DEVELOPMENT OF A WHEY PROTEIN-ENRICHED ORANGE DRINK FOR THE JAPANESE MARKET

A Thesis presented in partial fulfilment of the requirements for the degree of Master of Philosophy in Food Technology at Massey University.

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ABSTRACT

A whey protein fortified orange beverage was developed for the Japanese market as a result of this project.

Whey protein concentrates are unique protein ingredients with high nutritional values and varied functionality. They are produced in New Zealand in increasing quantities and, as they are not fully utilised in Japan, the Japanese market is seen as a major potential outlet.

Product idea generation techniques were used to create a range of *66* new product ideas for the Japanese market, incorporating whey protein concentrates. After screening, the most promising new product idea was a protein enriched orange juice. The concept of a health food drink enriched with whey protein and vitamin C was developed.

Functionality of the whey proteins in whey protein concentrates (WPC) was studied in a model orange juice system. High protein WPCs were more stable than low protein WPCs in view of serum formation. However, both high and low protein WPCs needed citric acid/sodium citrate to prevent serum formation on storage. Pectin had to be added to give enough heat stability so that the drink could be UHT processed. A pH less than 4 was necessary to give enough sourness to the drink and also for heat stability. Sulphuric WPC gave a more acceptable flavour in the final drink than lactic WPC.

Two market trials and storage tests were carried out on the drinks from the pilot scale production runs. The first trial indicated a need for flavour and colour improvements, which led to the second trial.

From the results of the second trial, some minor reformulation to improve the flavour and the viscosity of the drink is still required. None the less, the product has a considerable market potential for utilizing the whey protein concentrate, in the order of 600 tonnes/year.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

Whey protein concentrates (WPC) are now being produced in New Zealand and some WPC powders are being exported to Japan for addition to food products. However, these high protein powders could be more widely used in the Japanese food industry. Therefore this study was made to investigate a wide range of food products and to identify the most suitable products to be enriched with whey protein concentrates.

1.1 WHEY PROTEIN CONCENTRATES IN NEW ZEALAND

As cheese grew in popularity and also as more casein was formulated in foods, an increasing volume of fluid whey was produced as a by-product of the manufacture of these products.

In New Zealand, approximately 2 million tonnes of whey is produced annually, and this amount tends to increase as cheese and casein production grow, depending on the market demand (Zall et al., 1979). Therefore utilization of whey became important so as to reduce the level in the effluent and also to recover the nutritional value of the whey. However, the economy of whey utilization has been dependent on the development of a processing technology which is commercially feasible.

Because of the progressive development of membrane technology, it is now a reality that this dilute whey is effectively treated by such techniques as Electrodialysis (ED), Ion Exchange and Ultrafiltration (UF). Above all, processing whey by UF changed the concept of whey utilization dramatically; because in UF, whey proteins can be concentrated without damaging their native forms as there is virtually no heat involved in processing. This process results in a range of products called whey protein concentrates (WPC) which have unique functional properties and differ from a traditional lactalbumin where a process of acid/heat is involved and hence the proteins are totally denatured.

There are four commercial UF plants in operation in New

Zealand, producing some 2400 tonnes of various types of WPC annually from both sweet and acid wheys (see Figure 1.1). For the New Zealand dairy industry, it is extremely important to utilize these plants at maximum capacity as a large capital investment was involved in constructing them. Moreover, the economy of the New Zealand dairy industry is often affected by the fluctuations in the world milk production. Only a slight surplus of milk in Europe and North America can have a detrimental effect on an international market which the New Zealand dairy industry is desperately trying to penetrate. Therefore the general policy initiated by the New Zealand Dairy Board (Wellington, New Zealand) with regard to the marketing of WPC powders is that they must not be seen as a simple skim milk powder replacer but as specialized products that have a unique functionality required by an individual customer. In this way, stable production and sales of WPC can be guaranteed without being disturbed by any other surplus skim milk powders from the rest of the dairy producing countries.

1.2 JAPAN AS A MARKET FOR WHEY PROTEIN CONCENTRATES

Japan is regarded as an ideal market for the New Zealand dairy industry. The Japanese people do not eat as much dairy products as New Zealanders on the per-capita basis, but because of the size of the population (118 million as at 1982, Whitakers Almanack) a little increase in dairy products' intake by each person can affect significantly the total volume of the consumption.

Unfortunately for New Zealand as a dairy products' exporter, the trade in dairy products is strictly regulated by the Japanese government to protect their own farmers. With regard to the trading of WPC, only those WPC powders with protein content of 75% or more can be imported from overseas as an Automatic Approval (known as AA) item. Otherwise a licence must be obtained from the government authority for the use of WPC in a speciality food such as a baby food where they see difficulty in producing it domestically. In Japan, WPC is not produced domestically as there is not enough whey to accommodate production of commercial WPC.

Taking functionality and nutritional characteristics of WPC into account, there could be a considerable potential use of WPC by the Japanese food industry. However, admittedly, WPC must compete for cost and functionality with other food proteins such as soy protein and caseinate. This competition can be overcome by applying unique functionality to WPC which no other proteins can match.

Therefore it would be useful to the New Zealand Dairy Board and also some companies in the Japanese food industry, if a study was made to investigate the use of WPC, and preferably WPC with over 75% protein, in Japanese food products and to determine the suitability of WPC powders in the Japanese food formulations.

1.3 RESEARCH AND DEVELOPMENT ON WHEY PROTEIN CONCENTRATES

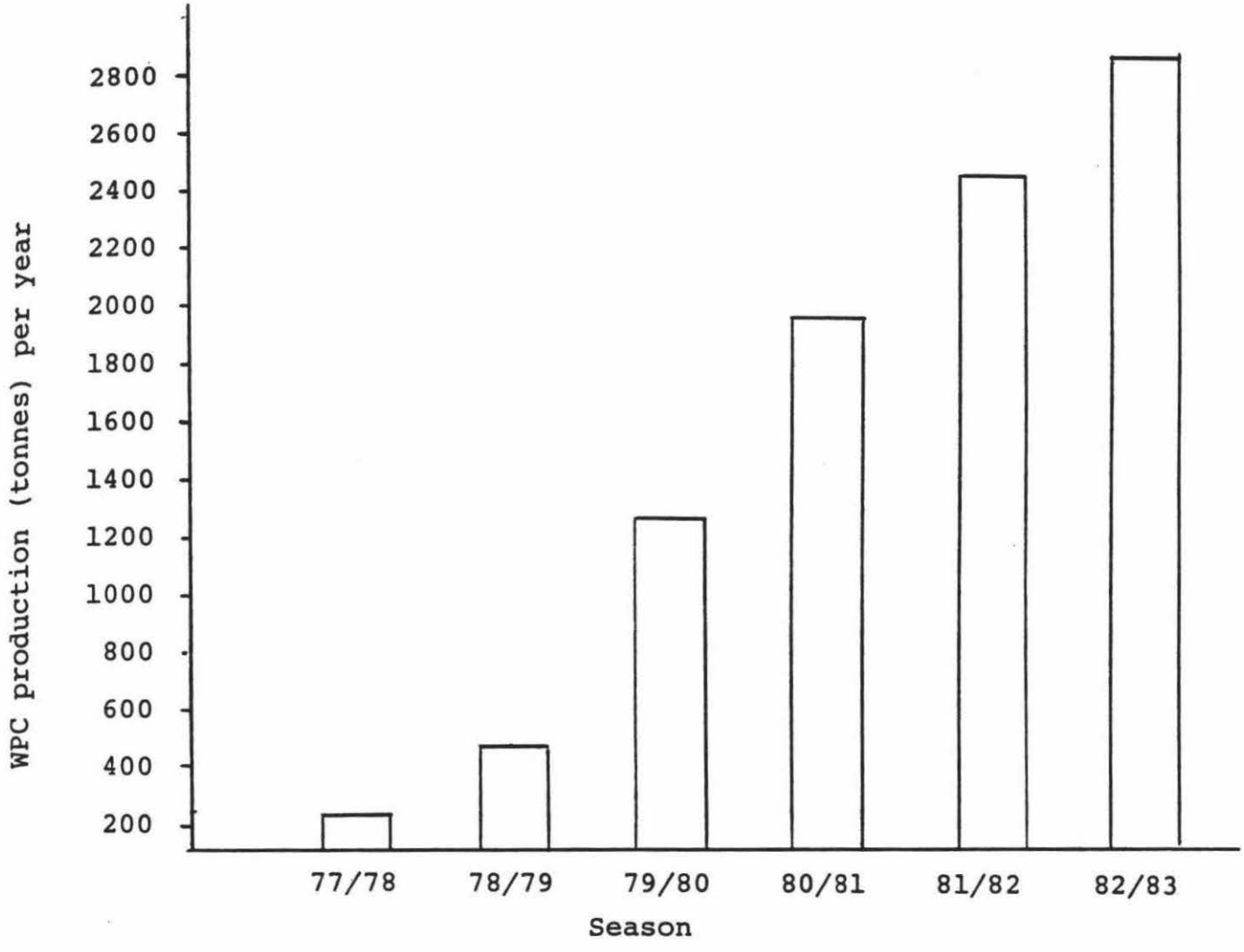
The characteristics of WPC from UF varies with source of whey, e.g. lactic, sulphuric and rennet casein manufacture and cheese making, and the method of manufacture of WPC. The functional properties and the nutritional values of the WPC powders can vary markedly. Therefore WPC powders could be used as ingredients in the food industry in a variety of foods.

The present situation in the use of WPC is that research and development is still in its infancy as the food industry has just seen the entry of WPC powders as a group of food ingredients. Although there are a number of formulations reported so far in which WPC can possibly be incorporated, most of them are commercially not feasible; partly because of the relatively high cost of WPC and partly because of the failure in the acceptance of the resulting products by the consumers (Harper, 1984).

There is therefore a great deal of research and development at the present time in New Zealand studying the use of WPC powders in various types of food formulations. The aim of New Zealand WPC research is to match the functional and nutritional properties of the WPC with the needs of the overseas food manufacturers. However, it is always a difficult task for the New Zealand dairy researcher to

FIGURE 1.1 : WPC production in New Zealand from 1977/78 season to 1982/83 season.

(Quantity totalled from four different factories)



Sources: Annual reports of the Manawatu Co-op Dairy Company, Te Aroha Thames Valley Co-op Dairy Company (TATV) and Rangitaiki Plains Dairy Company (RPD). Production figures from Lactose Company (N.Z.) were obtained by telephoning the company.

develop the customers' exact formulations incorporating WPC as the customers are overseas. Therefore, prior to the study in the final food formulation overseas, it is recommended that the functionality of WPC be studied in model food systems that closely simulate the major conditions in the end-product formulation with respect to compositional and processing conditions (Morr, 1979).

With regard to the Japanese food industry, there was a need to first identify the products in which WPC might be incorporated; then to select the products for which the functional and nutritional properties of WPC would be very suitable; then, after studying the processing and marketing needs in Japan, to select one product area which appeared the most promising for use of New Zealand WPC powders. Finally, a model food system for this product area, using WPC obtained in New Zealand, had to be developed and studied. Different WPC powders had to be compared in the system to find the WPC powder which had the functionality suitable for the food system. Thus the WPC powder could be matched with the Japanese food product.

1.4 AIM, OBJECTIVES AND CONSTRAINTS FOR PROPOSED PROJECT

From this identified need to match the functional properties of a suitable WPC powder with a food product acceptable to the Japanese market, the following aim and objectives were developed for the project.

1.4.1 Aim

To develop a food product based on the nutritional and functional properties of whey protein concentrate for Meiji Milk Products Co. Ltd. in Japan.

1.4.2 Objectives

The objectives were:

* To generate product ideas which could incorporate WPC.
* To select the most suitable product area for use of New Zealand WPC.

* To compare the types of New Zealand WPC powders in the product formulation.
* To determine the nutritional needs of the Japanese consumers in such a product.
* To optimize the sensory properties of the product formulation using a laboratory taste panel.
* To develop the process on a pilot scale basis.
* To test the acceptability of the product to the Japanese people in Wellington.

1.4.3 Constraints

Product, processing, marketing and legal constraints on the project were identified.

1.4.3.1 Product Constraints

The product constraints were:

* Product must contain WPC.
* The protein concentration in the WPC is preferably 75% or more.
* The product should be stable at ambient temperature and its shelf life be a minimum of 3 months.
* Preferably the product must contain only naturally-obtained ingredients.
* The product should be nutritionally suitable for the Japanese diet.

1.4.3.2 Processing Constraints

The processing constraints were:

* Preferably existing plant equipment should be used; but the purchase of equipment will be considered.
* Raw materials should be readily available domestically or internationally at steady and competitive prices throughout the year.

1.4.3.3 Marketing Constraints

Marketing must be carried out using the following channels:

* Supermarkets.
* Health food shops.
* Fitness centres.

* Department stores.
* Convenience stores

1.4.3.4 Financial Constraints

Financial constraints were:

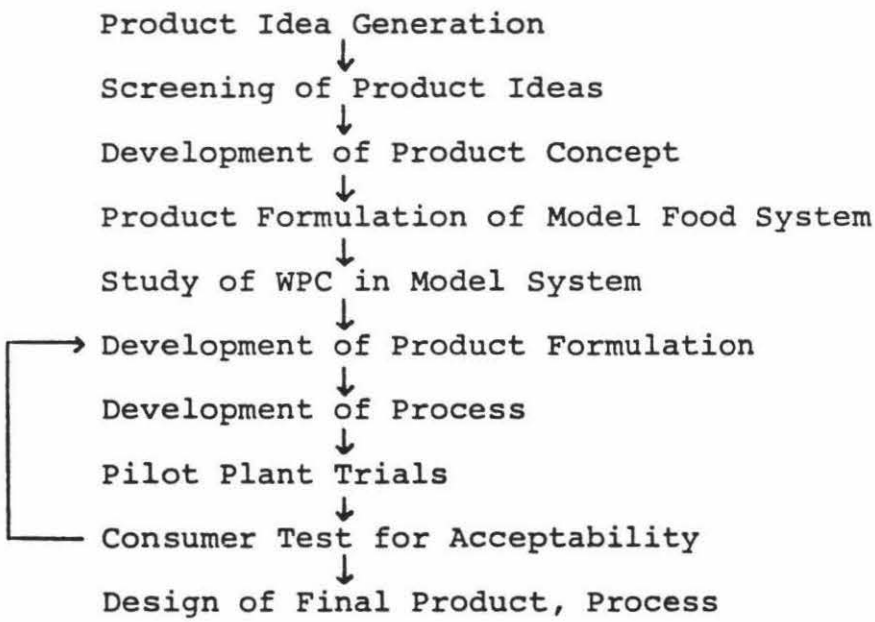
* Priority shall be given to a process that uses the existing Meiji Milk Products Co. Ltd. equipment but if a definite market is identified, the company is willing to invest in the product line.
* Marketing cost and launching cost must be in the normal range being used by Meiji Milk Products.

1.4.3.5 Legal Constraints

The product must satisfy the Japanese Food and Sanitary Laws.

1.5 OUTLINE PLAN FOR THE PROJECT

The project was planned in several stages, very similar to the product development process used in many food companies.



CHAPTER 2

PRODUCT IDEA GENERATION AND SCREENING

Ideas for products suitable for incorporation of WPC were found using as many techniques as possible, so that a wide variety of product ideas was obtained. The number of products were then reduced by three sequential screening methods so that the products most suitable for the Japanese market could be identified.

2.1 PRODUCT IDEA GENERATION

New product ideas were generated by using idea creation techniques: brainstorming, attribute analysis, morphological analysis, needs analysis, synectics and lateral thinking.

2.1.1 Brainstorming

A group of six people (three from the marketing departments and three from the technical division of the New Zealand Dairy Board) were encouraged to generate new product ideas using a "brainstorming" technique.

The words used as 'stimuli' for the discussion were 'juice', 'cheese food', 'ice-cream', 'yoghurt' and 'butter'.

2.1.2 Attribute Analysis

In this technique, new ideas were developed by enumerating attributes of milk beverages only. Different ideas were found by combining the different attributes. The "attributes" used were uses for the product, modification of the product features, magnification and reduction of the product size. They were specified as follows:

The uses for the product:

* To be consumed during exercise.
* To be consumed by invalids, sportsmen, preschool children and university students.

Modification of the product features:

* To add WPC to give more nutritional value.

* To make the product clear rather than cloudy milk colour.

Magnification and reduction of the product size:

* In Japan, the carton sizes available are 200 ml, 500 ml and 1000 ml. In addition to these sizes, 250 ml, 750 ml can be considered, depending on the consumers' needs.
* The size can also be reduced to 125 ml and 100 ml.

2.1.3 Morphological Analysis

In this technique, new ideas were generated by using the morphological table which is shown in Table 2.1. The functionality of WPC was used as one of the characteristics as the aim was to study the different types of WPC powders available in different types of food products.

Product ideas were developed by combining different characteristics, one from each column, e.g. a canned mango bread using the swelling WPC to give a light structure or a whipped lime cheese sterilized with UHT, made with a whipping WPC.

2.1.4 Needs Analysis

This technique was used to gauge the needs of Japanese consumers for food products. The needs were obtained through Japanese newspapers and industrial journals (see Table 2.2).

2.1.5 Synectics

In this technique, one was required to give a problem that had to be solved. The problem was analysed from various viewpoints and summarized to get better understanding. This problem was then forced to analogize a certain animal (direct analogy) which was personified (personal analogy) to give some attributes of a food (compressed conflict). The attributes were submitted to produce 'the second direct analogy' which led to 'the second compressed conflict'. This concept was finally to fit in a practical situation in which one could eventually produce some solutions.

TABLE 2.1 : Morphological table for generating new product ideas which must contain WPC.

Functionality of WPC	Processing of final product	Flavours	Product form	Types of food product
Solubility	HTST	Orange	Liquid	Beverage
Emulsification	UHT	Mandarin	Concentrate	Yoghurt
Whipping	Retort	Lemon	Powder	Cheese
Foaming	Microwave	Lime	Tablet	Butter
Swelling	Infrared	Grapefruit	Pulp	Ice cream
Gelation	Spray-drying	Berries	Granular	Pudding
Cohesion	Freeze-drying	Kiwifruit	Flake	Confectionary
Viscosity	Canning	Black & Red Currants	Slice	Bread
Baking	Aseptic filling	Pineapple	Jelly	Cereal
Cheese flavour	Bottling	Grape	Sponge	Noodle
Casein flavour	Cartoning	Mango	Frozen	Spread
Creamy-yellow colour	Shrink packaging	Peach	Carbonated	Biscuit
White colour	Vacuum packaging	Pear		Soup
	Film wrapping	Vanilla		Ham & sausages
	Nitrogen-filling	Banana		Slimming food
		Yoghurt		Sauce
		Chocolate		Soya bean products
		Green tea		Fish products
		Coffee		

TABLE 2.2 : Needs of Japanese consumers for food products.

Nutritional/Physiological Needs for Foods		Needs of the Consumers' Life Style	Needs of Safety for Foods	Needs of Foreign Foods
Foods with 'low':	Foods with 'high':			
Fat	Protein	Foods for eating out	Natural foods	Italian foods
Salt	Vitamins	Frozen foods	Plain type foods	Chinese foods
Calorie	Calcium	Instant foods	Cancer-free foods	
Sucrose	Vegetable Oils	Convenience foods	Health foods	
Cholesterol	Dietary fibre			
Cafeine	Iron			
Lactose				

This technique was applied in the following manner:

(1) An identified problem that had to be solved was to find out uses of WPC.

(2) Analysis of the problem was described as follows:

* WPC must contain 75% or more protein according to the Japanese trade regulation.
* There are many possible applications of WPC.
* High-protein WPC is very expensive.
* WPC have a variety of functional and nutritional characteristics.

(3) Problems summarized were to use functional and nutritional characteristics of WPC in foods.

(4) Direct analogy was done by choosing a Beijing duck which was forced to eat too much feed in order to gain weight as fast as possible.

(5) Personal analogy was done by personifying the Beijing duck so as to get some idea of the situation in which it had experienced. One might feel 'hopeless' in this environment.

(6) Compressed conflict created ' a hopeless food'.

(7) Second direct analogy forced one to generate 'mouldy' foods which was a hopeless food.

(8) Second compressed conflict led to the idea of 'healthy mouldy foods'.

(9) Practical force fit was set up for use of WPC in the healthy mouldy foods.

(10) A suggested solution was a blue cheese cake mixed with WPC which was a new product idea.

2.1.6 Lateral Thinking

New ideas were thought of by using word association in this technique. A word was selected randomly from a dictionary, which was 'pan'. And the words associated with the word 'pan', were milk, butter, wheat flour and water mixed in the pan. This led to the idea of dough which was mixed with

WPC to improve texture and the nutritional value of the resulting bread.

2.1.7 Summary of Product Ideas Generated

It appeared from the idea generation studies that WPC could be added to a wide variety of food products. For example, it could be incorporated with a range of flavours to create new types of cereals and meat products; it could be used for nutritional fortification of bread, cereals, noodles, biscuits and fish products where limiting amino-acids could be supplemente to enhance biological values of protein. Unique functionality of WPC would facilitate its use in beverages, yoghurts, soups and sausages. From the viewpoint of the Japanese consumer, as WPC is rather a new product, it can create a new concept of foods, in particular, by changing non-protein foods to protein foods and by adding WPC to traditional Japanese foods.

The product ideas generated were divided into groups, e.g. beverages, baked goods, cheese foods, ice-cream, yoghurt, butter desserts and miscellaneous foods (see Appendix 2.1).

2.2 PRODUCT SCREENING BY SEQUENTIAL AND CHECKLIST SCREENING METHODS

2.2.1 Sequential Screening

The important factors to affect the overall feasibility of the product ideas were identified:

* Raw Material

The product must contain WPC.

* Processing

The product must be produced by the use of the present equipment that the company has.

* New Product Line for the Company

The product should be either a new product that the company has not offered to the market or the WPC-fortified present product which can create a new product concept.

Taking each essential factor into consideration, all the product ideas were evaluated on a pass or fail basis (see Appendix 2.2).

The following product ideas were dropped after this screening because they were already being made by the company and the project required a new product; cheese cakes, cheese spreads, sliced cheese, milk jelly, sweet cream, dry yoghurt mix, yoghurt-flavoured ice creams, extended butter, low calorie butter, infant formula, dairy bread, breakfast cereal, dough mix, low fat/high protein/high calcium/high vitamin-enriched bread, low cholesterol/high protein/high dietary fibre/high unsaturated fatty acid-enriched bread.

2.2.2 Checklist Screening

The important factors to study the product ideas in checklist screening were health, newness and market potential.

A scale and a "weight" were determined for each factor.

