.0%)
Stronger bond	6 (7.9%)		6 (4.7%)
Not messy	6 (7.9%)		6 (7.4%)
Dry slowly	4 (5.3%)	4 (7.8%)	8 (6.3%)
Disintegrate	3 (3.9%)	1 (2.0%)	4 (3.1%)
Low disintegrate	2 (2.6%)	1 (2.0%)	3 (2.4%)
No unpleasant odour	1 (1.3%)		1 (0.8%)
Not wrinkly	1 (1.3%)		1 (0.8%)
Very slippery	1 (1.3%)		1 (0.8%)
Colour too white	1 (1.3%)		1 (0.8%)
Messy	1 (1.3%)		1 (0.8%)
Low degree of coating		1 (2.0%)	1 (0.8%)
Column total	76 (59.8%)	51 (40.2%)	127 (100.0%)

APPENDIX 9.4

Cross-tabulation of Comparison of Developed Glue Stick with Glue Stick Consumers Normally Used by Purchase Intention

Source	Buy	Not buy	Row Total
Very much better	4 (100.0%)		4 (2.3%)
Slightly better	22 (88.0%)	3 (12.0%)	25 (14.5%)
The same	46 (93.9%)	3 (6.0%)	49 (28.5%)
Slightly worse	25 (34.7%)	47 (65.3%)	72 (41.9%)
Very much worse	1 (4.5%)	21 (95.5%)	22 (12.8%)
Column total	98 (57.0%)	74 (43.0%)	172 (100.0%)

Chi-square = 79.273 df = 4 Significance = 0.000

Comparison	Chi-square	df	Significance
Very much&slightly better	0.535	1	0.464
(Very much+slightly better)&the same	0.457	1	0.499
Very much&slightly worse	7.669	1	0.006
(Better+the same)&slightly worse	54.337	1	0.000
(Better+the same)&very much worse	67.057	1	0.000

Source	Buy	Not buy	Row total
Better+the same	72 (92.3%)	6 (7.7%)	78 (45.3%)
Slightly worse	25 (34.7%)	47 (65.3%)	72 (41.9%)
Very much worse	1 (4.5%)	21 (95.5%)	22 (12.8%)
Column total	98 (57.0%)	74 (43.0%)	172 (100.0%)