Health (the product is categorized as a health food product) = 40 units

1	20	40
Never be identified as a health food	Could be identified as a health food	Very high value as a health food

Newness = 32 units

1	16	32
Traditional	Similar to the present new products	Very unique

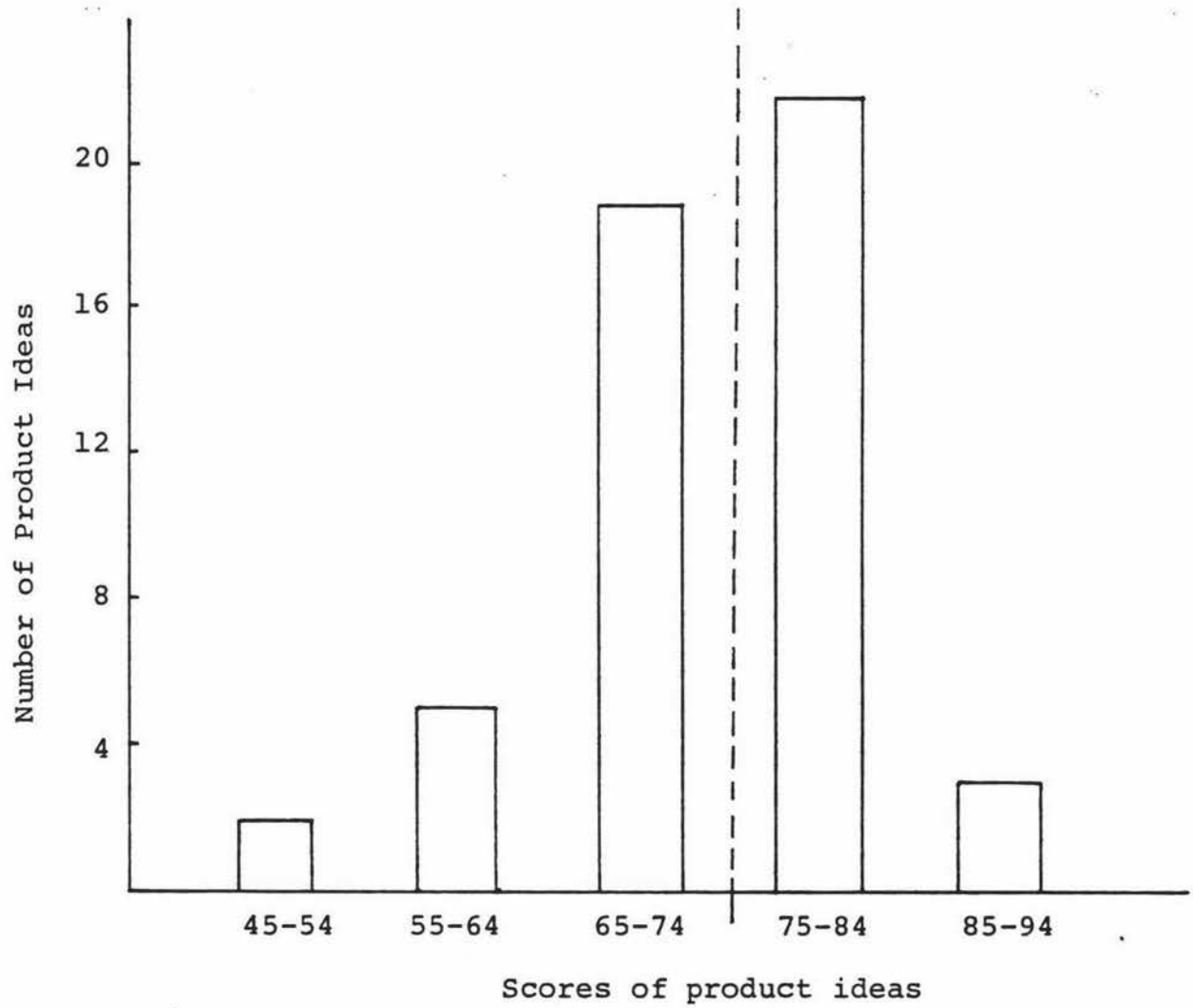
Potential Growth of Market = 28 units

1	14	28
Poor sales potential	Moderate sales potential	High sales potential

The total maximum score for the product was 100. Each product was scored by the author and a total sum determined (see Appendix 2.3).

The scores of the checklist screening are shown in the frequency diagram (see Figure 2.1).

FIGURE 2.1 : Frequency diagram of scores of product ideas screened by a checklist screening method: total number of product ideas = 50; total units = 100.



It was decided to drop all products with scores below 74. The 26 products deleted were:

Cheese and Cheese Products

* Sweet cheese with WPC
* Cheese dip
* Cheese food with WPC
* Cheese with low fat/high protein/high calcium/high vitamins
* Processed cheese with low cholesterol/high dietary fibre/high vitamins/high unsaturated fatty acids/high protein
* Processed cheese with low calorie/high protein/high vitamins
* Cheese whip
* Cream cheese sandwich with WPC
* Blue cheese cake mix with WPC

Ice Cream Products

* Ice cream mixture with WPC
* Low fat/high protein/high calcium/high vitamin ice creams
* Low cholesterol/high dietary fibre/high vitamins/high unsaturated fatty acids/high protein ice creams
* Low calorie/high protein/high vitamin ice creams

Yoghurt

* Yoghurt with WPC

Butter

* Spreadable butter with WPC

Jellies and Desserts

* Spreadable jelly with WPC
* Cream jelly with WPC
* Sweet cream with WPC
* Shiruko
* Aseptic type desserts with WPC

Salad Dressing

* Dairy-based salad dressing

Milk Powder

* Skim milk powder with WPC

Dried Soups

* Chicken soup with WPC
* Pumpkin soup with WPC

Meat and Fish Products

* Ham and sausages with WPC
* Fish sausages

The products remaining and their scores are shown in Table 2.3.

2.3 DESCRIPTION OF REMAINING PRODUCT IDEAS

In order to give shape to the new product ideas in Table 2.3, each of them was described in the following manner.

2.3.1 Drinking Yoghurt

Drinking yoghurt is a liquid-type fermented milk with yoghurt cultures. A variety of flavours such as orange, blueberry and pineapple can be added in this product to increase the acceptability by the consumers. WPC could help to enhance the nutritional value of the drink and to form the stable colloid instead of precipitating itself.

2.3.2 Orange Juice with WPC

Orange juice with WPC is a fortified orange juice with whey proteins in WPC. Soluble WPC of undenatured whey proteins are soluble in acid pH similar to the pH of citrus juice. This product can give consumers vitamin C from the orange juice and protein of high value from the WPC.

2.3.3 Clear Drink with WPC

Clear drink with WPC is a product which is fortified with WPC; it is 'clear' rather than 'cloudy'. It can be made with a variety of artificial and natural flavours.

TABLE 2.3 : Product ideas remaining after the checklist screening with scores more than 75.

Product Ideas	Health	Newness	Market Potential	Total
Drinking yoghurt	30	25	20	75
Orange juice with WPC	30	28	25	83
Clear drink with WPC in a 100 ml pack	30	29	25	84
Carbonated citrus juice with WPC	25	30	26	81
High protein/calcium/ vitamin-enriched drink	30	30	26	86
Low cholesterol-high protein/unsaturated fatty acids/vitamin-enriched drink	30	30	25	85
Soya milk with WPC	30	25	25	80
Egg beverages with WPC	30	27	25	82
Ice cream topping with WPC	30	25	20	75
Hydrolized lactose yoghurt with WPC	30	25	20	75
Yoghurt topping on cheese cakes	30	25	20	75
Yoghurt pudding in a tin	30	20	25	75
UHT yoghurt	30	28	22	80
Cheese jelly	30	30	20	80
Pudding with WPC/kiwifruit pulp	28	25	22	75
Uiroh with WPC	28	28	20	76
Low fat, high protein/ calcium/vitamin dessert with WPC	30	25	20	75
Low cholesterol, high dietary fibre/vitamins/unsaturated fatty acids/protein dessert	30	25	20	75
Low calorie, high protein/ vitamin dessert	30	25	20	75
Noodle with WPC	25	30	20	75
Miso soup with WPC	30	30	20	80
Slimming food with WPC	35	25	25	85
Tofu with WPC	35	20	21	76
Kamaboko with WPC	35	20	23	78

2.3.4 Carbonated Citrus Juice with WPC

Carbonated citrus juice with WPC is a carbonated type of 'orange juice with WPC'. This product gives a more refreshing sensation due to carbonation and is suitable for children and athletes.

2.3.5 High Protein/Calcium/Vitamin Enriched Drink

High/protein/calcium/vitamin enriched drink is a beverage product area in which those nutrients are used to fortify the products; WPC is a protein source for the product area. These products are suitable for children, convalescents and athletes who need those nutrients regularly.

2.3.6 Low Cholesterol, High Protein/Unsaturated Fatty Acids/Vitamin Drink

Low cholesterol, high protein/unsaturated fatty acids/ vitamin drink is a product area where those nutrients are used to fortify the beverage products. This product is more suitable for older people and the middle-aged who have more chances to suffer from heart disease. WPC is a source of the protein.

2.3.7 Soya Milk with WPC

Soya milk with WPC is a WPC-fortified soya milk. Because of the whey proteins in WPC, the quality of the protein in the product is enhanced with well-balanced amino acids. It is suitable for young people and weight-watchers who seek low calorie beverages.

2.3.8 Egg Beverages with WPC

Egg beverages with WPC are beverage products fortified with either egg yolk or whole egg, and WPC. A variety of both artificial and natural flavours can be added to make them organoleptically acceptable. They can be pasteurized and aseptically packaged; in this case food grade stabilizers must be added to prevent the protein colloid from precipitating on heat treatment. They are suitable for children, athletes, convalescents and invalids.

2.3.9 Ice Cream Topping with WPC

Ice cream topping with WPC is a topping product for ice cream use which is blended with WPC. A whipping property of the WPC enhances the whipping quality of the topping.

2.3.10 Hydrolized Lactose Yoghurt with WPC

Hydrolized lactose yoghurt with WPC is a yoghurt product in which the lactose is hydrolized and contains WPC. WPC could enhance the texture of the product and facilitate the yoghurt starter fermentation. This product is suitable for those who find themselves having difficulty digesting lactose due to the insufficiency of lactase activity.

2.3.11 Yoghurt Topping on Cheese Cakes

Yoghurt topping on cheese cakes is a topping product with yoghurt flavour for decorating the top of cheese cakes. WPC is added to enhance the whipping quality of the product.

2.3.12 Yoghurt Pudding in a Tin

Yoghurt pudding in a tin is a pudding product with a yoghurt flavour which is canned in a tin. WPC is added to enhance the gelling property and the nutritional value. As this product is a long-life type, it is suitable for picnic/ hiking and travel and for presents.

2.3.13 UHT Yoghurt

UHT yoghurt is a yoghurt product which is sterilized with UHT conditions so that all the starter bacteria are killed to prevent further fermentation, and thus stop acid production. It is aseptically packaged or canned to be a bacteriologically safe product. WPC could be incorporated to maintain the yoghurt texture and to enhance nutritional value. A variety of compatible flavours such as kiwifruit can be added according to the consumers' taste. As there is no need to refrigerate the product, it is suitable for a picnic and for travelling, and for those who live in a remote country without refrigeration.

2.3.14 Cheese Jelly

Cheese jelly is a jelly-type dessert flavoured with cheese. A variety of cheese can be added according to the consumers' taste. WPC is incorporated to enhance the nutritional values and the gelling structure of the product. It could be a low fat, low calorie type dessert suitable for young women or those who are sensitive to their weights.

2.3.15 Pudding with WPC/Kiwifruit

Pudding with WPC/kiwifruit is a pudding-type dessert fortified with WPC and flavoured with kiwifruit pulp. WPC acts as an enhancer of the pudding body and gives more nutritional value. It is suitable for children and young people who need a protein of high quality regularly.

2.3.16 Uiroh with WPC

Uiroh with WPC is a jelly-type dessert with agar, and is flavoured with Japanese tea. This is one of the traditional Japanese desserts. WPC is added to enhance the gelling structure, to give more nutritional value and to change the colour into slightly milky white. It is suitable for both the young and the old as it is regarded as a traditional type dessert but has a fresh image because of WPC from milk.

2.3.17 Low Fat, High Protein/Calcium/Vitamin Dessert with WPC

Low fat, high protein/calcium/vitamin dessert with WPC is a product area where those nutrients are fortified in a dessert. It is suitable for athletes, invalids, convalescents and children because of the enhanced nutritional value.

2.3.18 Low Calorie, High Protein/Vitamin Dessert with WPC

Low calorie, high protein/vitamin dessert with WPC is a product area where those nutrients are fortified in a dessert. WPC is added to give more protein of high quality and to replace fats and carbohydrates so that the product becomes the one with a low calorie content.

2.3.19 Noodle with WPC

Noodle with WPC is a noodle product which is categorised as a traditional type Japanese food. WPC is added to enhance

the nutritional value. It is suitable for children, athletes and convalescents who need a protein of high quality.

2.3.20 Miso Soup with WPC

Miso soup with WPC is a traditional Japanese miso soup, but is fortified with WPC to enhance the nutritional value. WPC may be compatible with only a white miso soup but can create a new concept of the product as it is a combination of traditional and European foods. It is suitable for children and young people who need a high supply of nutrition.

2.3.21 Slimming Food with WPC

Slimming food with WPC is a slimming food product which is fortified with WPC. WPC acts as an enhancer of the protein quality of the product. It is suitable for those who try to lose weight and are sensitive to their health.

2.3.22 Tofu with WPC

Tofu with WPC is a soya bean curd of Chinese origin, and is regarded as a traditional Japanese food. WPC is added to enhance the nutritional value and to give a slightly different texture. It is suitable for those who are sensitive to their health and try to lose weight.

2.3.23 Kamaboko with WPC

Kamaboko with WPC is a boiled fish paste product fortified with WPC. WPC is added to enhance the nutritional value and to give a slightly different texture. Although 'kamaboko' is regarded as a traditional Japanese food, the fortification with WPC creates a new product image. It is suitable for invalids, convalescents, children and weight-watchers who need a protein of high quality.

2.4 PROBABILITY SCREENING

Probability screening involves estimating the probability of reaching levels of weighted factors, based on total utility of the product.

For this project, important factors and their weightings were:

Factors	Points
Profitability	30
Healthiness	30
Compatibility with WPC	20
Newness	20
Total	100

Each factor was scaled from very poor to very good as shown below:

	Levels
Very good	10
Good	8
Average	6
Poor	4
Very poor	2

Total Utility* = 1000

*(Total points in factors) x (Maximum points of each factor)
= 100 x 10
= 1000

Detailed results of the probability screening are presented in Appendix 2.4. The product ideas with scores of more than 630 are shown in Table 2.4.

The drink products scored highest. This resulted mainly from the fact that the scoring by the author was strongly affected by the advice of the company manager. He thought the size of the beverage market in Japan was so big that higher profitability and bigger sales potential could be expected by introducing new products onto the market.

The only other products with a total sum over 630 were yoghurt pudding, UHT yoghurt and slimming food (see Table 2.4). The

TABLE 2.4 : Product ideas remaining after the probability screening, with scores more than 630 (total utility = 1000)

Products	Scores
Drinks	
Orange juice with WPC	684
Clear drink with WPC	670
Egg beverages with WPC	666
Low cholesterol, high protein/unsaturated fatty acids/vitamin-enriched drink	666
Soya milk with WPC	652
Carbonated citrus juice with WPC	650
High protein/calcium/vitamin-enriched drink	642
Puddings	
Yoghurt pudding in a tin	648
UHT yoghurt	638
Slimming food	
Slimming food with WPC	636

drinks had a higher profitability than the other products and were identified as new products as there have been no protein enriched drinks on the Japanese market, except for soya milk and flavoured milk beverages. During this study one pharmaceutical company launched a fermented whey drink with a pineapple flavour and also a plain type in Tetra pack onto the market. But this product did not appear to contain WPC powder. Therefore only the drink products were considered further.

2.5 DRINK PRODUCTS

Soya milk, egg beverages, clear fruit flavoured drinks and fruit juices were regarded as suitable beverages for enrichment with WPC.

2.5.1 Soya Milk

Soya milk can be fortified with WPC as a supplement to improve the quality of soya protein. The pH of the product should be a neutral range as the soya protein tends to precipitate in the acid pH. However, the idea would not be attractive to the consumers as they could hardly recognise it as a new product in itself. From the viewpoint of the marketing, the company which has already got a line of soya milk products on the market, may find difficulty in selling the WPC-fortified soya milk strongly as this might give the consumers the impression that the current soya milk products are not so nutritious.

2.5.2 Egg Beverages

WPC can be incorporated into egg beverages. As they are currently not on the market in Japan, there is a chance to attract some consumers. However, it is the idea of drinking eggs that bothers many consumers, which might be one of the major reasons why egg beverages have not yet been marketed in Japan. Moreover, WPC cannot be regarded as a nutritional enhancer in egg drinks as it is obvious that egg protein itself is seen as one of the most nutritious proteins.

2.5.3 Clear Fruit Flavoured Drink

Small amounts of high protein WPC could fortify a clear drink without giving turbidity. This product is generally flavoured with artificial flavourings as natural fruit juice makes the product 'cloudy'. It is envisaged, however, that development work is difficult: the WPC powder is required to be highly soluble in order to keep 'clearness' on heat treatment especially with the presence of calcium ion, which may result in a costly powder. Amounts of WPC added to the drink might be so limited to avoid turbidity that the resulting product could not supply enough protein to cover a significant part of the recommended dietary allowance. In the end, the product may not be seen as a health food product as the amount of added protein would be small.

2.5.4 Citrus Juices

Finally, WPC can be incorporated into citrus juices as it is soluble in acid pH (2-4). The product should have a 'cloudy' appearance and this would be produced by the citrus juice cloud and partly by the whey proteins in WPC which is heat-treated during processing.

As this type of beverage product has not been marketed in Japan, the consumers can see it as an entirely new product, combining the benefits of citrus juice with those of milk proteins. It could be regarded as a health food as it is formulated with both protein and vitamin C.

2.6 CONCLUSION

It was concluded that WPC-fortified orange juice would be developed further as this idea had the top score in the probability screening and WPC could be best utilized in the acid pH where many other proteins tend to precipitate. The WPC-fortified orange juice could also have added poly-unsaturated fatty acids, calcium and a variety of vitamins. It could also be carbonated, which would be considered at a later stage for development of another new product.

A line of citrus juices fortified with WPC can be regarded as health foods and their target market would be children, athletes, convalescents and everybody who needs a protein of good quality.

CHAPTER 3

REVIEW OF USE OF WPC IN BEVERAGES

Although there are a number of papers published on the use of whole whey in beverages, there are few reports on the use of 'WPC powder'. This is partly because whey is utilized in beverages in the form of liquid rather than powder in Europe and North America where they can consume it domestically and partly because WPC powder is so new a product that manufacturers are not ready to use it.

The use of WPC has been reported in soft drinks, fruit juices and fermented milk drinks.

3.1 SOFT DRINKS

In soft drinks, WPC needs to have certain properties:

* Low fat (Coca Cola Company 1972. Quoted from De Boer et al., 1977).
* High protein/ash ratio (Coca Cola Company, 1972).
* Low in mineral salts (Malaspina, A. et al., 1975. Quoted from Mann, 1977).
* Low bacterial count (Malapsina, A. et al., 1975).
* pH with range 2.7-3.6 (Malaspina, A. et al., 1975).
* Soluble in acid solution (Malaspina, A. et al., 1975).
* Free from off-flavours.

If fat is not removed, it forms an oily layer at the top of the bottle. An ash content gives a salty taste to the product. The powder needs to have a high acid pH, 2.7-3.6, so that the protein can dissolve in the acid soft drinks.

Various methods have been used to remove fat, mineral salts, microorganisms from WPC. For example, Malaspina, 1975, used filtering through diatomaceous earth, ultrafiltration and acidic cationic exchange resins to produce an acid soluble WPC powder suitable for addition to beverages.

Holsinger et al., 1973, developed a wide range of soft drinks, both carbonated beverages and "ade" powder mixes. The carbonated beverages with 1% whey protein maintained excellent clarity but developed a slight stale whey flavour during one year of storage at room temperature. They compared

TABLE 3.1 : Sensory evaluation of whey protein-fortified non-carbonated soft drinks (Holsinger, 1973)

	Hedonic ranking[a]		
Flavour	Control	0.5% protein	1.0% protein
Cherry	7.0	6.5	5.5
Grape	7.2	6.8	6.3
Tart lemon	5.7	5.2	5.5
Lemon-lime	7.2	6.5	6.2
Orange	6.2	5.9	6.0
Raspberry	6.3	6.7	6.4
Strawberry	6.5	5.9	6.0

[a] on a 9 point hedonic scale; the higher, the better flavour

different levels of whey protein in the "ade" powders as shown in Table 3.1. The addition of WPC powder decreased the acceptability of all flavoured drinks except raspberry. Generally, they concluded that fortification with 1% protein was acceptable, but it must be difficult to produce soft drinks with a protein level approximating that of milk (ca. 3.5%) due to undesirable flavour changes.

WPC has been added to a variety of soft drinks - blackcurrant, cherry, grape, tart lemon, lemon-lime, orange, raspberry and strawberry using Gouda cheese WPC and cottage cheese WPC (De Boer et al, 1977, Holsinger et al, 1973). De Boer et al. developed a blackcurrant soft drink, using a clarified 60% protein WPC powder, which had a clear appearance and remained stable during storage. The corresponding non-clarified product, on the other hand, gave a turbid soft drink, especially at higher protein levels. Moreover, a sediment was formed during storage and there was a fat layer in the top of the bottle (ringing). After storage periods up to one month, the transmission of the non-clarified product at 0.5% protein had increased due to protein sedimentation. At protein contents higher than 1%, off-flavours of an oxidative nature were detected in the non-clarified product. On the other hand, the product with the clarified WPC was quite normal even at 3% protein, although the blackcurrant flavour became less pronounced due to some masking of the flavour by the protein.

In an application for a patent by Coca Cola Company (1972), it was stated that soft drinks should preferably be fortified with WPC having a high protein/ash ratio. In addition a thorough removal of the fat components by means of a clarification step was necessary.

3.2 JUICE PRODUCTS

In juice products, WPC must have the following properties:

* low fat
* high protein/ash ratio
* low in mineral salts

* soluble in acid solution
* free from off-flavours
* low pH, depending on the juice type

Instead of a clear drink, "cloud" is needed in the juice product. The juice is made from orange concentrate, orange juice and either orange pulp base, starches, pectin, or carboxymethylcellulose to form the cloud. Bangert, 1976, made a frozen orange juice concentrate fortified with WPC using orange juice concentrate, sugar, citric acid, orange pulp base and fruit flavours. The resultant drink could be diluted 1:1 or 2:1; the 1:1 drink contained 0.25 to 5.0% whey protein, 0.05 to 8.0% sugar, 0.005 to 1.5% citric acid and 9.5 to 20% orange juice concentrate (Brix 45°).

Citrus juice was also fortified with whey protein powder from cheese whey by Attaway et al. at Florida Citrus Commission (Anon., 1978). This beverage product was a creamy liquid which was stabilized by the interaction of soluble protein and the starch dissolution products. It could be made with orange, grapefruit, lemon or lime juices, and it did not require the addition of various inorganic salts.

The product contained at least 50% by weight of full strength citrus juice, depending largely on the type of citrus fruit, its acidity and the Brix of that juice. Protein level was at 1 to 6% (3 to 4% was best), and starch at 0.5 to 3%.

About 0.1 to 1.0% soluble food stabilizers (e.g. sodium carboxymethylcellulose) were added to improve texture and viscosity, and to further help in preventing separation during storage. One formulation is presented in Table 3.2. Protein source in this formulation was defatted concentrated cheese whey (presumably WPC) whose protein concentration was 74%.

A technical bulletin (The Copenhagen Pectin Factory Ltd., 1982) said that WPC could be incorporated into fruit juices to produce refreshing and nutritious drinks by using Genu Pectin type JM. One formulation is presented in Table 3.3.

TABLE 3.2 : Formulation of whey protein-enriched orange juice beverage (3% protein) (Anon., 1978)

Ingredients	% by Wt.	% Sol. Solids
Orange conc. (60 Brix)	19.48	11.69
Sugar	5.85	5.85
Conc. cheese whey protein (74%)	4.21	4.21
Corn starch	0.53	0.53
Water	69.38	-
Terpeneless orange oil	0.02	-
FD & C Yellow #5	0.06	-
FD & C Red #6	0.06	-
Vanilla extract	0.41	-

TABLE 3.3 : Formulation of WPC-fortified fruit drink (3% protein) (The Copenhagen Pectin Factory Ltd., 1982).

Ingredients	Protein content of drink (%)		
	0.7	3.0	3.0
Fresh whey	75.70	-	-
WPC 35% protein	-	8.50	-
80% protein	-	-	3.80
Genu pectin type JM	0.10	0.30	0.30
Sugar	6.00	6.00	6.00
Citric acid, $2H_20$	0.65	0.65	0.65
Tri-sodium citrate, $2H_20$	0.55	0.55	0.55
Fruit juice concentrate (65 Brix)	15.00	15.00	15.00
Flavour	q.s*	q.s	q.s
Water	-	69.40	74.00

*(q.s. (qui suffit) - according to taste)

In this table, they used WPC from Danmark Proteins, Aarhus, Denmark. They suggested that pectin should be about 10% of the protein concentration; somewhat higher at the lowest protein concentrations and the minimum concentration depended on the heat treatment, the acidity, the desired shelf life and the quality of WPC. They said that homogenization was not necessary when the pectin was dissolved in water before mixing with the WPC, even though it looked as if a slightly more stable product could be obtained with homogenization.

3.3 FERMENTED MILK DRINKS

It was reported from Italy that WPC powder was used for the production of fermented beverages (Costamagna, 1980. Quoted from Mann, 1983). WPC obtained by ultrafiltration and spray-drying was reconstituted and mixed in varying proportions with milk for the production of fermented beverages using various cultures including Lactobacillus acidophilus, Bifidobacterium bifidum or a yoghurt culture. The result of this study was that the addition of the WPC apparently enhanced the quality of the coagulum and the protein content of the beverages whilst reducing the residual lactose content and having little effects on acidity and bacterial counts. The best organoleptic quality was obtained with yoghurt culture.

3.4 CONCLUSION

As discussed in Chapter 2, Section 5.4, fruit juice products fortified with WPC seemed to be more attractive than soft drinks with WPC. This is because the consumers would see them as more natural products.

Fermented drinks would be produced efficiently with WPC, but this would not always seem to attract consumers as the drinks had already contained milk protein.

Therefore, fruit juice products would be considered further.

WPC powders can be used in citrus juices to produce a drink with about 3-4% protein. Some type of stabiliser needs to be used in the formulation - carboxymethylcellulose and pectin have been used successfully in the past. Also buffer salts such as citric acid and trisodium citrate need to be added to stabilise the pH. There was no published information on the use of New Zealand WPC powders in beverages.

CHAPTER 4

PRODUCT FORMULATION DEVELOPMENT

A product concept was developed for the proposed protein enriched citrus fruit juice drink. This drink was a health food drink and a source of protein and vitamin C in the diet of the Japanese consumer. The formula was developed from the information in the literature. A study was made of the effects of pectin and buffer salts on the heat coagulation of the proteins during sterilisation, and on the sedimentation and serum formation during storage. The sensory properties of the product were developed to an acceptable level by use of a laboratory taste panel. Different WPC powders were tested in the model product system to find the New Zealand WPC powders most suitable for this product.

4.1 PRODUCT CONCEPT

4.1.1 General

A whey protein-fortified nutritious drink containing natural orange juice was developed. The product differs from the normal flavoured milk type drink in the sense that it is more fruity-sour in taste, therefore gives a more refreshing sensation and that it contains only whey protein rather than whole milk and less minerals so that it has a less milky and salty taste. The colour of the product is orangey milk-white but less whitish cloudy than the normal milk beverages in order to be seen as a type of drink positioned between soft drinks and the milk beverages.

The product is very nutritious because of the fortification by the whey proteins and can give a considerable supply of protein. It can be categorised in the group of health foods as the main ingredients formulated are naturally obtained materials.

4.1.2 Packaging

The product is an aseptic type of drink so that it keeps its quality for a long time at room temperature. As such, it

has to be packaged in a container which gives good protection from contamination by bacteria, from electric light or sunshine, and from physical distortion; the protection needed will depend on the storage stability. Accordingly, the packaging materials are cans, aseptic-type cardboard cartons or dark coloured glass bottles. It is individually packed so that it can be available to anybody anytime.

4.1.3 Consumers

The target market for this product will be children and their mothers, athletes, convalescents and everybody who needs a protein of good quality and are concerned with their health.

The consumers will be throughout Japan as the company possesses the marketing branches nationwide.

4.1.4 Pricing

As the product is marketed as a health food drink which is regarded as a slightly expensive product, the price will be set in a similar range to that of fermented milk drinks. It can be slightly higher than that of normal flavoured milk drinks and soft drinks with artificial flavouring.

4.1.5 Marketing

The product can be distributed by using the present channels that Meiji Milk Products Company possesses. Types of retailers will be health food shops, supermarkets, department stores and fitness/sport centres.

Budgetary requirements for advertising and promotion are expected to be high as the consumers do not know what whey proteins are.

4.2 PROTEIN AND VITAMIN C REQUIRED IN THE PRODUCT

The product concept was that the drink was a source of protein and vitamin C and therefore it was thought that it should have about 15-20% of the recommended dietary allowance of these nutrients. Recommended dietary allowances (RDA) are recommendations for the average daily amounts of nutrients that the population groups should consume over a

period of time. The RDA for the Japanese people was referred to for aiding the formulation of the current product.

In the following sections, the nutritional implications of whey proteins will be briefly reviewed, and then the RDA for protein for the Japanese people will be studied to establish some idea of the protein required in the formulation and the product size for a single serving.

4.2.1 Nutritive Value of Whey Proteins

Generally, the nutritive value of dietary protein is essentially related to its amino-acid composition as well as to the physiological availability of these amino-acids. In this respect, it is well known that milk proteins, especially whey proteins have a high content of essential amino-acids (see Table 4.1). Thus, the whey proteins in WPC can represent very valuable supplements in the human diet. There is a further aspect to the nutritive value of the whey proteins; they appear to have distinct physiological and biochemical roles, e.g. lactoferrin strongly binds iron, α-lactalbumin is a constituent of lactose synthetase and lysozyme is an enzyme that destroys the bacterial cell wall (Hambraeus, 1982).

From the viewpoint of the physiological availability of amino-acids, it is the practice to measure the true value of a protein by observing its effect upon the growth of test animals. The most widely accepted procedure for this is referred to as the 'Protein Efficiency Ratio' or 'PER'. PER is the ratio of weight gain to protein eaten by test animals as shown in the following equation:

$$\text{PER} = \frac{\text{Grams Weight Gained}}{\text{Grams Protein Consumed}}$$

PER of a variety of proteins is presented in Table 4.2.

The adjusted PER for New Zealand WPC (ALACEN), which would be used for the present formulation, ranges from 2.9 to about 3.0 (Lohrey, 1976) and these values are significantly higher than those of vegetable proteins.

TABLE 4.1 : Essential amino-acid contents of skim milk powder, whey proteins and casein, and amino-acid pattern in FAO egg reference (1965) and FAO provisional amino-acid scoring pattern (1973)[a].

Amino-acid	Skim Milk Powder	Casein	Whey Protein	Human Milk		FAO Egg Reference Pattern (1965)	FAO Provisional Amino-acid Scoring Pattern (1973)
Isoleucine	52	54	76	40	49	66	40
Leucine	97	95	118	86	91	88	70
Lysine	71	81	113	67	65	64	55
Methionine + cysteine	34	32	52	29	37	55	35
Phenylalanine + tyrosine	96	111	70	66	76	100	60
Threonine	41	47	84	44	44	51	40
Tryptophan	14	16	24	NA[b]	NA[b]	16	10
Valine	63	75	72	45	52	73	50
Total essential amino-acids	468	511	609				360

[a] The values refer to mg amino-acid per g protein

[b] NA, not analysed

TABLE 4.2 : Biological measures (PER) of various protein products (Anon.)[a]

Product	Average PER*	Adjusted** PER (casein=2.50)	Limiting Amino-acid
Cows' milk	3.1	2.6	None
Casein	2.9	2.5	Cystine and Methionine
Lactalbumin	3.4	2.9	None
Rice, polished	2.2	1.9	Lysine
Wheat flour, white	0.6	0.5	Lysine
Soybeans	2.3	1.9	Cystine and Methionine

* FAO (1970)

** PER corrected on the basis that Casein's PER = 2.5

[a] ANON, Technical Bulletin. The Nutritional Value of New Zealand Milk Proteins, New Zealand Dairy Board,(Wellington New Zealand).

4.2.2 Estimation of Protein Required in the Formulation

According to the United States Food and Drug Administration (USFDA), if the PER of the protein is equal to or better than that of casein (= 2.5), RDA is 45 grams for adults and 20 grams for infants under 4 years; if the PER of the protein is between 0.5 and 2.5, the RDA is 65 grams for adults and 28 grams for children (Jukes, 1979). RDA of protein for the Japanese people is presented in Table 4.3, in which no relationships between RDA and PER of protein is defined. Therefore, RDA from the USFDA was taken for the calculation of quantity of protein which would be required in the proposed product. As the PER of whey proteins is more than that of casein, RDA of whey proteins is 45 grams for adults and 20 grams for children.

If a beverage product is fortified with WPC on the basis of 1% (w/w) protein and packed in a 250 ml container as a single serving, it would represent only 6% of the RDA for adults. However, the increase of protein fortification to 2% and 5% would give 11% and 28% of the RDA respectively (see Table 4.4). Therefore, it is recommended that the product should be fortified with more than 2% of whey proteins in order that the consumer can take a significant percentage of the RDA of protein from a single serving. This can be compared with cow's milk where protein content is around 3.5% (Webb and Johnson, 1965). If 250 ml of milk is consumed, the protein content of about 9 grams of milk would give 20% of the RDA of protein for adults.

TABLE 4.3 : Japanese recommended dietary allowances (RDA) for energy, protein, calcium and vitamin C.

Age		Energy (Cal)		Protein (g)		Calcium (g)		Vitamin C (mg)
		Man	Woman	Man	Woman	Man	Woman	
(Months)								
0	0 -	120/kg		3.3/kg				
	2 -	110/kg		2.5/kg		0.4		35
	6 -	100/kg		3.0/kg				
(Year)								
1 -		1000	950	35	30			
2 -		1250	1200	40	40			
3 -		1350	1300	45	40	0.4	0.4	
4 -		1500	1400	45	45			40
5 -		1600	1500	50	50			
6 -		1800	1700	60	55	0.5	0.5	
9 -		2100	2000	70	70	0.7	0.7	
12 -		2500	2400	85	80	0.9	0.7	
15 -		2700	2200	85	70	0.8	0.6	
18 -		2700	2100	80	65	0.7	0.6	
20 -		2500	2000					50
40 -		2300	1900	70	60			
60 -		2000	1700			0.6	0.6	
70 -		1800	1500	65	55			
Pregnant Women	In the first half	+150		+10		+0.4		+10
	In the second half	+350		+20		+0.4		+10
	Lactating	+800		+25		+0.5		+35

TABLE 4.4 : Relationship of protein needed for the RDA to percentage of whey protein in the formulation

Fortification by Whey Protein (%) (w/w)	Percentage of the protein RDA in the product	
	Adults	Children under 4 years
1	6	4
2	11	8
3	17	12
4	22	16
5	28	20

RDA of protein: 45 g for adults and 20 g for children under 4 years of age. (%) of protein quantity to RDA was calculated by assuming that the product was packed in 250 ml containers for adults and 80 ml for children as a single serving.

4.2.3 Estimation of Vitamin C Required in the Formulation

According to the Japanese RDA, which is presented in Table 4.3, daily requirement of vitamin C is 50 mg and 40 mg for adults over 12 years of age and children under 12 years, respectively.

Assuming the target market is adults and the size of product is 250 ml for a single serving, the product which contains 25 mg and 50 mg of vitamin C respectively covers 50% and 100% of its RDA, for example.

On the other hand, a natural orange juice contains about 50 mg of vitamin C per 100 ml of the juice fluid. As the proposed product would have to be regarded as a health food, it might need to have the same level of vitamin C as that of natural orange juice. On that basis, the product would have to contain 125 mg of vitamin C in a single serving size of 250 ml.

It is suspected that some of the vitamin C will be destroyed during the processing and on storage. However, it is unknown at this stage how much of the vitamin C will be lost before the consumer actually drinks the product.

Therefore it was decided that 50% of RDA of vitamin C in the formulation should be a minimum level for a single serving and the maximum level be set on the basis of a natural orange juice. This was calculated as follows:

For adults over 12 years:
Minimum level = 25 mg per 250 ml (50% of RDA)
Maximum level = 125 mg per 250 ml (250% of RDA)

Likewise, for children under 12 years, assuming the product size for them for a single serving is 80 ml:
Minimum level = 20 mg per 80 ml (50% of RDA)
Maximum level = 40 mg per 80 ml (100% of RDA)

This would mean 62.5 mg and 125 mg per 250 ml container.

It was decided to add 125 mg per 250 ml. This would allow for the losses during processing and storage, which could be 40% and still provide the RDA for adults drinking 250 ml and at least 50% of the RDA for children and old people drinking only 80-100 ml.

4.3 AIMS OF FORMULATION

* To identify the possible quality problems which might appear in the formulation.

* To select a suitable WPC and determine its maximum concentration which supplies a significant amount of the recommended dietary allowance of proteins but to the point where no off-flavour is exhibited in the end-product.

* To choose type of stabilizer and determine its minimum concentration to prevent whey protein coagulation on heat treatment.

* To adjust sweetness and sourness according to a sensory panel by manoeuvering the levels of sucrose and citric acid/sodium citrate.
* To maximise the orange juice flavour by changing sucrose and citric acid/sodium citrate levels and the orange juice strength up to 50% (w/w).

4.4 SUMMARY OF THE FORMULATION METHOD

A beverage was formulated by using whey protein concentrate (WPC), orange juice concentrate and sucrose as starting materials.

There were three major problems; whey protein and juice cloud were destabilized (serum formation) and precipitated during storage (sediment), and undesirable flavour changes appeared mainly due to the WPC added in the formulation.

Lactic WPC 75 which contained 75% whey protein from whey of lactic casein manufacture was mainly used in the preliminary experiments as it was found most stable in view of the serum formation. The basic model system consisted of juice solids (6.5%), sucrose (5.5%) and protein (0.5-4.0%). As the total solid of a natural orange juice is approximately 13%, the orange juice strength of the system was regarded as 50%.

There was less immediate serum formation (SF) with the higher levels of protein. The least SF was observed with the lactic WPC 75 at the 3% protein level on storage. The stabilizers such as pectin and CMC did not prevent the serum formation, but even had an adverse affect at a natural pH in the basic model system. The system, however, was stabilised to a great extent with citric acid/sodium citrate buffer.

During storage, a sediment was observed regardless of types of WPC, protein and stabilizer concentrations.

The addition of pectin markedly prolonged the coagulation time (CT) on heat treatment at 85^{o}C. The more pectin was added, the longer was the CT. However, the CT decreased with the increased level of protein while pectin

level was kept constant. The shortest CT was noted with the sulphuric WPC 80 (4 min at 85^{o}C) while the longest CT (more than 15 min at 85^{o}C) with the lactic WPC 55.

Unpleasant flavour was detected by a sensory panel of five members due to the addition of WPC at 3% protein level.

The final formulation after sweetness, sourness and orange flavour were optimized was orange juice solid 5.2% (juice strength 40%), lactic WPC 75 4.0%, sucrose 3.5%, citric acid 0.736%, sodium citrate 0.441% and pectin 0.3%, and the remainder is water.

4.5 EXPERIMENTAL

4.5.1 Materials

Materials used in the present experiments are listed in Table 4.5.

Four types of commercial WPC (ALACEN) were obtained from the New Zealand Dairy Board (Wellington, New Zealand). They were: ALACEN 312 - a lactic WPC 75 (l-WPC 75) which contained 75% protein and was manufactured from lactic casein whey, likewise, ALACEN 343 - a sulphuric WPC 80 (s-WPC 80), 80% protein from sulphuric casein whey, ALACEN 451 - a lactic WPC 55 (l-WPC 55) and of sulphuric WPC 55 (s-WPC 55, DRI pilot plant sample).

TABLE 4.5 : Materials used in the experiments and their sources.

Materials	Source
Orange juice concentrate (Brix 52)	Milk Processing (PN) Ltd., Palmerston North, New Zealand
WPC powders*, (Alacen 312, 343, 451)	New Zealand Dairy Board, Wellington, New Zealand.
Pectin, Genu pectin (Citrus) Type JM.	The Copenhagen Pectin Factory Ltd., Denmark.
CMC, DAICEL, Grade 1250	Daicel Ltd., Tokyo, Japan
Citric acid anhydrous (chemical grade)	BDH Chemicals Ltd., England
Tri-sodium citrate dihydrate (chemical grade)	Sigma Chemical Company, U.S.A.
Sucrose (commercial grade)	-

*Alacen 312 = Lactic WPC 75%, Alacen 343 = Sulphuric WPC 80%, Alacen 451 = Lactic WPC 55%, Sulphuric WPC 55%

4.5.2 Processing Methods

For the basic model system, the WPC and sucrose were dry-blended and dissolved in water before orange juice concentrate was mixed in.

For the system where stabilizers and buffer salts were incorporated, 1 part of the stabilizer was dry-blended with 10 parts sucrose and dissolved in approximately 65 parts water by a magnetic stirrer. The temperature of the solution was raised to 75°C with the heater of the magnetic stirrer, and the solution was then cooled to 20°C (Solution A) after the stabilizer was completely dissolved. Each of buffer salts (citric acid and sodium citrate) were dissolved in approximately 40 parts water (Solution B and C respectively). A WPC powder was dry-blended with the remaining

FIGURE 4.1 : Processing methods of WHEY PROTEIN ENRICHED ORANGE DRINK (laboratory scale)

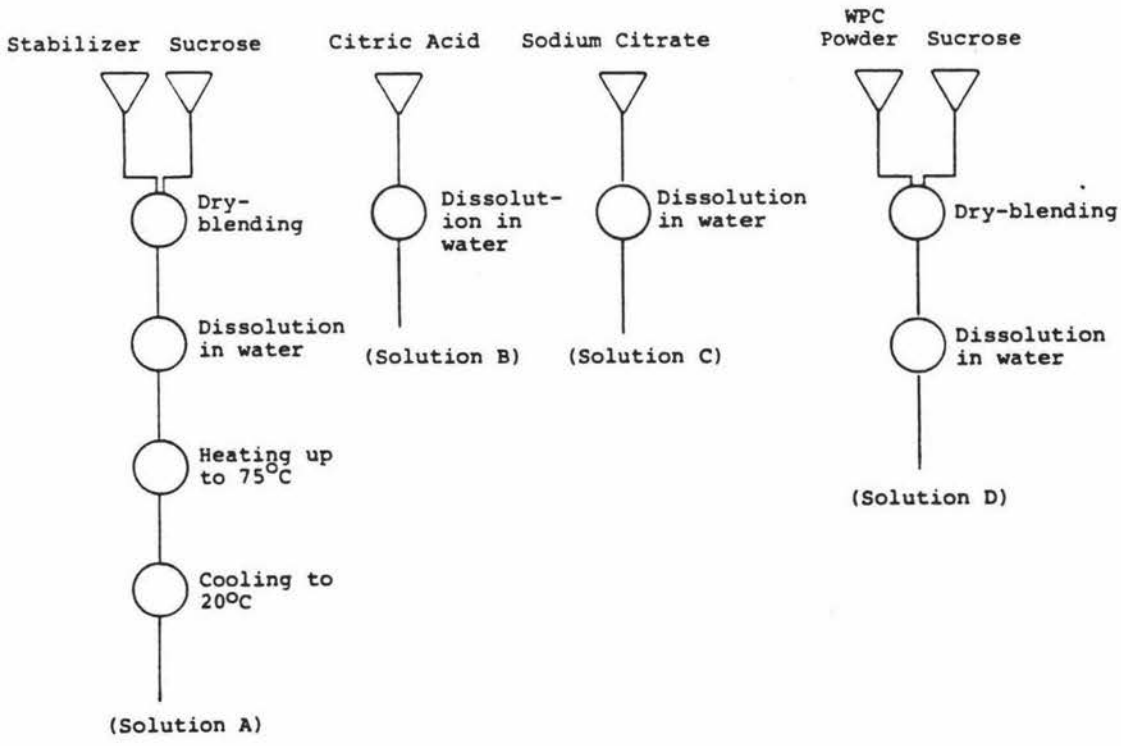
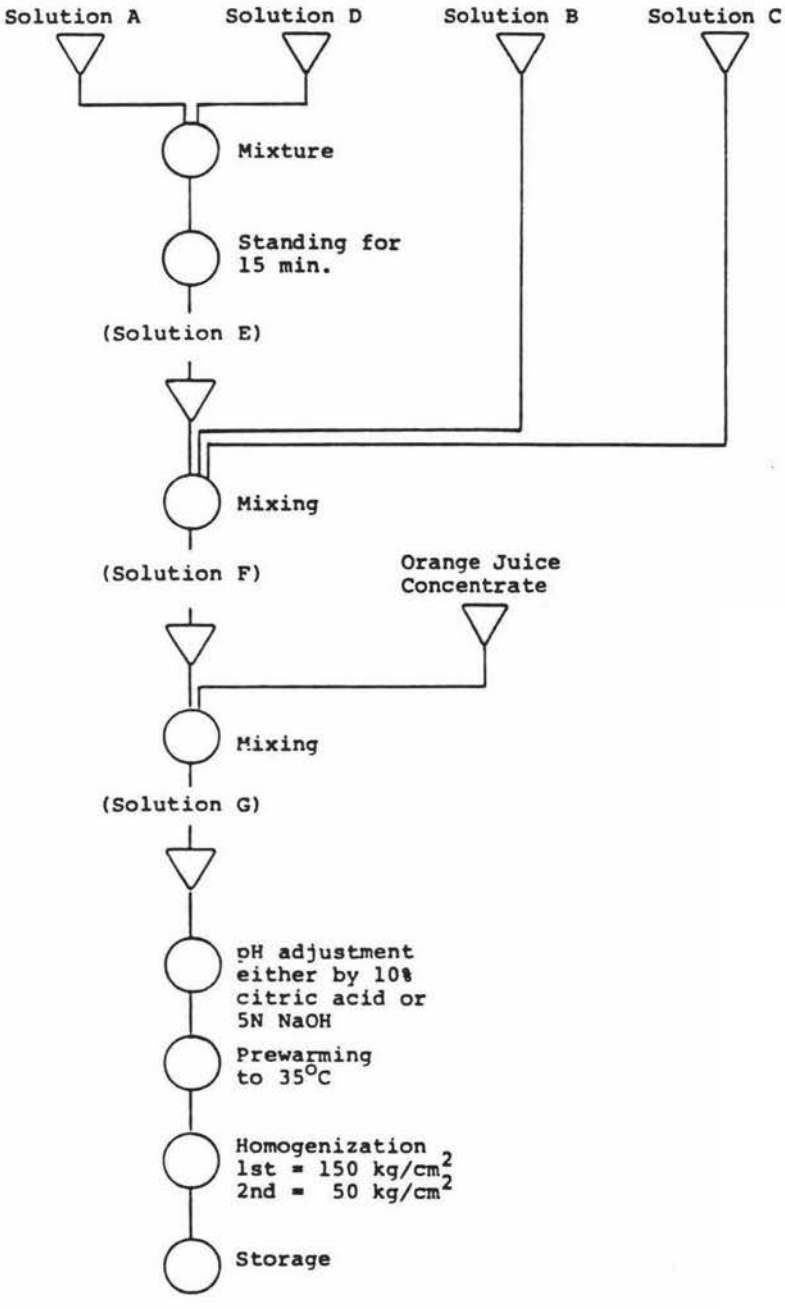


FIGURE 4.1 (continued)



quantity of sucrose and dissolved in remaining quantity of water (solution D). The solution A was mixed with the solution D and left for 15 minutes for hydration (solution E). The solution B and C were then added slowly to the solution E where the liquid was being stirred vigorously by the magnetic stirrer (solution F). Finally an orange juice concentrate was slowly added to the solution F (solution G). Where necessary, the pH of the solution G was adjusted to various pHs with either 10% citric acid or 5N NaOH. When the effect of homogenization was studied, the solution G was prewarmed to 35°C before being homogenized at 150 kg/cm^2 for the first stage and 50 kg/cm^2 for the second stage (see Figure 4.1).

4.5.3 Test Methods

4.5.3.1 Serum Formation and Sediment Tests

200 ml of the formulated samples were placed in a 300 ml-capacity conical flask to see serum formation and sediment. Serum formation and sediment were subjectively observed by the author 20 minutes after the preparation of the solution G (immediate appearance) and after storage at 2°C. The degree of serum formation and sedimentation was evaluated on the basis of the following scores:

-	=	absent
x	=	very slight detection
xx	=	slight detection
xxx	=	noticeable
xxxx	=	very noticeable

4.5.3.2 Heat Stability Test

According to the Food Sanitary Law in Japan, the heat treatment conditions required for soft drinks with pH less than 4 is 65°C/10 minutes or its equivalent, and those with pH more than 4 is 85°C/30 minutes or its equivalent. Therefore a heat stability test of protein was performed at both 65°C and 85°C.

It is a commercial practice in New Zealand that a citrus

juice product of long-life type is heat-treated with High Temperature Short Time (HTST) method which is 90°C/30 seconds. Therefore, the protein coagulation time of more than 30 seconds at 90°C could be a criterion for the heat stability test to ensure microbiological quality of the product.

Heat stability of milk protein was investigated by many scientists such as Lister (1969) and Davies et al.,(1966). A subjective test developed by Davies et al., which was a reasonably accurate measure in comparison with an objective test, required a specially designed heater with a rocking arm and affiliated parts.

In the present experiment, the heat stability of the drink was measured in a simple way using a subjective test, knowing that the aim of the test was to get relative coagulation times among the samples and to establish the CT to ensure heat stability of whey proteins during heat treatment through a plate heat exchanger.

5 ml of the solution G was placed in a 16 ml-capacity glass test tube. The unstoppered test tube was placed in a shaker and immersed in a hot water bath where the temperature was automatically controlled at 65°C and at 85°C. The time for coagulation to take place was counted from when the sample temperature reached 65°C and 83°C. Coagulation time was recorded when a slight precipitate was subjectively noted on the test tube wall.

4.5.3.3 Sensory Tests

The samples were evaluated organoleptically by a sensory panel of 5 members. The sensory attributes specified were sweetness, sourness, orange flavour and off-flavour. A verbal scale was used to score the attributes as shown in Figure 4.2. The panelists were given the form on which they were asked to check the point which best described the product attribute. After completion of the test, the scores were numbered according to the intensity of the attribute for statistical treatment.

The sensory panel at Massey University, who knew taste panel

FIGURE 4.2 : Scoresheet for evaluation of whey protein-enriched orange drink (scores in parenthesis were assigned later for analysis), used for formulation.

Name: Date:

SCORESHEET FOR THE PROTEIN-ENRICHED ORANGE JUICE

INSTRUCTIONS: You are given coded samples of protein-enriched orange juice. Please check the point in the scale which best describes the product attribute specified.

	CODE NO.	CODE NO.	CODE NO.	CODE NO.	CODE NO.
1. Sweetness:					
Very sweet	(5)				
	(4)				
Right blend of sweetness	(3)				
	(2)				
Not sweet	(1)				
2. Sourness:					
Too sour	(5)				
	(4)				
Right blend of sourness	(3)				
	(2)				
Insipid	(1)				
3. Orange-flavour:					
Very pronounced	(5)				
	(4)				
Recognizable	(3)				
	(2)				
None	(1)				
4. Off-flavour:					
Very pronounced	(5)				
	(4)				
Recognizable	(3)				
	(2)				
None	(1)				

Please describe the off-flavour if detected.

( ) ( ) ( ) ( ) ( )

Thank you.

procedures, was instructed on the test methods to be used and they then tasted the drinks in a sensory panel room, in single booths and under standard white lighting. The samples were presented simultaneously in glass containers, identified by coded random numbers and were evaluated in random order at each session.

4.5.4 Experimental Design

A first series of experiment was carried out to determine the effects of different levels of protein stabilizers and buffer salts on serum formation, sediment, heat stability and sensory characteristics (Experiment 1). In this experiment the basic model was selected, consisting of orange juice solids6.5%, sucrose 5.5%, and protein (0.05-4.0%) by weight.

The second series of experiments was aimed at optimization of the formulation established in Experiment 1 in view of sweetness, sourness and orange flavour by using the sensory panel, and also to improve the process so that it was as practical as possible. This work led to the pilot-scale trial.

4.6 RESULTS OF FORMULATION DEVELOPMENT

4.6.1 Comparison of Types of WPC

The 4 types of commercial New Zealand WPC (ALACEN s-WPC 55, l-WPC 55, s-WPC 80, l-WPC 75) were compared for the colloidal stability of the protein, in order to choose the most suitable WPC type for the subsequent development work. Each of them was incorporated into the basic orange juice system of orange juice, sugar and water (see Table 4.6a). The weights of WPC powder were adjusted so that in all samples the protein contents were either 0.5, 1.0 or 1.5%.

It was found that high protein WPCs, namely, s-WPC 80 and l-WPC 75 were more stable than the low protein WPCs from the immediate appearance of the model system. However, all the formulations were totally destabilized and the solids settled out (serum formation), together with the orange juice cloud, after 2 weeks of storage (see Table 4.6b).

TABLE 4.6a : Formulation to study serum formation using 4 different WPCs.

Ingredients	% Solids ***		
OJC * (Brix 52)		6.5	
Sucrose		5.5	
Protein **	0.5	1.5	3.0

* Orange Juice Concentrate

** Protein source: s-WPC 55, l-WPC 55, s-WPC 80 and l-WPC 75; weight of powder adjusted to give % protein in drink.

***Note in all formulations the remainder is water either from the orange juice or from added water.

TABLE 4.6b : Serum formation, at 3 different levels of protein, observed immediately and after 2 weeks.

	% Protein		
	0.5	1.5	3.0
Immediate Appearance			
s-WPC 55	xxx	xxx	-
l-WPC 55	xxx	xxx	xxx
s-WPC 80	-	-	-
l-WPC 75	-	-	-
After 2 weeks			
s-WPC 55	xxxx	xxxx	xx
l-WPC 55	xxxx	xxxx	xxxx
s-WPC 80	xxxx	xxxx	xxxx
l-WPC 75	xxxx	xxxx	xxxx

key: - = absent, x = very slight detection,
xx = slight detection, xxx = noticeable,
xxxx = very noticeable.

4.6.2 Serum Formation

Therefore the effort was centred on avoiding serum formation in the next series of experiments.

Glahn, 1982, from the Copenhagen Pectin Factory Ltd., said that pectin could be used to stabilize milk protein during heat treatment and also to avoid subsequent formation of precipitate and whey separation on storage. This finding of the use of pectin was applied to the whey proteins from WPC which were incorporated in the basic system.

0.1% and 0.3% of pectin (Genu Pectin, (Citrus), Type JM) was added at the different protein levels (see Table 4.7a). The table 4.7b indicates that pectin did not improve serum stability, but had an adverse effect in some cases. All the formulations were destabilized after 2 weeks of storage at $2^{o}C$.

Buffer salts can facilitate the solubility of proteins, this is known as the 'salting in' process (Anglemier, et al.,1976). Citric acid and its sodium salt were mixed and were used as buffer salts in the model system containing pectin (see Table 4.8a).

Table 4.8b shows that after storage of 1 week the buffer salts had a marked effect on serum stability within the pH range of 3.5 to 4.0, at all protein levels (1.0 to 3.0%). The level of the buffer salts needed to stabilize the system was found to be more than 0.28% and 0.24% of citric acid and sodium citrate, respectively (see Table 4.9a and Table 4.9b).

Sodium carboxymethyl cellulose (CMC), a synthetic gum, was used to prevent separation during storage by Attaway et al., (Anon, 1978). The next series of experiment was performed to confirm the effect of CMC reported by them.

Three different levels of CMC (DAICEL, 1250) were added to the basic system in the presence of citric buffer salts (see Table 4.10a).

Table 4.10b shows that CMC had an adverse effect even with

TABLE 4.7a : Formulation to study the effect of pectin on the serum formation with different protein levels.

Ingredients	% Solids		
OJC (Brix 52)		6.5	
Sucrose		4.5	
Protein*	0.5	1.5	3.0
Pectin	0	0.1	0.3

*Protein source: 1-WPC 75.

TABLE 4.7b : Serum formation with pectin, observed immediately, after 1 day and after 2 weeks

	% Protein		
	0.5	1.5	3.0
Immediate Appearance			
Pectin (%)			
0	xx	xxx	-
0.1	xxxx	xxx	-
0.3	xxxx	xx	-
After 1 day at 2°C			
Pectin (%)			
0	xxxx	xxxx	x
0.1	xxxx	xxx	xxx
0.3	xxxx	xxxx	xxx
After 2 weeks at 2°C			
Pectin (%)			
0	xxxx	xxxx	xxxx
0.1	xxxx	xxxx	xxx
0.3	xxxx	xxxx	xxxx

TABLE 4.8a : Formulation to study the effect of citric buffer on the serum formation.

Ingredients	% Solids		
OJC (Brix 52)		6.5	
Sucrose		5.5	
Protein*	1.0	2.0	3.0
Pectin		0.1	
Citric acid		0.65	
Sodium citrate		0.55	

*Protein source: 1-WPC 75

TABLE 4.8b : Serum formation observed immediately and after 1 week at different pHs.

	% Protein		
	1.0	2.0	3.0
Immediate Appearance			
pH 3.8-4.0 (natural pH)	-	-	-
pH 3.5*	-	-	-
After one week at 2°C			
pH 3.8-4.0 (natural pH)	-	-	-
pH 3.5*	-	-	-

*pH was adjusted with 10% citric acid.

TABLE 4.9a : Formulation to determine the level of citric acid buffer needed to prevent serum formation.

Ingredients	% Solids			
OJC (Brix 52)	6.5			
Sucrose	5.5			
Protein*	1.0			
Pectin	0.1			
Citric acid	0	0.09	0.28	0.47
Sodium citrate	0	0.08	0.24	0.40

*Protein source: 1-WPC 75

TABLE 4.9b : Serum formation observed immediately and after 1 week.

Citric Acid/ Sodium Citrate % / %	0 / 0	0.09 / 0.08	0.28 / 0.24	0.47 / 0.40
Immediate appearance	-	-	-	-
After 1 week at $2^{o}C$	xxxx	xx	*	*

*Slight sediment was observed.

TABLE 4.10a : Formulation to study serum formation with CMC at different levels.

Ingredients	% Solids			
OJC (Brix 52)			6.5	
Sucrose			5.5	
Protein*			1.0	
CMC	0	0.05	0.10	0.15
Citric acid			0.66	
Sodium citrate			0.56	

*Protein source: 1-WPC 75

TABLE 4.10b : Serum formation with CMC observed immediately.

	CMC %			
	0	0.05	0.10	0.15
Immediate appearance	-	xxxx	xxxx	xxxx

the buffer salts, resulting in a total serum formation immediately after the preparation. However, the system was markedly stabilized at the elevated pH (up to 5.0) and the increased level of the buffer salts (see Table 4.11a and 4.11b).

The effect of CMC was further investigated with increased levels of protein (1.0 to 4.0%) and the elevated level of citric buffer (see Table 4.12a).

Table 4.12b shows that there was no serum formation immediately after preparation at all protein levels, but after the extended storage time (19 days) all the systems were destabilized and settled out except those at the pH of 4.5.

Therefore CMC was only suitable as a stabilizer at pH above 4.5 and increased levels of buffer salts. But the formulations where the pH was more than 4.5 did not taste sour and this lack of sourness would not be acceptable to the consumers. Thus, it was decided that CMC, as a stabilizer of separation, should be dropped for the present development work.

The comparison of the four different types of WPC was repeated in the presence of the citric buffer which had been proven necessary to stabilize the protein in the previous experiments (see Table 4.13a).

Table 4.13b shows that all the systems were stable immediately after the preparation, but high protein WPCs (l-WPC 75 and s-WPC 80) were mostly destabilized after storage of 2 weeks at $2^{o}C$. However, it was noted that the pH varied from sample to sample, which presumably made the system unstable. Thus, the next experiment was carried out to study the effect of pH by changing the ratio of citric acid to sodium citrate in the systems containing l-WPC 75 and s-WPC 80 (see Table 4.14a and Table 4.15a respectively).

Table 4.14b and Table 4.15b respectively show that there was no serum formation with both l-WPC 75 and s-WPC 80

TABLE 4.11a : Formulation to study serum formation with CMC and citric acid buffer at elevated levels.

Ingredients	% Solids		
OJC (Brix 52)		6.5	
Sucrose		5.5	
Protein*		1.0	
CMC		0.15	
Citric acid	0.99	1.32	1.65
Sodium citrate	0.84	1.12	1.40

*Protein source: 1-WPC 75

TABLE 4.11b : Serum formation with CMC and elevated levels of citric acid buffer at different pHs.

Citric Acid/ Sodium Citrate	% $0.99/_{0.84}$	$1.32/_{1.12}$	$1.65/_{1.40}$
Immediate Appearance			
pH*			
3.70-3.74 (natural pH)	xxx	x	-
4.0	-	-	-
4.5	-	-	-
5.0	-	-	-
After 1 day at $2^{o}C$			
pH			
3.70-3.74 (natural pH)	xxxx	xxx	x
4.0	xxxx	xx	x
4.5	-	-	-
5.0	-	-	-

*pH was adjusted with 5N NaOH

TABLE 4.12a : Formulation to study serum formation with CMC and protein at different levels.

Ingredients	% Solids		
OJC (Brix 52)	6.5		
Sucrose	5.5		
Protein*	2.0	3.0	4.0
CMC	0.2	0.3	0.4
Citric acid	1.65		
Sodium citrate	1.40		

*Protein source: 1-WPC 75

TABLE 4.12b : Serum formation with CMC at different pHs observed immediately and after storage (19 days).

% Protein % CMC	2.0 0.2	3.0 0.3	4.0 0.4
Immediate Appearance			
pH* 3.89-4.03 (natural pH)	-	-	-
4.0	-	-	-
4.5	-	-	-
5.0	-	-	-
After 19 days at $2^{o}C$			
pH 3.89-4.03 (natural pH)	xxxx	xxxx	xxx
4.0	xxx	xxx	xxx
4.5	xxx	x	x
5.0	xxx	xx	xx

*pH was adjusted with 5N NaOH.

TABLE 4.13a : Formulation to compare different types of WPC using unfortified juice as a control

Ingredients	% Solids	
	Fortified Juice	Unfortified Juice
OJC (Brix 52)	6.5	6.5
Sucrose	5.5	5.5
Protein*	3.0	0
Pectin	0.3	0
Citric acid	0.578	0
Sodium citrate	0.662	0

*Protein source: s-WPC 55, l-WPC 55, l-WPC 75 and s-WPC 80

TABLE 4.13b : Comparison of 4 different WPCs with regard to the pH, serum formation, heat stability and sensory profile.

	Fortified Juice with different WPC types				Unfortified Juice
	s-WPC 55	l-WPC 55	l-WPC 75	s-WPC 80	
pH	3.85	4.00	4.24	4.21	N.A.
Serum formation					
Immediate appearance	-	-	-	-	
After 1 week at 2°C	-	-	xx	xx	
After 2 weeks at 2°C	-	-	xxx	xxx	
Heat Stability					
Coagulation time (min) at 85°C	6	7.5	6	4	
Sensory Score*					
Sweetness	3.8	3.4	3.6	4.2	3.4
Sourness	3.0	3.0	2.8	2.4	3.0
Orange flavour	2.8	3.0	2.6	3.0	4.2
Off-flavour	3.2	3.0	2.4	2.0	1.8

*Mean scores obtained from 5-member panel (Score of 5 = very (sweet or sour), 3 = right blend of (sweetness or sourness) and 1 = not (sweet or sour); 5 = very pronounced, 3 = recognizable and 1 = none for orange flavour and off flavour).

TABLE 4.14a : Formulation to study the effect of pH on serum formation, sediment and heat stability with different levels of pectin and protein.

Ingredients	% Solids		
OJC (Brix 52)	6.5		
Sucrose	5.5		
Protein*	1.0		3.0
Pectin	0.1	0.2	0.3
Citric acid	0.578	0.683	0.788
Sodium citrate	0.662	0.515	0.368

*Protein source: 1-WPC 75

TABLE 4.14b : Serum formation, sediment and heat stability within the pH range of 3.4 to 4.0

Protein (%)		1.0		3.0		
Citric acid (%)		0.578	0.788	0.578	0.788	0.683
Sodium citrate (%)		0.662	0.368	0.662	0.368	0.515
Pectin (%)	pH	4.00	3.40	4.22	3.73	NS*
	Serum formation					
	Immediate appearance	-	-	-	-	NS
0.1	After 1 week	-	-	-	-	NS
	Sediment					
	Immediate appearance	-	-	-	-	NS
	After 1 week	xx	xx	xx	xx	NS
	Heat stability at 85°C (min)	>15	≒15	≒4	>15	NS
Pectin (%)	pH	NS	NS	NS	NS	3.99
	Serum formation					
	Immediate appearance	NS	NS	NS	NS	-
0.2	After 1 week	NS	NS	NS	NS	-
	Sediment					
	Immediate appearance	NS	NS	NS	NS	-
	After 1 week	NS	NS	NS	NS	xx
	Heat stability at 85°C (min)	NS	NS	NS	NS	10<<15
Pectin (%)	pH	4.00	3.40	4.24	3.74	NS
	Serum formation					
	Immediate appearance	-	-	-	-	NS
	After 1 week	-	-	-	-	NS
0.3	Sediment					
	Immediate appearance	-	-	-	-	NS
	After 1 week	xx	xx	xx	xx	NS
	Heat stability at 85°C (min)	>15	>15	10<<15	10<<15	NS

*NS : Data not studied

TABLE 4.15a : Formulation to study the effect of pH on the sensory scores.

Ingredients	% Solids		
OJC (Brix 52)		6.5	
Sucrose		5.5	
Protein*		3.0	
Pectin		0.3	
Citric Acid	0.631	0.683	0.736
Sodium Citrate	0.588	0.515	0.441

*Protein source: s-WPC 80

TABLE 4.15b : Sensory scores and other characteristics at different pHs.

	pH 3.79	pH 3.92	pH 4.04
Serum Formation			
Immediate appearance	-	-	-
After 2 weeks	-	-	-
Sediment			
Immediate appearance	-	-	-
After 2 weeks	xxx	xxx	xxx
Heat Stability			
65°C (min)	> 10	> 10	> 10
85°C (min)	> 15	> 15	≒15
Sensory Score*			
Sweetness	3.86	3.57	3.86
Sourness	3.00	2.71	2.43
Orange flavour	4.00	3.29	3.29
Off-flavour**	1.29	1.29	1.43

* Mean scores obtained from a 5-member panel.

** Off-flavour specified: 'milk powdery flavour'.

provided the pH was below 4.

It was concluded that in order to avoid serum formation a citric buffer was absolutely necessary, and the pH should be below 4. Pectin did not appear to have a significant effect on the serum formation. CMC only was effective if the pH was 4.5 and higher levels of citric buffer were present.

4.6.3 Sedimentation

Following the solution of the serum formation problem, it was the sedimentation that had to be decreased. It was not observed until the whey protein and orange juice cloud became stable on storage and there was no serum formation. The sediment was first observed in the experiments presented in Table 4.14b and Table 4.15b.

It was suggested that homogenization might effectively prevent sedimentation due to the high pressure which could break the agglomerated particles into a fine suspension. Thus, the effect of homogenization was investigated to confirm this (see Table 4.16a).

From the results shown in Table 4.16b, there was no indication of improvement of sedimentation. It was decided at this stage, however, that further research to avoid sedimentation should be withheld, as it was not so serious as serum formation. Consumers could hardly recognize it if the product was packed in a cardboard carton and also the original suspension was easily restored when the sample was shaken.

4.6.4 Heat Stability

Heat stability of whey protein was tested in the basic system with the protein level within the range of 1 to 3% (see Table 4.17a).

Coagulation time (CT) of more than 10 minutes was observed at 65^{o}C for all protein levels. However, at 85^{o}C where a practical UHT process was simulated, CT decreased markedly; there was less than 1 minute in CT at 3% protein level (see

16a : Formulation to study the effect of homogenization on the sedimentation.

ıts	% Solids
: 52)	6.5
	5.5
	3.0
	0.3
:id	0.736
.trate	0.441

source: 1-WPC 75

6b : Sedimentation with and without homogenization* observed immediately and after storage.

	Homogenized		Non-homogenized	
	Serum Formation	Sediment-ation	Serum Formation	Sediment-ation
appearance	-	-	-	-
ay at 2°C	-	-	-	-
eek at 2°C	-	x	-	x
eeks at 2°C	-	xx	-	xx
eeks at 2°C	-	xxx	-	xxx
ility				
65°C (min)	>10		> 10	
85°C (min)	>20		> 20	

zation: 150 kg/cm^2 (1st stage) + 50 kg/cm^2 (2nd stage) at 35°C.

TABLE 4.17a : Formulation to study heat stability in the absence of pectin

Ingredients	% Solids		
OJC (Brix 52)		6.5	
Sucrose		5.5	
Protein*	1.0	2.0	3.0
Citric Acid		0.65	
Sodium Citrate		0.55	

*Protein source: 1-WPC 75.

TABLE 4.17b : Heat stability at 65°C and 85°C with different levels of protein (1 to 3%) and no pectin.

	% Protein		
	1.0	2.0	3.0
pH	3.75	3.88	4.00
Serum Formation			
Immediate appearance	-	-	-
After 2 weeks	-	-	-
Sediment			
Immediate appearance	-	-	-
After 2 weeks	xxx	xxx	xxx
Heat Stability			
at 65°C (min)	> 10	> 10	> 10
at 85°C (min)	< 5	< 3	< 1

Table 4.17b).

It was needed to prolong CT so that the system could be used in a UHT process and also to secure storage stability of protein after UHT.

Pectin, Genu (citrus), Type JM was admixed for this purpose, as reported by Glahn (1982).

Tables 4.13b and 4.14b show that the incorporation of pectin had a marked effect on CT, depending on WPC type, pH and concentration of pectin. For example, in the system where 1-WPC 75 was incorporated to give 3% protein, CT at 85°C was only 4 min with 0.1% pectin, while it was more than 15 min with 0.2% pectin. The effect of pH was also important. In the same system where the pH was 4.24, CT at 85°C was 6 min while it was more than 15 min when the pH was 3.74.

It was concluded from the viewpoint of the heat stability that the product should contain at least 0.2% of pectin with the 3% protein level and the pH not more than 4. These conditions should prevent coagulation of whey proteins during heat treatment by the plate heat exchanger which would be used in the pilot-scale trial.

4.6.5 Sensory Profile

Orange juice fortified with four different types of WPC (s-WPC 55, 1-WPC 55, 1-WPC 75 and s-WPC 80) were compared with an unfortified juice (Table 4.13a).

The scores obtained from a five-member panel were averaged and are presented in Table 4.13b . It indicated that all the samples tasted significantly sweeter than what the panel thought was the right level. In view of sourness, those with s-WPC 55 and 1-WPC 55 were about right while there was less sourness with s-WPC 80 and 1-WPC 75 apparently due to the relatively high pHs.

The fortified samples scored lower in orange flavour than the unfortified juice although they had the same level of juice strength.

Significant unpleasant flavours were detected in the fortified samples which were specified by the panelists as salty, milk powdery, vinegar type acid, fermented and bitter.

Table 4.15b shows how the pH affected the sensory scores, in the system where s-WPC 80 was used.

It was concluded from the sensory viewpoint that firstly there needed to be a change in the basic system where orange juice solid was 6.5% and sucrose 5.5% to have more acceptable levels of sweetness, sourness and orange flavour; secondly, the high protein WPCs were more suitable as they had lower levels of off-flavour than the low protein WPC; and thirdly, the pH should not be more than 4 to give the acceptable sourness.

4.6.6 Summary of the Experiments

The experiments that had been done so far were summarised as shown in Table 4.18.

It was especially noted that the pH should be below 4 to avoid serum formation, to give higher heat stability and to have enough sourness; the optimum for all these response variables were in the same pH range. Buffer salts ($> 0.5\%$) had to be present to prevent serum formation and pectin ($> 0.2\%$) to prevent heat coagulation of proteins in the UHT treatment.

4.7 OPTIMIZATION OF FORMULATION

4.7.1 Aim of Optimization

In the previous experiments (Table 4.13b and 4.15b), the panelists noted that the basic system was significantly higher in sweetness than what they thought should be the right level; and also to a lesser extent, that there were fluctuations in sourness and orange flavour because of different types of WPCs and different pHs.

The present experiment was carried out to determine the right levels of sweetness, sourness and the maximum level of orange flavour by changing the concentrations of sucrose and orange juice solids, allowing orange juice strength within

TABLE 4.18 : Factors studied in the formulation development and the optimum levels of the response variables; serum formation, sedimentation, heat stability and sensory profile.

Response Variables / Factors	Serum Formation	Sediment-ation	Heat Stability	Sensory Profile (Sourness)
pH	< 4	NA*	< ca 4	< ca 4
(%) Level of citric buffer (conc. of citric acid + sodium citrate)	> 0.52	NA	NA	NA
Type of WPC	Type of WPC was not significant	NA	NA	High protein WPCs had less off-flavours
(%) Protein level	More serum formation with low level	NA	Low heat stability with higher level	Less acceptable with higher level
Homogenization	No effect	No effect	No effect	NA
CMC	Produced more serum formation unless at pH 4.5	NA	NA	NA
Pectin	Produced more serum formation	NA	Increased heat stability at above 0.2% level	NA

*NA : Data not studied.

TABLE 4.19a : Factorial design of 2 level, 2 factor, 1 centre point experiment to determine optimum orange juice strength and sucrose level.

Ingredients	% Solids		
OJC (Brix 52)	5.2	5.85	6.5
Sucrose	3.5	4.0	4.5
Protein*		3.0	
Pectin		0.3	
Citric Acid		0.736	
Sodium Citrate		0.441	

*Protein source: 1-WPC 75

TABLE 4.19b : Serum formation, sediment, heat stability and sensory score studied according to the factorial design.

OJC (%)	5.2	5.2	6.5	6.5	5.85
Sucrose (%)	3.5	4.5	3.5	4.5	4.0
pH	3.97	3.96	3.91	3.91	3.93
Serum Formation					
Immediate appearance	-	-	-	-	-
After 14 days	-	-	-	-	-
Sediment					
Immediate appearance	-	-	-	-	-
After 14 days	xx	xx	xx	xx	xx
Heat Stability					
65°C (min)	> 10	> 10	> 10	> 10	> 10
85°C (min)	> 15	> 15	> 15	> 15	> 15
Sensory Score*					
Sweetness	3.0	3.0	3.6	3.8	4.0
Sourness	3.0	3.4	2.8	2.6	3.4
Orange-flavour	3.0	3.4	3.0	3.4	3.4
Off-flavour	1.4	1.6	1.6	1.4	1.4

*Mean scores obtained by a sensory panel of 5 members, on a 5-point descriptive scale. (Score of 5 = very (sweet or sour), 3 = right blend of (sweetness or sourness), and 1 = not (sweet or sour); 5 = very pronounced, 3 = recognizable and 1 = none for orange flavour and off-flavour).

the range of 40 to 50%, while the total levels of citric acid and sodium citrate were kept constant.

The levels of protein, pectin, citric acid and sodium citrate selected were respectively 3, 0.3, 0.736 and 0.441% so that the systems would be stable enough on heat treatment and on storage (especially serum formation)(see Table 4.19a).

A lactic WPC 75 was chosen as the protein source from the viewpoint of the ease of importation to Japan and lower cost in comparison with lower-protein WPCs and higher-protein WPC (s-WPC 80), respectively.

4.7.2 Experimental Design and Results

A factorial design for a 2-factor, 2-level and 1-centre point experiment is shown in Table 4.19a and Appendix 4.1, and the results in Table 4.19b.

Yates analysis (see Appendix 4.2, 4.3., and 4.4) showed that orange juice had a significant effect on sweetness and sourness, but no effect on orange flavour itself within the range tested. Increasing orange juice decreased sourness and increased sweetness.

TABLE 4.20 : Effect of orange juice, sugar and orange juice/sugar on sweetness, sourness and orange flavour.

	Sugar	Orange Juice	Sugar + Orange Juice
Sweetness	Very small	Significant	Very small
Sourness	Small	Significant	Very small
Orange flavour	Significant	None	None

On the other hand, sucrose had a significant effect on the orange flavour, but only small effects on sweetness and sourness. Increasing sugar increased the strength of the orange flavour. This was summarised as shown in Table 4.20.

The sweetness and sourness were the "right blend" with a score of 3 at the lowest concentration of orange juice and sugar but the orange flavour was slightly weak. The level of off-flavour was not changed by increasing either the orange juice or the sugar or both. At these levels of orange juice and sucrose, the off-flavour cannot be masked.

It was noted that all the combinations of factors and levels exhibited no serum formation, and were heat-stable enough to ensure heat treatment in the UHT plant without protein coagulation, and the volume of the sediments were at normally acceptable levels. These systems were therefore stable during processing and storage except for a slight formation of sediment during storage.

4.8 CONCLUSION

The factorial experiment showed that the right levels of sweetness and sourness were obtained in the system where orange juice solid was 5.2% and sucrose was 3.5%. Although the level of orange flavour was slightly lower than that of the other three systems, it was decided that this formulation should be used for the pilot-scale production which would be performed subsequently and is described in the next chapter.

CHAPTER 5

PILOT PRODUCTION TRIAL AND STORAGE TEST

A process was developed using the final formulation and this was studied during a pilot plant trial. A storage test was made on the product from the pilot plant trial to study the effects of storage temperature on loss of colour and flavour, and on serum formation and sedimentation.

5.1 PILOT PRODUCTION TRIALS

5.1.1 Aims of Trial

The pilot-scale production was performed to determine the efficiency of the process design and to produce sufficient samples for a consumer market trial and a storage test.

5.1.2 Equipment

Equipment for the trial is listed in Table 5.1.

TABLE 5.1 : List of equipment used for the pilot-scale trial.

Type of Equipment	Capacity	Location	Make & Model
Steam-jacketed pan with vertical stirrer with variable speed drive.	Circa 70 litres	Massey University	C. & H., Australia
Homogenizer	45 litres/hour (12 gallons/ hour)	Massey University	APV, 15M Laboratory homogenizer
Plate Heat Exchanger	115 litres/hour	New Zealand Dairy Research Institute	Alfa-Laval, P20HB

5.1.3 Formulation and Scale of Production

The formulation used for the trial is presented in Table 5.2. This is the one that had been established in Chapter 4, Section 3.

The production scale of 50 kg was determined on the basis of the volume required for a market trial and a storage test: capacity of bottles = 330 ml; number of the bottles for the market trial and the storage test = 106 (bottles). Assuming overall loss during processing = 30%, then amount of liquid needed is:

$$330 \times 106 \div ((1 - 0.30) \times 1000)$$
$$\doteqdot 50 \text{ kg}$$

5.1.4 Processing

Similar processing operations were taken to those in Chapter 4, Section 4.5.2. The flow chart of the processing is shown in Figure 5.1.

Briefly, all the powdered ingredients were dissolved in water before orange juice concentrate was added. The mix was then homogenized (1st = 150 kg/cm^2; 2nd = 50 kg/cm^2 at 35°C) and transferred to two milk cans for storage overnight at 2°C.

The operations up to this stage were performed in the processing hall at Massey University. The milk cans were transferred to the New Zealand Dairy Research Institute (Palmerston North, New Zealand). After the prepared liquid mix was indirectly heat-treated by a plate heat exchanger (90°C, 30 seconds) and subsequently homogenized (1st = 100 bar; 2nd = 0), at 66°C and then cooled to room temperature, filling was carried out aseptically in a clean air room under a laminar flow cabinet. The mix was then filled up to the top of the glass bottles to avoid air incorporation and caps were hand-clamped by an operator who wore clean gloves and a cap. The bottles used were commercially available standard beer bottles with 300 ml capacity which, together with the caps, had been sterilized by autoclaving.

TABLE 5.2 : Formulation used for the pilot plant trial and quantity of ingredients needed to produce 50 kg of the product.

Ingredients	Solid (%)	Weight (%)	Quantity needed to produce 50 kg of liquid (kg)
Protein, Lactic WPC 75 (Alacen 312, NZ Dairy Board)	3.000**	4.000	2.000
Sugar, sucrose (commercial grade)	3.500	3.500	1.750
Pectin (Genu, Pectin type JM*. The Copenhagen Pectin Factory Ltd., Denmark)	0.300	0.300	0.150
Citric acid anhydrous (chemical grade)	0.736	0.736	0.368
Tri-sodium citrate dihydrate (chemical grade)	0.441	0.441	0.221
Orange juice concentrate (Brix 60.2)	5.200	8.638	4.320
Water	-	82.385	41.192

*Lot Nos. SC 83405 and SC 84174

**Protein content

FIGURE 5.1 : Flow chart for the production of whey protein-enriched orange drink.

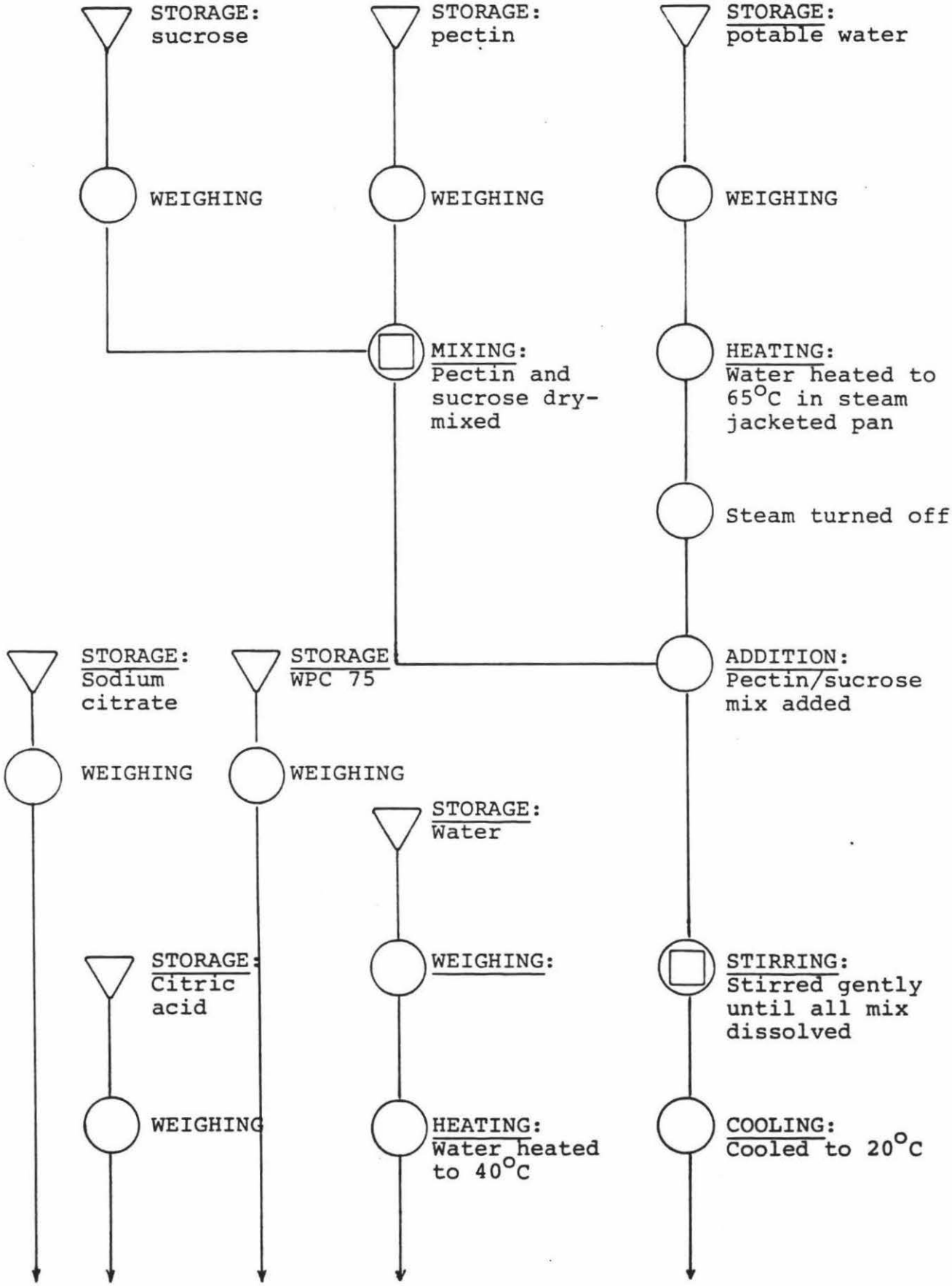


FIGURE 5.1 (Continued)

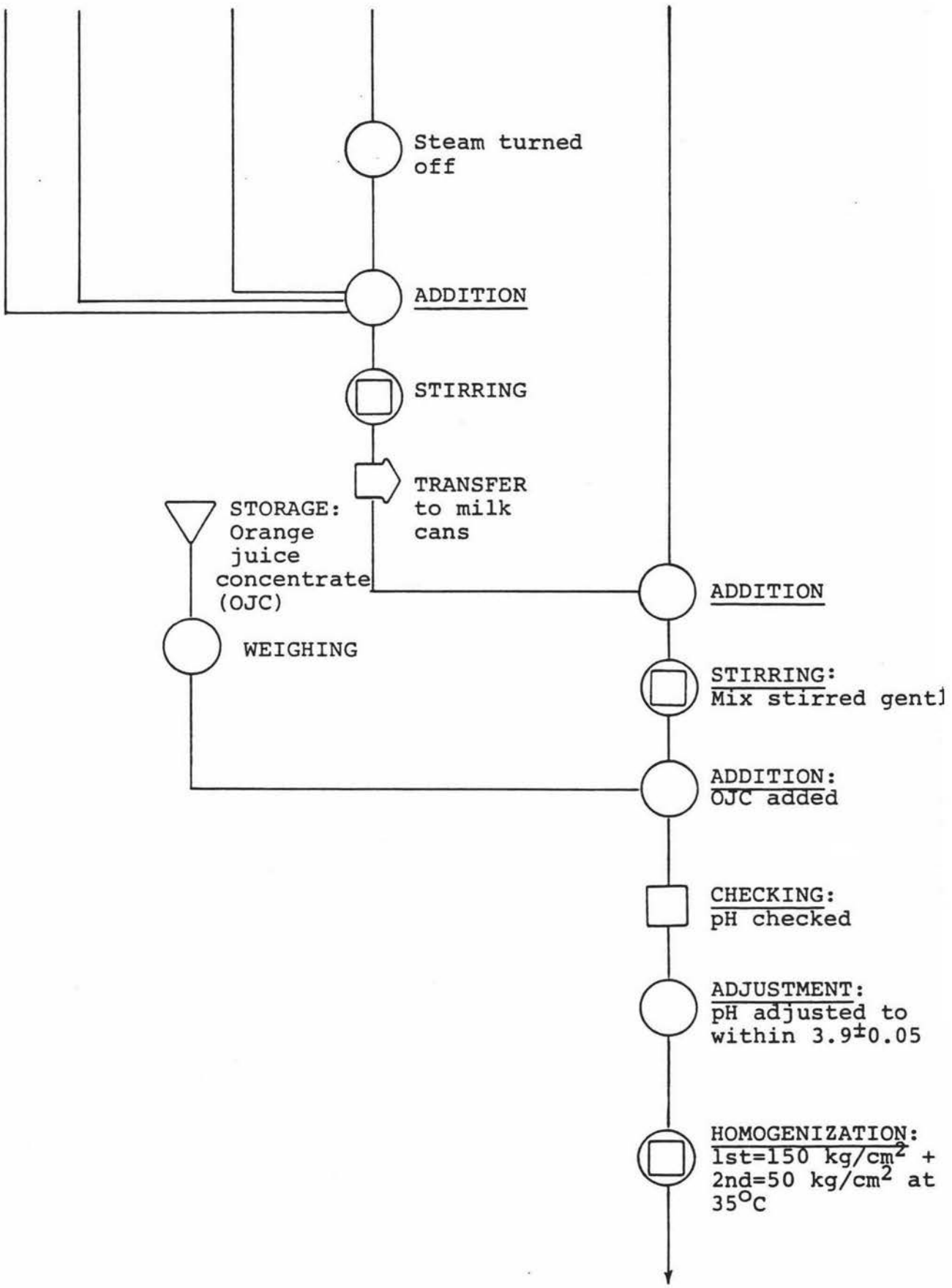
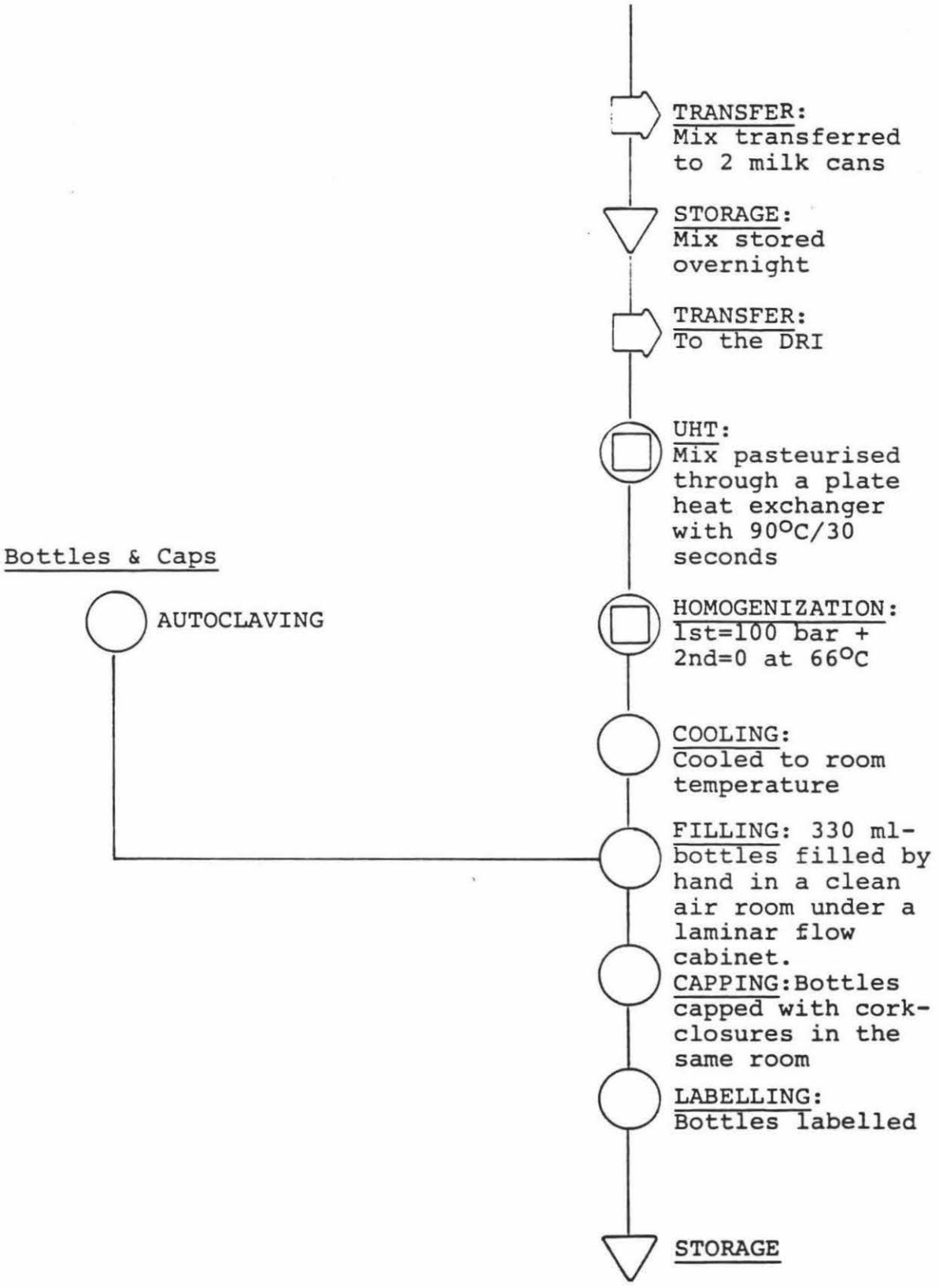


FIGURE 5.1 (Continued)



5.1.5 Results and Discussion

Dissolution of pectin was smoothly accomplished in warm water (60-70°C) with gentle stirring whereas there was lump formation in the case of WPC powder, resulting in an extended processing time. To avoid this and also to dissolve the lumpy powder, the stirring speed was accelerated, which caused bubbling on the surface of the mix. It took about 1 hour to dissolve all powders in the end. It was found that there was no need to adjust the pH as it was within the range of 3.9 $\pm$0.05. There was no problem with processing during the heat treatment by the plate heat exchanger. In total, 83 bottles were obtained. Therefore overall yield was calculated:

$$330 \times 83 \div 50{,}000 \times 100 = 55\%$$

assuming the specific gravity of the product was 1.00.

The loss of 50% occurred mainly due to the nature of the manual filling/capping operation and disposal of a blend of the product and water which was used to fill the plate heat exchanger and its affiliated pipes.

5.1.6 Conclusion

Although there was lump formation in dissolving WPC powder, this could be overcome by adopting a blending pump with a funnel in a larger operation. Standard milk plant equipment would be appropriate and no specially designed machines required. However, there may be a limited time of continuous operation of a plate heat exchanger due to the precipitate deposited on the surface of the plates. Overall yield of 50% was much less than what had been expected. Thus, the number of the bottles for the market trial had to be reduced.

5.2 STORAGE TEST

5.2.1 Aim of Storage Test

The storage test was carried out to determine the shelf life of the product.

5.2.2 Test Design

Bottles of the product were randomly sampled from the production run and were stored in three different environments:

* at 10°C in a dark incubator
* at 20°C in a dark incubator
* at 30°C in a dark incubator

In total, nine bottles were placed at each temperature and duplicate bottles were evaluated weekly over the four week duration of the storage trial and one bottle evaluated for the extended period (up to three months).

5.2.3 Methods of Storage Test

5.2.3.1 Serum Formation and Sediment Determination

Since the colour of the bottles from the pilot production was brown, all the liquids were poured carefully into beakers so as not to disturb the possible serum formation and sediment.

Serum formation was observed while the liquid was being poured and the sediment observed by inspecting the bottom of the bottles. The degrees of serum formation and sediment

were subjectively noted by the author according to the criterion used in Chapter 4, Section 4.5.3.

5.2.3.2 Sensory Evaluation

Orange flavour and off-flavour, and the colour during storage were evaluated by a sensory panel of five members. The scoresheet used is shown in Figure 5.2. The sensory panel procedure was as in Chaper 4, Section 4.5.3 except that red lights were used for the flavour determinations to remove probable bias affected by knowledge of the sample colour and also the drinks were presented in blue plastic cups rather than glasses.

After the flavour sessions terminated, the red lights were replaced by white lights for the colour determinations in which the panelists were asked to check the point that best described their perception on the 7-point verbal scale (see also Figure 5.2).

5.2.3.3 Vitamin C Determination and pH Measurement

Vitamin C was determined according to J.T. Baker's method which was based on the Association of Official Analytical Chemists.

The pH was measured using PHM61 Laboratory pH Meter, Radiometer, Copenhagen.

5.2.4 Results and Discussion

5.2.4.1 Serum Formation and Sediment

There was no serum formation within the storage time tested (4 weeks) regardless of the storage temperature. On the other hand, there was a 'slight' amount of sediment after 1 week and, to a larger extent, from the second week onward (Table 5.3). There was no visible effect of temperature on the degree of sediment.

When the bottles were shaken, the sedimented materials disappeared quickly and the original state of suspension was easily restored and maintained for at least five hours.

FIGURE 5.2 : Scoresheet for evaluation of whey protein-enriched orange drink, (Scores in parenthesis were assigned later for analysis), used for storage test.

SCORESHEET FOR WHEY PROTEIN-ENRICHED ORANGE DRINK

Name: _____ Date: _____

Set No. _____

INSTRUCTIONS: Please evaluate these coded samples by ticking (✓) the point in the scale that best describes your feeling:

		Sample Code		
1. Orange flavour:		( )	( )	( )
Very pronounced	(5)			
Pronounced	(4)			
Slight	(3)			
Just recognizable	(2)			
None	(1)			
2. Off-flavour:				
Very pronounced	(5)			
Pronounced	(4)			
Slight	(3)			
Just recognizable	(2)			
None	(1)			

Please describe the off-flavour if detected:

_____ _____ _____

_____ _____ _____

Next, please determine the colour under the white lighting:

3. Colour:				
Milky white	(7)			
Slight orangey white	(6)			
Slight brownish/orangey white	(5)			
Brownish orangey white	(4)			
Brownish white	(3)			
Whitish brown	(2)			
Brown	(1)			

Please give any comments if you have any. _____

_____

_____

TABLE 5.3 : Serum formation and sediment of the stored samples from the pilot plant trial at 3 different temperatures (10, 20 and 30°C).

	Temperature (°C)	Storage Period (Weeks) 1		2		3		4	
Serum Formation	10	-	-	-	-	-	-	-	-
	20	-	-	-	-	-	-	-	-
	30	-	-	-	-	-	-	-	-
Sediment	10	xx	xx	xxx	xxx	xxx	xxx	xxx	xxx
	20	xx	xx	xxx	xxx	xxx	xxx	xxx	xxx
	30	xx	xx	xxx	xxx	xxx	xxx	xxx	xxx

- = absent
x = very slight detection
xx = slight detection
xxx = noticeable
xxxx = very noticeable

5.2.4.2 Sensory Evaluation

The mean scores evaluated by the sensory panel are shown in Table 5.4.

Intensity of orange flavour decreased with the storage time and the samples lost more orange flavour at the higher temperatures (20°C and 30°C) than at 10°C. At 10°C, the flavour fell markedly between 3 and 4 weeks. This sudden drop cannot be explained and will have to be confirmed with later experiments.

There was a less than 'just recognizable' level of off-flavour throughout the storage period. However, some panelists noted slightly unpleasant flavours with the increased storage temperatues. They were described by the panelists as 'cooked', burnt', caramel', 'milk powdery', 'unclean', 'acidic', 'starchy' and 'nasty'.

The colour of the stored samples, which was observed by the sensory panel, changed from whitish/orangey to whitish/orangey/pinky/brownish with the increased temperatures and the time of storage (Figure 5.3). The change in colour occurred possibly due to the non-enzymatic browning (Maillard Reaction) between lactose in WPC, sugars in orange juice concentrate and added sucrose, and amino groups of whey proteins in WPC; and possibly because of loss of orange juice colour which was bleached during storage.

5.2.4.3 pH and Vitamin C Content

The pH of the drink remained constant regardless of the temperature throughout the storage period. It was noted that the vitamin C content was very low, which might lead to the experimental error and explain a slight increase with the storage time and temperature (see Table 5.5).

5.3 CONCLUSION

The factors to limit the shelf-life (SL) of the product would be the colour and loss of orange flavour. Subject to the result from the market trial, the SL would be approximately 4 weeks at 10°C and 2 weeks at 20°C from the

TABLE 5.4 : The mean scores for orange flavour and off-flavour (score of 5 = very pronounced; 1 = none) of samples from the pilot plant trial stored at 3 different temperatures (10, 20 and 30°C).

Sensory Attributes	Temperature (°C)	Storage Period (Weeks) 1	2	3	4
Orange-flavour	10	4.8	4.0	4.3	3.4
	20	4.2	3.6	3.3	3.0
	30	4.2	3.9	3.8	3.2
Off-flavour	10	1.2	1.4	1.2	1.4
	20	1.5	1.4	1.5	1.0
	30	1.7	1.3	1.7	1.4

TABLE 5.5 : The pH and vitamin C contents, monitored weekly, of samples from the pilot plant trial stored at 3 different temperatures (10, 20 and 30°C).

	Temperature (°C)	Storage Period (week) 1	2	3	4
pH	10	3.91	3.91	3.90	3.91
(at 20°C)	20	3.90	3.91	3.89	3.91
	30	3.89	3.90	3.87	3.90
Vitamin C	10	7.2	7.1	7.4	7.5
(mg/100 ml)	20	6.8	6.8	7.3	7.1
	30	6.4	7.9	8.4	8.4

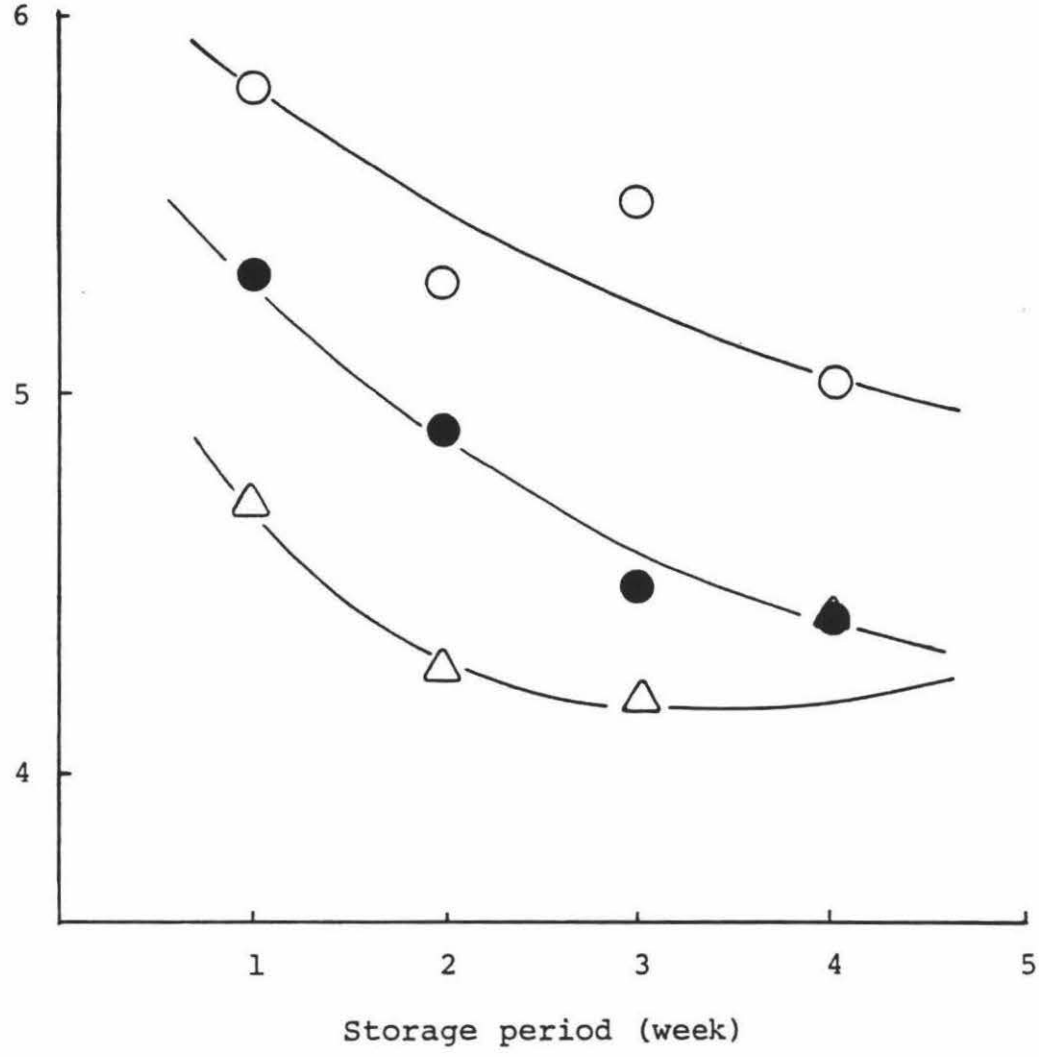


FIGURE 5.3 : Mean scores for the colour during 4 weeks of storage at (○) 10°C; (●) 20°C; (Δ) 30°C, scored by the sensory panel of 5 members on a 7-point verbal scale, e.g.
(score of 4 = brownish/orangey white
5 = slight brownish/orangey white, and
6 = slight orangey white)

viewpoint of the colour if the level of the colour should be more than that of 'slight brownish/orangey white'. From the viewpoint of the orange flavour, SL would be approximately 3 weeks at 10°C and only about 1 week at 20°C if the 'pronounced' level of orange flavour was required.

According to the product specification, it must keep its quality for at least 3 months at 10°C and for at least 2 months at 20°C. Thus, the quality of the present product did not satisfy the SL required by the specification because of loss of orange flavour and the undesirable colour change.

It is recommended then that orange flavour should be intensified by adding a natural flavouring and/or increasing orange juice concentrate level, and that the colour profile be improved with the incorporation of some colouring.

From the viewpoint of the processing, further study is required to relax time/temperature conditions of heat-treatment as it was noted that the product markedly lost its orangey colour after the heat treatment.

The vitamin C content of the juice needs to be increased by addition of ascorbic acid as it was below the level originally wanted in the product.

CHAPTER 6

MARKET TRIAL

A market trial of the product was carried out with the cooperation of Japanese housewives in Wellington.

6.1 AIMS OF THE MARKET TRIAL

The basic aims set for the consumer market trial were:

* To establish the acceptability of the new product.
* To obtain ideas for further improvements and modifications.
* To determine the reasons for buying the product and to aid the development of the marketing strategy.
* To estimate the market potential.

6.2 SURVEY METHOD

Because of the limited number of Japanese families in Wellington, the samples, together with the questionnaires, were distributed to as many families as practically possible.

They were businessmen and diplomats, and their families, who pursued either their commercial business or official duties in Wellington. They are regarded as belonging to the lower-middle to high socio-economic class.

A total of 36 bottles was distributed to 31 families and 25 men, 40 women and 26 children under 12 years of age responded to the survey.

6.3 QUESTIONNAIRE OF SURVEY

The questionnaire was designed originally in English and was translated into Japanese later for the survey. The English questionnaire is given in Appendix 6.1a and its Japanese version in Appendix 6.1b. It includes questions regarding opinions on:

* Overall acceptability of the product on the 9-point facial hedonic scale for adults and on the like or dislike-type question for children under 12 years of age.

* Sweetness, sourness, orange flavour and off-flavour of the product on the five-point descriptive scale.
* Whether they would buy it or not, and the reasons for doing or not doing so.
* Preferred flavours other than orange.
* Container size.
* Frequency of use.
* Type of packaging.
* Price.

The respondents were asked their age and sex, and their overall comments on the product at the end of the questionnaire.

6.4 RESULTS AND DISCUSSION

Detailed tables concerning the results of the present survey are given in Appendices 6.2 to 6.14.

The survey results are summarized in the following sections.

6.4.1 Overall Acceptability of the Product

The majority of the adult respondents (men 25, women 40) liked the product: 57% of them rated it as 'like moderately'; 18% as 'like very much' and 5% 'like extremely', i.e. 80% liked the product moderately or better (Table 6.1, Appendix 6.2). 81% of the children under 12 years of age also liked the product (Table 6.2).

6.4.2 Sensory Profile of Product

As regards sweetness of the product, 64% of the men thought it was 'the right level' and 24% 'moderately sweet', while 58% of women found it was 'the right level', and 28% and 2% 'moderately sweet' and 'very sweet' respectively (Appendix 6.3). Generally, sweetness was about right for men and slightly higher than the right level for women.

For sourness, 48% of the men and 53% of the women thought it was at the 'right level', while 52% of men and 30% of women rated it as 'moderately sour' (Appendix 6.4). This suggested that there was a significant difference in sourness

TABLE 6.1 : Consumer acceptability* of the whey protein-enriched orange drink (percentage distribution of responses of consumers above 12 years of age).

Type of Respondent	Total No.	Like Extremely (%)	Like Very Much (%)	Like Moder-ately (%)	Like Slightly (%)	Neither Like Nor Dislike (%)	Dislike Slightly (%)	Tota (%)
Men	25	4	24	60	0	4	8	10(
Women	40	5	15	55	5	8	12	10(
Total	65	5	18	57	3	6	11	10(

*9-point facial hedonic scale

TABLE 6.2 : The acceptability of the product to children under 12 years of age (percentage distribution of responses of children below 12 years of age).

Total Number	Like (%)	Dislike (%)	Total (%)
26	81	19	100

TABLE 6.3 : Reasons for buying the product (percentage distribution of consumers who would buy the product).

Type of Respondent	Total No.	Reasons for Buying: Nutritional Supplement	Nice Taste	Absence of Preservatives	Convenience	Fresh Combination of Whey Protein + Orange Juice	Others	Total
Men	18	24	28	0	8	36	4	100
Women	28	41	20	15	0	24	0	100
Total	46	34	23	9	3	29	2	100

Table 6.4 : Reasons why consumers would not buy it (percentage distribution of the consumers who would not buy).

Type of Respondent	Total No.	Reasons for not Buying: Too Sweet (%)	Too Sour (%)	No Orange Flavour (%)	Unpleasant Flavours (%)	Unattractive Colour (%)	Similar Products on the Market (%)	Others* (%)	Total
Men	7	22	11	11	0	11	45	0	100
Women	12	6	0	13	25	0	19	37	100
Total	19	14	5	14	18	5	22	22	100

*Other reasons specified: 'Yakult' is better; Calpis is better; I want to make it myself at home; it is not my favourite type, and there was nothing special in taste.

profile between men and women. In short, the product had a slightly higher level of sourness than the consumers wanted.

For orange flavour, 84% of the men thought it had a 'pronounced' level of orange flavour, while significantly lower percentage (62%) of the women rated it in the same way (Appendix 6.5). 8% of the men and 28% of the women detected unpleasant flavours (Appendix 6.6) which were described by the respondents by a variety of terms. It was noted that the women were significantly more sensitive to unpleasant flavours than the men. It was suspected that the unpleasant flavours of 'medicine', 'instant juice powder', 'orange-flavoured tooth-paste' and 'penicillin' resulted from sodium citrate which was necessary to stabilize the protein colloidal suspension and the juice cloud, and those of 'cheesey', 'milky', 'fermented', 'lactic-bacterial like', 'rotten' and 'skim milk powdery' originated from the lactic WPC.

6.4.3 Purchasing of Product

71% of the respondents indicated that they would buy the product if it was available on the market (Appendix 6.7). A breakdown of the age group showed that there was a strong buying intention from the women in their thirties (93%). The reasons for buying the product varied as shown in Appendix 6.8, and are summarised in Table 6.3.

For example, 36% of the men and 24% of the women would buy it for the 'fresh combination of whey protein and orange juice', which suggested people would buy it simply because they thought it was new.

The reasons why consumers would not buy it again are shown in Table 6.4.

The reasons which were attributed to the product formulation (too sweet, too sour, no orange flavour and unattractive colour) were given by 56% of the respondents and those which belonged to the product concept (e.g. similar products on the market) 44%. Therefore one could have a significant

percentage of people change their minds and purchase the product solely by improving the formulation.

6.4.4 Flavour Preference

The respondents were asked to indicate their preference for fruit flavours other than orange flavour (Appendix 6.9).

Pineapple ranked first, apple second and lemon third among the six flavours presented. This could provide ideas when one wanted to extend the product range by incorporating different flavours.

6.4.5 Size of Product

42% of the respondents indicated that they would prefer a 200 ml-capacity container (Table 6.5). It was especially noted that some people preferred a size less than 200 ml e.g.80 ml, the size of 'Yakult',which is a popular brand of fermented milk drink in Japan. There was a comment in which one consumer said that the product was too thick to drink at one time. This suggested that the product was regarded as a 'Yakult' type drink by some people and if one wants them to drink more,the product needs to be thinner and easier to drink.

6.4.6 Frequency of Use of Product

79% of the respondents would consume at least one 250 ml-pack a week (Table 6.6). It was noted that the women said they would consume it more often than the men.

6.4.7 Type of Container

30 out of 43 respondents preferred a cardboard carton (Appendix 6.10).

There was a strong indication of a preference for a plastic bottle from a group of women who commented at the end of the questionaire that they would like to see the colour of the product.

6.4.8 Price of Product

59% of the respondents were prepared to buy it at 100 yen

TABLE 6.5 : The container size wanted (percentage distribution of consumer response who would buy the product).

Type of Respondent	Total No.	200 ml (%)	250 ml (%)	500 ml (%)	1 L (%)	Others* (%)	Total (%)
Men	17	45	25	15	5	10	100
Women	26	40	17	13	13	17	100
Total	43	42	20	14	10	14	100

*Others specified: 80 ml, 100 ml, less than 200 ml and the size of 'Yakult'.

TABLE 6.6. : Frequency of use of the product (percentage distribution by sex of the respondents who would buy the product).

Type of Respondent		Total	One Every 3-4 Weeks	One Every 2 Weeks	One Every 4-7 Days	One Every 2-3 Days	One Every Day
			0.29 packs a week	0.50 packs a week	1.27 packs a week	2.80 packs a week	7.00 packs a week
Men	No.	17	1	0	7	7	2
	%	(100)	(6)	(0)	(41)	(41)	(12)
Women	No.	26	4	4	8	4	6
	%	(100)	(15)	(15)	(31)	(15)	(24)
Total	No.	43	5	4	15	11	8
		(100)	(12)	(9)	(35)	(26)	(18)

*( ) shows percentage

and 2% and 22% of them at 110 yen and 120 yen, respectively (Appendix 6.11). This indicated they expected to pay a high price for this product.

6.4.9 Overall Comments on Product

A detailed description of overall comments and criticism of the product is given in Appendix 6.12.

There were comments on the colour of the product from 5 different persons who generally did not like it.

The serving temperature concerned 4 persons who suggested it was better to drink it chilled rather than served at ambient temperature.

There were 3 persons who thought the product was similar in taste to 'Yakult', and so they recommended it be packed in a 'Yakult' size container.

There were also 3 persons who thought it too thick to drink much at a time although there were two who thought vice-versa.

6.5 ESTIMATION OF THE MARKET POTENTIAL

The market potential was estimated on the basis of the following assumptions.

* The product is marketed nationwide.
* 80% of the Japanese people regard themselves as members of middle class or higher, who should be represented by the respondents of the present survey.
* 71% of the population would buy the product (this was indicated by the survey).
* One of the target markets chosen was: (A) women in their late twenties, thirties and early forties who have pre-school and school children and buy it for their families and 80% of the corresponding population group come under this classification.
* The other market chosen was: (B) young people of 15 to 24 years of age who live separately from their parents but are not married and 30% of the

corresponding population group come under this classification.

In the case of (A), the size of the target market population who would potentially buy the product was derived, allowing for the above-mentioned assumptions:

18.55 million* x 0.80 x 0.71 x 0.80 = 8.43 million

*the population of women of 25 to 45 years of age in Japan (Appendix 6.13).

and frequency of use of the product was obtained from Table 6.6:

0.29 (pack/week) x 15/100 + 0.50 x 0.15 + 1.27 x 0.31 + 2.8 x 0.15 + 7 x 0.24
= 2.58 250 ml-pack a week

In the case of (B), the size of the target market population was likewise determined:

15.96 million* x 0.80 x 0.71 x 0.30 = 2.72 million

*the population of people of 15 to 24 years of age in Japan (Appendix 6.13).

and frequency of use of the product was obtained from Appendix 6.14:

0.29 (pack/week) x 18/100 + 0.50 x 0.18 + 1.27 x 0.28 + 2.80 x 0.08 + 7 x 0.28
= 2.68 250 ml pack a week

Optimistic Calculation

Assuming that the product captures 30% of the market and the price is set at 100 yen where 83% of the respondents are prepared to buy it (Appendix 6.11), then the estimated market potential would be:

(8.43 x 2.58 + 2.72 x 2.68) x 52* x 0.83 x 0.30 x 100
≒ 37,600 million yen per year

*52 weeks a year

Pessimistic Calculation

Assuming that the product takes only 5% of the market due to the possible severe competition, lack of marketing ability and failure to educate consumers, and the price is set at 120 yen a pack where only 22% of the respondents are prepared to buy it (Appendix 6.11), then the estimated market potential would be:

$$(8.43 \times 2.58 + 2.72 + 2.68) \times 52 \times 0.22 \times 0.05 \times 120$$
$$\doteqdot \text{2,000 million yen per year}$$

Most Likely Calculation

Assuming that the product captures 20% of the market and the price is set at 120 yen a pack where 22% of the respondents are prepared to buy it, then the estimated market potential would be:

$$(8.43 \times 2.58 + 2.72 \times 2.68) \times 52 \times 0.22 \times 0.20 \times 120$$
$$\doteqdot \text{8,000 million yen a year}$$

(NZ$ = 120 yen, August 1984)

In the Japanese food industry, it is generally accepted that if the annual sales of a single product reach 10 billion yen, it is a great success. Thus, 8 billion yen of the sales potential based on the most likely calculation is considered to be large enough to have a test market trial in Japan.

It is envisaged that the company will capture a significantly large market share at the time of launching and for the time being. However, after the news of the success for the product is known to the public, relatively simple development work may give its competitors a quick response and the share will shortly drop until it is stabilized by the efforts of the company which will try to promote its brand.

6.6 CONCLUSIONS AND RECOMMENDATIONS

6.6.1 Sensory Profiles

Overall acceptability of 80% which includes 'like moderately' level and higher acceptability levels is very satisfactory.

Sweetness and sourness of the product were positioned in the right levels by more than half of the respondents, but the percentage of those who thought both profiles were slightly higher than the right levels was much larger than that of those who thought them slightly lower than the right levels. This suggests that one needs to reduce sweetness and sourness to a certain extent, but not so far that the majority in the centre move and say it is not sweet nor sour enough.

For orange flavour, the product needs to have slightly more orange flavour. This can be done by increasing orange juice level or adding a natural flavouring if the cost allows.

It was significant that 20% of the respondents detected unpleasant flavours (Appendix 6.6). Therefore it is necessary that the level of sodium citrate, together with citric acid, be reduced to the minimum range which ensures that the colloidal system is not affected on storage. This would also help to improve sourness profile. A sulphuric WPC could replace a lactic WPC to avoid the off-flavours which were attributed to the fermentation process in the lactic WPC manufacture. In addition, some kind of flavouring could be added to mask the unpleasant flavours.

There were many comments on the colour which was, so to speak, whitish/pinky/brownish/orangey and was not very attractive to the respondents generally. These comments arise because the product lost its orangey colour markedly during the UHT process and gained a whitish/brownish colour instead presumably due to the whey proteins that were partially denatured by heat treatment but kept its colloidal state by the action of pectin.

It is recommended that some kind of colouring (preferably naturally-obtained) be added to improve the colour profile.

6.6.2 Purchasing of Product

A considerable percentage of the respondents (34%) would

buy it because they regarded it as a nutritional supplement. Therefore it would be more attractive if one could incorporate more nutrients such as vitamins and minerals into the product.

Some people would not buy it because they thought there were similar products on the market.

It is necessary to promote the product intensively explaining its uniqueness.

6.6.3 Size and Type of Container

For the present product, the size of 200 ml or less is suitable because the consumers may not be able to drink much at a time. However, as the product is designed to be consumed at least at 200 ml a day according to the Recommended Dietary Allowances, it should be thin enough to be accepted at the intake. This could be done by lowering sodium citrate/citric acid, pectin and sucrose levels. Replacement of the lactic WPC 75 by a sulphuric WPC 80 can also slightly contribute because of the same level of protein (3%) with less minerals and lactose. Then a size of 200-250 ml would be suitable for a single serving.

It was decided that the product should be packed in a card-board carton because many respondents preferred it. It is also advantageous as the consumers fail to see the colour and sediment in the carton which might get worse during storage.

6.6.4 Frequency of Use of Product

It is reasonably satisfactory that 79% of the respondents would consume at least one 250 ml pack a week.
This would increase if the formulation is improved and an appropriate pricing taken.

6.6.5 Price of Product

It is recommended that the product is priced within the range of 100 and 130 yen. Considering the retail price of 'Milful', which was a whey drink and marketed about a year ago at 130 yen, this range would be about right.

CHAPTER 7

REFORMULATION OF WPC-FORTIFIED ORANGE FRUIT JUICE

It was decided that the product needed to have some changes made to the formula after the results of the market trial were known. These were identified as the improvement of the profiles of sweetness, sourness, orange flavour, off-flavour and the colour of the product.

There was also a need to increase the vitamin C level as it was noted in the storage test that it was too low to even satisfy the minimum level of the requirement as discussed in Chapter 4, Section 4.2.3.

7.1 AIMS OF THE REFORMULATION

* To reduce the levels of sourness and off-flavours by decreasing the levels of citric acid and sodium citrate, and by using a sulphuric WPC rather than a lactic WPC.
* To improve the colour profile by adding colouring.
* To increase the level of vitamin C by adding ascorbic acid.

The orange flavour profile would be improved by carrying out the second pilot trial where the heat treatment would be reduced so that the extent of loss of the flavour could be reduced significantly.

It was decided that the sweetness profile would not be changed as this might lead to a complicated reformulation; thus it would bring the work beyond the time limit for this project, knowing that the majority of the respondents thought the sweetness was the right level.

7.2 SUMMARY OF THE REFORMULATION

In order to increase the vitamin C level and also to change the colour to the orangey side, 92 mg/100 ml of ascorbic acid and 0.05% or 0.10% of 1% CWS (Beta-Carotene, F. Hoffman-La Roche & Co. Ltd., Switzerland) were respectively added to the formulation of the last market trial.

There was a need to reduce slightly the amount of citric acid to keep the pH at 3.9 because of the added ingredients. Other than this, there appeared to be no single side effects. For the colour, 0.1% of 1% CWS gave the product enough orangey/yellowy colour after the heat treatment at 85°C for 30 seconds, while there was not enough orangey/yellow colour with 0.05% of 1% CWS under the same conditions.

Reduction of citric buffer salts to 75% of the original levels revealed no serum formation during the storage period of 3 weeks and the heat stability was within the normal range. This should help to decrease the levels of sourness and off-flavours associated with sodium citrate.

The use of s-WPC 80 as a means of a possible reduction of off-flavours associated with the fermentation process which appeared in a lactic WPC manufacture showed that there was no serum formation on storage. It also showed that the heat stability was within the normal range, which should ensure the heat treatment process in the subsequent pilot-scale trial was possible.

7.3 EXPERIMENTAL

7.3.1 Materials

Materials used in the present experiments were obtained from the same sources as listed in Table 4.5. In addition to these, beta-carotene (1% CWS = cold water soluble, F. Hoffman-La Roche & Co. Ltd., Switzerland) and ascorbic acid of chemical grade (L-Ascorbic Acid, BDH Chemicals Ltd., England) were used.

7.3.2 Processing Methods and Test Methods

The samples were prepared in a similar way to that described in Chapter 4, Section 4.5.2. Serum formation and sediment tests, and heat stability testswere carried out in a similar manner to that described in Chapter 4, Section 4.5.3. Flavour tests were not performed as these would be done in the second market trial using the Japanese people in Wellington.

For the colour determination, the following procedure was taken:

Approximately 10 ml of the sample liquid was placed in 20, 16-ml capacity, test tubes and immersed in a hot water bath where the temperature was controlled at 87°C. They were left for 30 seconds until the sample temperature had reached 83°C. All the liquids in the test tubes were then cooled to about 20°C in an iced cold water bath, and were poured into a 250 ml capacity conical flask where the colour was determined. The colour determination was carried out by the use of 'Munsell book of colour' (Baltimore, Maryland, USA) which was regarded as an objective method.

7.4 RESULTS OF THE REFORMULATION DEVELOPMENT

Ascorbic acid and beta-carotene were added to the formulation of the last market trial to increase the vitamin C level and also to improve the colour profile (see Table 7.1a). There was a need to reduce the amount of citric acid to 0.633% to keep the pH at 3.90 due to the added ascorbic acid and 1% CWS.

Samples with 0.1% and 0.05% CWS both looked very orangey, but they lost the colour significantly during the heat treatment at 85°C for 30 seconds. For example, the sample with 0.1% CWS showed 7.5 YR, 7/10 (Munsell book of colour) before the heat treatment at 85°C for 30 seconds and 10 YR, 8/8 afterwards (see Table 7.1b). This represents a decrease in orangey colour and an increase in milky appearance.

It was subjectly noted by the author that 1% CWS level of 0.05% did not give a sufficient orangey colour whereas 0.1% of 1% CWS was about the right level. Therefore, the next two experiments would be done with 0.1% of 1% CWS.

The next experiment was performed to study the effect of the reduced amounts of citric acid and sodium citrate on the serum formation, sediment and the heat stability (see Table 7.2a). This was aimed at lowering the levels of sourness and also off-flavours associated with sodium citrate.

There was no serum formation within the storage period of 3 weeks and the heat stability was within the normal range (see Table 7.2b).

TABLE 7.1a : Formulation to study the effects of ascorbic acid and beta-carotene on pH and colour.

Ingredients	% Solids
OJC (Brix 52)	5.2
Sucrose	3.5
Protein*	3.0
Pectin	0.3
Citric acid	0.633 (0.736)**
Sodium citrate	0.441
1% CWS	0.10, 0.05
Ascorbic acid	0.092

* Protein source: 1-WPC 75

**The amount of citric acid was reduced to 0.633% to give the pH of 3.90.

TABLE 7.1b : pH, sediment, serum formation, heat stability, and colour with ascorbic acid and beta-carotene addition.

	% 1% CWS	
	0.1	0.05
pH	3.90	3.90
Sediment		
Immediate appearance	-	-
After 1 week at 2°C	xxx	xxx
After 2 weeks at 2°C	xxxx	xxxx
After 3 weeks at 2°C	xxxx	xxxx
Serum Formation		
Immediate appearance	-	-
After 1 week at 2°C	-	-
After 2 weeks at 2°C	-	-
After 3 weeks at 2°C	-	-
Heat Stability		
Coagulation time (min.)		
at 65°C	> 10	> 10
at 85°C	> 15	> 15
Colour		
Before heat treatment*	7.5YR 7/10**	NS***
After heat treatment	10YR 8/8	7.5YR 8/6

* Heat treatment: 85°C for 30 seconds

** The colour standard: Munsell book of colour, Baltimore, Maryland, USA.

***Data not studied

TABLE 7.2a : Formulation to study the effects of the reduced amounts of citric acid and sodium citrate on serum formation and heat stability

Ingredients	% Solid
OJC (Brix 52)	5.2
Sucrose	3.5
Protein*	3.0
Pectin	0.3
Citric acid	0.575**
Sodium citrate	0.331
1% CWS	0.1
Ascorbic acid	0.092

* Protein source: 1-WPC 75

**The pH was adjusted to 3.9 by adding the amount of citric acid

TABLE 7.2b : Serum formation and sedimentation on storage, and heat stability with the reduced levels of citric buffer solids.

	Heated Sample*	Non-heated Sample
pH	3.90	3.90
Sediment		
Immediate appearance	-	-
After 1 week at 2°C	xx	xx
After 2 weeks at 2°C	xxx	xxx
After 3 weeks at 2°C	xxxx	xxxx
Serum Formation		
Immediate appearance	-	-
After 1 week at 2°C	-	-
After 2 weeks at 2°C	-	-
After 3 weeks at 2°C	-	-
Heat Stability		
Coagulation time (min.)		
at 65°C	-	> 10
at 85°C	-	> 15
Colour		
Munsell book of colour	7.5YR, 8/6	7.5YR, 7/10

* Heated in a hot water bath at 85°C for 30 seconds.

TABLE 7.3a : Formulation to study the effects of s-WPC on storage characteristics and heat stability.

Ingredients	% Solid
OJC (Brix 52)	5.2
Sucrose	3.5
Protein*	3.0
Pectin	0.3
Citric acid	0.575**
Sodium citrate	0.331
1% CWS	0.1
Ascorbic acid	0.092

* Protein source: s-WPC 80 (ALACEN 343)

**The pH was adjusted to 3.9 by adding the amount of citric acid

TABLE 7.3b : Serum formation and sedimentation on storage and heat stability with s-WPC 80.

	Heated Sample*	Non-heated Sample
pH	3.90	3.90
Sediment		
Immediate appearance	-	-
After 1 week at 2°C	xxx	xxx
After 2 weeks at 2°C	xxxx	xxxx
After 3 weeks at 2°C	xxxx	xxxx
Serum Formation		
Immediate appearance	-	-
After 1 week at 2°C	-	-
After 2 weeks at 2°C	-	-
After 3 weeks at 2°C	-	-
Heat Stability		
Coagulation time (min.)		
at 65°C	-	10
at 85°C	-	15
Colour		
Munsell book of colour	7.5YR, 8/6	7.5YR, 7/10

* at 85°C for 30 seconds

The final experiment was to study the effect of a sulphuric WPC on the storage characteristics and the heat stability in the previously established system including 1% CWS and ascorbic acid (see Table 7.3a). An s-WPC 80 (ALACEN 343) was expected to help to reduce the off-flavours associated with the fermentation process which appeared in the lactic WPC manufacture.

Again, there was no serum formation on storage with both the heated and non-heated samples. Sedimentation and heat stability were within the normal range (see Table 7.3b). There appeared to be no difference in colour between the s-WPC and l-WPC containing systems according to the 'Munsell book of colour' (see Tables 7.2b and 7.3b).

7.5 CONCLUSION

Ascorbic acid and beta-carotene were successfully added to the formulation of the last market trial without requiring much alteration of the ratio of citric acid to sodium citrate to achieve the desired pH. It was decided that 0.1% of 1% CWS was necessary to give the sufficient orangey colour to the product.

The levels of citric acid and sodium citrate were also successfully reduced to 75% of the original amounts without affecting storage within the storage time tested, although the long term effect on storage would be subject to a longer storage trial.

The performance of s-WPC 80 was assessed as equally as l-WPC 75 with regard to the heat stability and the storage characteristics Thus, s-WPC could also be used to fortify the system.

It was decided that for the second market trial 2 kinds of samples, namely an l-WPC 75-containing sample and an s-WPC 80-containing sample should be presented to the consumers to compare them to each other and also to choose the better one.

CHAPTER 8

PILOT PRODUCTION TRIAL AND STORAGE TEST OF THE REFORMULATED PRODUCTS

A pilot-scale production trial of the reformulated products was carried out producing two kinds of drinks, namely, a drink with s-WPC 80 and the one with l-WPC 75. The products from the trial were studied with regard to the effects of storage temperatures on loss of colour, serum formation, sedimentation, loss of vitamin C and microbial characteristics.

8.1 PILOT PRODUCTION TRIAL

8.1.1 Aims of Trial

The pilot-scale production was performed to produce samples for a consumer market trial and a storage test. The trial also aimed at improving the colour and decreasing the loss of orange flavour by reducing the heating time during the operation in the plate heat exchanger.

8.1.2 Equipment

The same equipment was used as listed in Table 5.1.

8.1.3 Formulation, Scale of Production and Processing

The two kinds of formulations used for the trial are presented in Table 8.1. This is the formulation that had been established in Chapter 7. Due to the limited quantities of some of the raw materials available, a production scale batch of 24 kg was determined.

The processing operations were similar to those that had been done previously except that the liquid was heat-treated at 90^{o}C for 22 seconds (30 seconds for the first trial).

8.1.4 Results

32 bottles of the drink with s-WPC 80 and 41 bottles of the one with l-WPC 75 were obtained from the pilot production trial. There were no particular problems throughout the production run, although there was some difficulty in

TABLE 8.1 : Formulation used for the second pilot plant trial and quantity of ingredients to produce 24 kg of the drink with either s-WPC 80 or l-WPC 75.

Ingredients	Solid (%)	Weight (%)	Quantity needed to produce 24 kg of liquid (kg)
Protein (sulphuric WPC 80 - ALACEN 343 or lactic WPC 75 - ALACEN 312, N.Z. Dairy Board)	3.000**	3.750 (4.000)*	0.900 (0.960)*
Sugar, sucrose (commercial grade)	3.500	3.500	0.840
Pectin (Genu, pectin type JM. The Copenhagen Pectin Factory Ltd., Denmark)	0.300	0.300	0.072
Citric acid anhydrous (chemical grade)	0.473 (0.575)*	0.473 (0.575)*	0.114 (0.138)*
Sodium citrate (chemical grade)	0.331	0.331	0.079
Beta-Carotene (1% CWS, F. Hoffmann-La Roche & Co. Ltd., Switzerland)	0.100	0.100	0.024
Orange juice concentrate (Brix 52)	5.200	10.000	2.400
Ascorbic acid (chemical grade)	0,092	0.092	0.022
Water	-	81.454 (81.102)*	19.549 (19.465)*
Total	-	100.000	24.000

*( ) represents the use of lactic WPC 75 (ALACEN 312).

** Protein content.

dissolving the WPC powders as described in Chapter 5, Section 5.1.5. The sample bottles obtained in the trial would be used for the storage test and also the market trial.

8.2 STORAGE TRIAL

A storage trial of the reformulated products of the two kinds were performed by using the sample bottles obtained from the pilot production run.

8.2.1 Aim of Storage Test

The storage test was carried out to determine the shelf life of the product by measuring sediment, serum formation, colour, flavours, vitamin C content and microbial quality, (e.g. E. coli, yeast and moulds and total plate count). Special attention was given to the possible change of colour and loss of vitamin C during the storage trial.

8.2.2 Test Design

Because of the shortage of the sample bottles, only 3 bottles of each product (total 6 bottles) were randomly sampled from the production run. One of each product was stored at 10°C, 20°C and 30°C for 2 months in the same dark incubators as had been used previously.

The samples were analysed after 2 months' storage.

8.2.3 Methods of Storage Test

Serum formation and sediment were determined as described in Chapter 5, Section 5.2.3.1. Orange flavour and off-flavour, and the colour were evaluated only by the author due to the limit of the time of the project. The same scoresheet was used as shown in Figure 5.2. The colour was also determined by the use of 'Munsell Book of Colour'.

Vitamin C determination and microbial tests (yeasts and moulds, total plate count and E. coli) were carried out by the Food Technology Research Centre at Massey University (Palmerston North, New Zealand).

TABLE 8.2 : Changes in physical and sensory characteristics during the storage trial.

	Storage Temp. (°C)	s-WPC Storage Period (month) 0	s-WPC Storage Period (month) 2	l-WPC Storage Period (month) 0	l-WPC Storage Period (month) 2
pH	10	3.89	3.90	3.92	3.91
	20		3.89		3.92
	30		3.90		3.90
Sedimentation	10	-	xxxx	-	xxxx
	20		xxxx		xxxx
	30		xxxx		xxxx
Serum formation	10	-	-	-	-
	20		-		-
	30		-		-
Orange flavour*1	10	Pronounced	Pronounced	Pronounced	Pronounc
	20		Pronounced		Pronounc
	30		Pronounced		Pronounc
Off-flavour*1	10	None	Just recognizable	None	None
	20		None		None
	30		None		None
Colour (Munsell Book of Colour)	10	2.5Y8/10*2	10YR8/8*3	2.5Y8/10	10YR8/6*
	20		10YR8/8		10YR8/8
	30		10YR8/8		10YR8/8
Vitamin C (mg/100 ml)	30	NS*5	77*6	NS	NS

*1 Evaluated on the scoresheet as shown in Figure 5.2. Levels of intensity of the flavours: very pronounced, pronounced, slight, just recognizable and none.

*2 Hue of yellow with the highest values of lightness and strength.

*3 Hue of reddish yellow with the highest values of lightness and strength.

*4 Hue of reddish yellow with the highest value of lightness and a slightly lower value of strength.

*5 Data not studied.

*6 Measured by the Food Technology Research Centre at Massey Univers:

8.2.4 Results and Discussion

Table 8.2 shows the results of the present storage trial. Figure 8.1 shows the colour of the s-WPC stored for 2 months at 10°C, 20°C and 30°C.

Both the s-WPC and the l-WPC exhibited no serum formation within the storage period of 2 months at every temperature (10, 20 and 30°C).

On the other hand, sediments were observed at the bottom of the bottles of both drinks regardless of the storage temperature. The sediments were easily incorporated into the liquid system and the original state of suspension restored immediately after the bottles were shaken. The volume of the sediments was within the normal range as observed in the previous storage trial.

Both the drinks appeared to have the same colour at the start of the storage trial. This colour was identified as 2.5 Y 8/10 according to the Munsell Book of Colour, which represented the hue of yellow with the highest value of lightness and the highest value of strength. Only a slight change of the colour occurred during the storage trial, but the different storage conditions did not differentiate the colour change of one sample from that of the others except the l-WPC stored at 10°C. The colour change was determined as 10 YR 8/8, which indicated the hue of reddish yellow with the highest value of lightness and the highest value of strength. The colour of the l-WPC that had changed during the storage at 10°C was determined as 10 YR 8/6, which showed the same hue and the same value of lightness but a slightly lower value of strength. The reason for this change is not clear.

The orange flavour was rated by the author as a 'pronounced' level in both samples at every storage temperature.

There was no off-flavour with every sample except the s-WPC stored at 10°C, in which 'unclean' flavour was detected by the author.

FIGURE 8.1 : The colour of the drink with s-WPC 80 stored for 2 months at 10°C, 20°C and 30°C.

A vitamin C level of 77 mg/100 ml was determined in the s-WPC stored for 2 months at 30°C. Loss of vitamin C during the preparation of liquid, the processing and the storage trial was calculated as follows:

$$\text{Loss of vitamin C (\%)} = 1 - \left(\frac{77}{92 + 8}\right) \times 100$$

$$= 23$$

where 92 is the amount of the added ascorbic acid (mg/100 ml) and 8 the approximate amount of vitamin C from orange juice concentrate (mg/100 ml), which was determined in the first trial.

The loss of vitamin C (23%) was considered to be significant, but it was much lower than the level that had been assumed; 30% during the processing and another 30% during the storage. As the RDA of vitamin C for adults in Japan is 50 mg and also the vitamin C level of natural orange juice is 50 mg/100 ml, the level of 77 mg/100 ml of vitamin C present in the product was considered to be too high. The loss of vitamin could be lower if the product was stored at lower temperatures.

Therefore, it will be necessary to reduce the level of added ascorbic acid and also to study further the loss of vitamin C in terms of processing and storage temperature/time conditions.

There was no microbial count obtained in the s-WPC stored for 2 months at 30°C (see Table 8.3).

TABLE 8.3 : Microbial quality of the s-WPC stored for 2 months at 30°C.

Microbial Quality*	No. of Colony
Total plate count	< 100/ml
Yeast and moulds	< 100/ml
Coliforms	< 100/ml

*Data analysed by the Food Technology Research Centre at Massey University.

8.2.5 Conclusion

It was believed that the product could be accepted by the consumers after 2 months' storage.

Considering the fact that the colour changed only slightly during the storage at even the extreme condition ($30^{o}C$), the colour of reddish yellow could be expected to last for a longer time at lower temperatures. In order to reduce the extent of loss of colour in processing, it may be possible to ease the heat conditions as microbial tests revealed no trace of microorganism as determined by such tests as 'Total Plate Count', 'Coliforms' and 'Yeasts/Moulds'. However, it would be necessary to study further the relationships between the heat treatment conditions and the resulting effects on the appearance of the product and the storage characteristics.

It is necessary to reduce the level of the added ascorbic acid as it was at a higher level than desired.

After the products are stored for up to 3 months, a laboratory taste panel would need to be organized to ensure that the product has a desired level of orange flavour and that it exhibits no significant levels of off-flavour.

CHAPTER 9

SECOND MARKET TRIAL

A market trial of the reformulated product was carried out among the Japanese persons in Wellington for the second time. Two kinds of drink samples, namely, one with s-WPC 80 (s-WPC) and one with l-WPC 75 (l-WPC) were used for the present survey.

9.1 AIMS OF THE SECOND MARKET TRIAL

The basic aims set for the second market trial were:

* To establish the acceptability of the reformulated products.
* To obtain ideas on the colour which had not been studied in the first market trial.
* To compare the two kinds of drinks with each other with regard to sensory profiles.

9.2 SURVEY METHOD AND QUESTIONNAIRE

The identical method was used in the survey as had been done previously. Because of the reduced number of sample bottles obtained in the pilot-scale trial, they were distributed to a smaller number of the families.

The two kinds of bottles were coded with numbers of three digits and presented to the consumers.

A total of 44 bottles of the two kinds (22 each) were distributed to 20 families, and 17 men, 24 women and 23 children under 12 years of age responded to the survey.

The English and Japanese questionnaires are given in Appendices 9.1a and 9.1b respectively. They include questions regarding opinions on:

* Overall acceptability of the products on the 9-point facial hedonic scale for adults and on the like/dislike-type question for children under 12 years of age.
* Off-flavours of the products.

* The colour of the products.
* Comparison with the sample drink from the previous market trial.
* Comparison of the two kinds of drinks with each other.

The respondents were asked their age and sex, and their overall comments at the end of the questionnaire.

9.3 RESULTS AND DISCUSSION

Detailed tables concerning the results of the present survey are given in Appendices 9.2 to 9.10.

The survey results are summarised in the following sections.

9.3.1 Overall Acceptability of the Products

The majority of the adult respondents (men 17, women 24) liked both drinks. The respondents rated as 'like slightly' the s-WPC (20%) and the l-WPC (13%);likewise 37% and 25% 'like moderately;, 22% and 30% 'like very much', for example. (See Table 9.1, Appendix 9.2a and 9.2b). It was noted that the acceptability was higher in the s-WPC than the l-WPC; 84% of the respondents indicated 'like slightly' or higher levels of acceptability with the s-WPC, while only 68% of them made the same indication with the l-WPC.

90% of the children under 12 years of age liked the products (see Table 9.2 and Appendix 9.3).

9.3.2 Off-flavour Profile of Products

7% and 18% of the respondents detected unpleasant flavours in the s-WPC and l-WPC, respectively. It was noted that the women were significantly more sensitive to unpleasant flavours than the men, which confirmed the results from the first survey (see Table 9.3). The flavours were described as 'medicine' and 'powdery' for the s-WPC, and as 'mixture of orange and Yakult', 'citric acid-like medicine' and 'rotten milk' for the l-WPC.

The off-flavour profile was significantly improved with the s-WPC. However, the l-WPC kept almost the same level as

TABLE 9.1 : Consumer acceptability* of the whey protein enriched orange drink (percentage distribution of responses of consumers above 12 years of age) in the second survey.

		s-WPC**			l-WPC***		
		Men	Women	Total	Men	Women	Total
Like extremely	(%)	6	4	5	0	0	0
Like very much	(%)	24	21	22	40	22	30
Like moderately	(%)	28	42	37	6	39	25
Like slightly	(%)	12	25	20	12	13	13
Neither like nor dislike	(%)	18	8	12	24	13	17
Dislike slightly	(%)	6	0	2	18	13	15
Dislike moderately	(%)	6	0	2	0	0	0
Dislike very much	(%)	0	0	0	0	0	0
Dislike extremely	(%)	0	0	0	0	0	0
		100	100	100	100	100	100

*9-point facial hedonic scale.

**Drink with s-WPC 80

***Drink with l-WPC 75

Number of respondents: Men = 17; Women = 24

TABLE 9.2 : The acceptability of the product by children under 12 years of age (percentage distribution of responses of children) in the second survey.

	Like	Dislike	Total
s-WPC (%)	91	9	100
l-WPC (%)	90	10	100

Number of children responded: 22

the previous sample from the first market trial where 20% of the respondents detected off-flavours. It was noted that such terms as 'medicine' and 'powdery' appeared again to describe the off-flavours in the present survey.

9.3.3 Colour of Products

78% of the respondents rated both of the colours of the drinks as 'whitish orange', and almost the rest of the respondents rated them as 'orange' (see Table 9.4 and Appendices 9.4a and 9.4b).

The majority of the respondents (some 60%) would not like the colour to be changed while some 20% to 30% of them wanted the drinks to be more orangey, and the rest of the respondents even more whitish (see Table 9.5 and Appendices 9.5a and 9.5b).

It was noted that there appeared to be no definite difference in the colour profile between the two drinks when they were observed by the respondents. It was worthwhile noting a comment on the colour given at the end of the questionnaire which could be interpreted that the change of colour to more orange would make the product seem artifical.

9.3.4 Comparison with the Previous Sample

The drinks were compared with the previous sample of the first market trial. Admittedly, some of the respondents said in the comment column that they could not recall the taste of the previous sample.

There were more respondents who thought the product was improved with s-WPC rather than l-WPC; 74% of the respondents thought the s-WPC was improved, while only 44% did so with l-WPC (see Table 9.6 and Appendix 9.6).

9.3.5 Comparison of the Two Drinks with Each Other

In order to get a more clear difference in sensory profiles between the two kinds of drinks, a direct comparison was asked for. The respondents were also required to describe the reasons why they thought one was better than the other.

TABLE 9.3 : Profiles of off-flavours* of the s-WPC and the l-WPC (percentage of the respondents by sex, who detected off-flavours).

	Men	Women	Total
s-WPC (%)	6	8	7
l-WPC (%)	12	23	18

*Off-flavours described: 'medicine' and 'powdery' in the s-WPC; 'mixture of orange and Yakult', 'citric acid-like medicine' and 'rotten milk' in the l-WPC.

TABLE 9.4 : Colour of the products (percentage distribution of responses of consumers)

Colour of the Products		s-WPC			l-WPC		
		Men	Women	Total	Men	Women	Total
Orange	(%)	12	22	18	18	22	20
Whitish orange	(%)	76	78	78	76	78	78
Brownish orange	(%)	0	0	0	0	0	0
Pinkish orange	(%)	0	0	0	0	0	0
Yellow	(%)	0	0	0	6	0	2
Whitish yellow	(%)	12	0	4	0	0	0
Brownish yellow	(%)	0	0	0	0	0	0
Pinkish yellow	(%)	0	0	0	0	0	0
Total	%	100	100	100	100	100	100

TABLE 9.5 : Colours to be changed according to the respondents' preference (percentage distribution).

Colour to be Changed		s-WPC			l-WPC		
		Men	Women	Total	Men	Women	Total
More orangey	(%)	26	26	27	28	22	24
More whitish	(%)	6	17	12	6	17	13
More pinkish	(%)	0	0	0	0	0	0
More yellowish	(%)	0	0	0	0	0	0
More brownish	(%)	0	0	0	0	0	0
Just the same	(%)	66	57	61	66	61	63
Total		100	100	100	100	100	100

TABLE 9.6 : Comparison with the previous sample from the first market trial (percentage distribution of responses of consumers).

Comparison with the Previous Sample		s-WPC			l-WPC		
		Men	Women	Total	Men	Women	Total
Better	(%)	69	78	74	50	39	44
Just the same	(%)	25	13	18	44	52	49
Worse	(%)	6	9	8	6	9	7
Total	(%)	100	100	100	100	100	100

There were more respondents who thought 'the s-WPC is better than the l-WPC' than those who thought vice versa. 34% of the respondents assessed that 'the s-WPC was slightly better than the l-WPC', 20% of them 'the s-WPC was much better than the l-WPC', and 7% of them 'the s-WPC was exceptionally better than the l-WPC'. On the other hand, only 29% of them thought the 'the l-WPC was slightly or much better than the s-WPC" (see Table 9.7 and Appendix 9.7). It was noted that the men and the women had nearly the same percentage on their preference of the s-WPC over the l-WPC.

The reasons why they preferrred the one to the other were described by a variety of expressions (see Appendix 9.8). For example, there were some who thought the s-WPC was better than the l-WPC: the former was more tasteful, more refreshing, and less sour (which was good); and it had a better aftertaste and also fewer unpleasant flavours. On the other hand, those who thought vice versa said that the l-WPC was easier to drink, milder and more refreshing.

The higher preference of the s-WPC over the l-WPC corresponds with the higher acceptability of the s-WPC, the fewer respondents who tasted the s-WPC and detected off-flavours, and the more respondents who tasted the s-WPC and thought it better than the previous sample.

However, slightly more children preferred the l-WPC to the s-WPC, as shown in Table 9.8 and Appendix 9.9. Considering the fact that there were 16 children under 6 years of age out of 22 who responded to the survey, the result might be neither reliable nor accurate. Also, the difference is not significant, and it can be assumed that the children had no preference.

9.3.6 Overall Comments on the Product

A detailed description of the overall comments is given in Appendix 9.10.

There were comments on flavours: one respondent detected bitterness in the l-WPC. This is presumably because whey proteins in a lactic WPC were enzymatically split, producing peptides which might cause a bitter flavour. An interesting comment from a female respondent suggested that a greater volume of the s-WPC could be consumed at a time as it was less sour and less orangey.

TABLE 9.7 : Comparison of the two kinds of drinks with each other (percentage distribution of responses of consumers).

		Men	Women	Total
s-WPC was extremely better than l-WPC	(%)	0	13	7
s-WPC was much better than l-WPC	(%)	12	25	20
s-WPC was slightly better than l-WPC	(%)	46	25	34
same	(%)	12	8	10
s-WPC was slightly worse than l-WPC	(%)	24	29	27
s-WPC was much worse than l-WPC	(%)	6	0	2
s-WPC was extremely worse than l-WPC	(%)	0	0	0
Total	(%)	100	100	100

TABLE 9.8 : Comparison of the two kinds of drinks with each other by children under 12 years of age.

Preference	Number of Children	(%)
s-WPC	6	27
l-WPC	8	36
Just the same	8	37
Total	22*	100

*One child did not answer

The product viscosity concerned five respondents who thought both drinks were too thick. Considering the fact that there were similar comments in the first survey, the product might need to be thinner in the future reformulation.

9.3.7 Conclusion

As regards the colour of the products, the majority of the respondents were satisfied with the whitish/orangey colour of the two products. However, the product needs to have slightly more orangey colour so as to be accepted by more consumers. This can be done by adding more beta-carotene, but not so much that the majority who do not want the colour change would consider it was too orangey and looked artificial.

Both the s-WPC and the l-WPC were highly accepted by the respondents. However, there were fewer respondents who detected off-flavours in the s-WPC than those who did so in the l-WPC. This could be interpreted to mean that the s-WPC might have lower intensity of the off-flavours and/or fewer off-flavours. This view was supported by the comparison with the previous sample, in which more respondents thought the product was improved with the s-WPC rather than with the l-WPC.

It is therefore concluded that an orange juice drink could be fortified more successfully with an s-WPC 80 rather than an l-WPC 75 in order to attain higher acceptability and also a better flavour profile.

Although it was not studied in the present survey, there were many respondents who commented on the thickness of the products, that is, the products were a bit too thick.

Considering there were similar comments in the first survey, it is recommended that the product should be reformulated to get the right viscosity.

CHAPTER 10

EVALUATION OF PROJECT

New Zealand WPC powders were successfully used to fortify orange fruit juice, creating a new product with a new concept. The drink was a nutritious health food and a source of protein and vitamin C, and could be included in the diet of the Japanese consumer. It tasted more fruity-sour than normal flavoured milk and gave a refreshing sensation. The colour of the drink was orangey/yellowish milk white which could be attractive to the consumers. All the materials used were of naturally obtained types, so that the product could be regarded in the group of health foods.

The target market for this product would be children and their mothers, convalescents, athletes and everyone who needs a protein of good quality and are concerned with their health. The drink would also be suitable for those urban dwellers who are too busy to have breakfast in the morning.

Data from the market trials showed that the majority of the respondents liked the drink, and so did most of the children under 12 years of age. However, some of the respondents detected unpleasant flavours. The proportion of those who detected off-flavours was reduced to a significantly low level by the use of a sulphuric WPC rather than a lactic WPC. Therefore the former was considered to be a more suitable type of WPC powder in this particular application.

The surveys also showed that the drink might need to be thinner to get the right viscosity so that the desired volume could be consumed. This could be done by the use of naturally obtained sweetners such as 'Aspartame' instead of sucrose. It is necessary to reduce the amount of the added ascorbic acid as it was found that the product contained too much vitamin C even after it was stored at the highest temperature. Further study needs to be done to find the relationships between heat/storage and time/temperature conditions, and the required level of vitamin C. The product may need to have a variety of vitamins and minerals such as calcium which are insufficient in the typical Japanese diet.

It is believed in the Japanese food industry that if the sales of a single food product reach 10 billion yen/year, it is a great success. From the results of the first market trial, the possible sales potential of 8 billion yen, which is nearly the success level, was estimated as a most likely case. It is obvious, however, that the sales would greatly depend on many factors, such as the competitors, the price and the way of marketing the product. During the course of the project, a Japanese company launched what they claimed to be a 'whey drink' onto the market. Although their product seemed to have different characteristics to a great extent from the present drink, considerable competition would be expected in the area of 'whey beverage', which is now being established in the Japanese food industry.

The drink was sucessfully produced in the pilot-scale production. From this experience, it is believed that standard dairy plant equipment only would be needed for a larger scale operation.

The product could be distributed through the sales channels such as supermarkets, health food shops and fitness/sport centres. As the company has its sales branches throughout Japan, the product could be sold nationwide.

It was clear from the formulation work that the different WPC powders exhibited different properties. For example, in the basic system, the heat stability of the whey proteins fluctuated markedly due to the pH change exhibited by the reconstituted WPC powder of different type. Morr, 1982, said food protein ingredients were generally required to be free of off-flavour and colour. It was found that a sulphuric WPC was more suitable than a lactic WPC in this regard when it was applied to the present drink.

The whey proteins are highly soluble at their isoelectric point (Harper, 1984). Therefore WPC powders could be best utilized in the acid pH. However, the commercial WPC powders supplied by the New Zealand Dairy Board showed that the whey proteins in the drink system (pH ≒ 4) failed to keep their colloidal state and settled out (serum formation) during the

storage. They were stabilized markedly by adding a combination of citric acid and sodium citrate to the system. Pectin, a food grade stabilizer, also needed to be added to prevent the whey proteins from agglomerating during heat treatment. During the course of the storage trial, sediment was observed, which could mean the whey proteins had been denatured in some way. Despite this fact, the sedimentation was considered to be insignificant as it was noted that the sedimented matter was easily incorporated into the liquid system and restored the original state of colloidal suspension when the liquid was shaken. Taking the above-mentioned facts into account, the WPC powders to be used would have to be highly soluble to ensure the drink could keep its quality throughout the shelf life.

Before the product is launched onto the market, the following procedures must be taken. First, a larger scale test market in Japan is necessary to collect more information as to the product itself and other marketing considerations. Secondly, the packaging style, design and volume must be considered to best suit the product and the consumers' requirements. The pricing and selection of the specific marketing channels and the factory are also to be determined. Thirdly, the product needs to be advertised and promoted to let the consumers know what the product can offer.

No attempt was made in this study to calculate the cost of the product. The factors principally to affect the total cost would be the costs of the WPC powder, the orange juice and packaging, scale of the production, and the costs of selling, advertisement and promotion. The economic feasibility of this product, however, would depend not only on the cost but also the price that the consumer can afford to pay. In this point, data from the first market trial showed that many of the consumers expected to pay for this product a higher range of price than that of normal flavoured milk. Therefore it is believed that the company would get a fair chance to make a reasonable profit on this product. Again, this would depend on how efficiently the company could produce and sell the drink, and on the market share that the company would take in the field of 'whey beverages'.

On the basis of the estimation made in Chapter 6, Section 6.5, in the most likely case, about 620 tonnes of the sulphuric WPC 80 could be sold annually for this product. Likewise, 3,520 tonnes and 160 tonnes in the optimistic and the pessimistic cases, respectively. The sales of the WPC could be respectively estimated as NZ$8.3 million, NZ$46.9 million and NZ$2.1 million. This is assuming that the current price of sulphuric WPC 80 is about 1600 yen/kg (the New Zealand Dairy Board, 1984, personal communication), and the value of the New Zealand dollar is 120 yen. Considering the total annual production of WPC in New Zealand is some 2400 tonnes (1982/83 season), the amount of 620 tonnes (most likely case) would be great enough to operate the New Zealand WPC plants at full capacity.

BIBLIOGRAPHY

ANGLEMIER, A.F. and MONTGOMERY, M.W., 1976, Amino acids, peptides, and proteins. In Principles of Food Science, Part 1, Food Chemistry (Fennema, O.R. ed.). New York, Marcel Dekker Inc. 230 p.

ANON, 1978, Anyone for citrus milk? Food Engineering International 11 : 20-21.

BAKER, J.T., Product Information Bulletin, Commodity No. H 114, Phillipsburg, N.J. 08865, J.T. Baker Chemical Co.

BANGERT, J.G., 1976, Nutritious orange drink concentrate, process and drink resultant therefrom. U.S. Patent No. 3,949,098.

COCA COLA, 1972, Dutch Patent Application No. 11,742, not sighted, referred to in De Boer et al., 1977.

COSTAMAGNA et al., 1980. Ann. Fac. Agr. Univ. Stud. Perugia 34,161, not sighted, referred to in Mann, 1983.

DAVIES D.T. and WHITE, J.C.D., 1966, The stability of milk protein to heat. I. Subjective measurement of heat stability of milk. Journal of Dairy Research 33 : 67-81.

DE BOER, R., DEWIT, J.N. and HIDDINK, J., 1977, Processing of whey by means of membranes and some applications of whey protein concentrate. Journal of Society of Dairy Technology 30,(2)(4): 112-120.

FOOD and AGRICULTURE ORGANIZATION (FAO), 1970, Amino acid content of foods and biological data of proteins, FAO Nutritional Studies, No. 24, Rome.

GLAHN, P. E., 1982, Hydrocolloid stabilization of protein suspensions at low pH. Progress in Food and Nutrition Science 6 : 171-177.

HAMBRAEUS, L., 1982, Nutritional aspects of milk proteins. In Dairy Chemistry - I (Fox, P.F., ed.) Essex, England, Applied Science Publishers. pp. 289-313.

HARPER, W.J., 1984, Whey proteins. Food Technology in New Zealand, 19,(3): 21-29.

HAYASHI, H., 1977, In Technical Handbook of Milk Industry Vol. 1. Tokyo, Dairy Technology Spreading Society. 92P.

HOLSINGER, V.H., POSATI, L.P., DE VILBISS, E.D. and PALLANSCH, M.J., 1973, Fortifying soft drinks with cheese whey protein. Food Technology 2 : 59-65.

LOHREY, E.E. and HUMPHREYS, M.A., 1976, The protein quality of some New Zealand milk products. N.Z. Journal of Dairy Science and Technology 11,(3): 147.

JUKES, T.H., 1979, In Nutrition, Metabolic and Clinical Applications (Hodges, R.E. ed.), New York Plenum Press. 258P.

LYSTER, R.L.J., 1970, The denaturation of α-lactalbumin and β-lactoglobulin in heated milk. Journal of Dairy Research 37 : 233-243.

MALASPINA A. et al., 1975. U.S. Patent 3896241, not sighted, referred to in Mann, 1977.

MANAWATU CO-OP DAIRY COMPANY, 1983, Annual Report, Longburn, New Zealand Manawatu Co-op Dairy Company.

MANN, E.J., 1977, Whey utilization in beverages and dairy products. Dairy Industries International 6 : 26-27.

MANN, E.J., 1983, Dairy beverages, part 1. Dairy Industries International 7 : 13-14.

MORR, C.V., 1979, Functionality of whey protein products. New Zealand Journal of Dairy Science and Technology 14,(2): 185-194.

MORR, C.V., 1982, Functional properties of milk proteins and their use as food ingredients, In Dairy Chemistry - 1 (Fox, P.F. ed.), Essex, England. Applied Science Publishers. pp. 375-399.

MUNSELL COLOR COMPANY INC., Munsell book of colour, pocket edition. Baltimore, Maryland, Munsell Color Company Inc.

NEW ZEALAND DAIRY BOARD, The nutritional value of New Zealand milk proteins. Technical Bulletin, Wellington, New Zealand Dairy Board.

RANGITAIKI PLAINS DAIRY CO-OP LTD., 1983, Annual Report, Edgecumbe, New Zealand, Rangitaiki Plains Dairy Co-op (RPD).

TE AROHA THAMES VALLEY CO-OP DAIRY COMPANY, 1983, Annual Report, Paeroa, New Zealand. Te Aroha Thames Valley Co-op Dairy Company Ltd. (TATV).

THE COPENHAGEN PECTIN FACTORY LTD., 1982, Whey drinks with GENU Pectin Type JM. Technical Bulletin, No. 1107-2. DK 4623 Lille Skensved, Denmark, The Copenhagen Pectin Factory Ltd.

THE TSUNETA YANO MEMORIAL SOCIETY (YANO-TSUNETA KINENKAI) ed., 1983, In Nippon, a chartered survey of Japan, 1983/84. Tokyo, Kokusei-Sha Corporation.

WEBB, B.H. and JOHNSON, A.H., 1975. The composition of milk. Fundamentals of Dairy Chemistry. Westport, USA, The AVI Publishing Co. Inc. 7P.

WHITAKERS CO. LTD., 1984, In Whitakers Almanack, London, Whitakers Co. Ltd., 867P.

ZALL, R.R., KUIPERS, A., MULLER, L.L. and MARSHALL, K.R., 1979, Trends in whey processing. N.Z. Journal of Dairy Science and Technology 14, 2 : 79-85.

APPENDICES

LIST OF APPENDICES

LIST OF APPENDICES (Continued)

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APPENDIX 2.1 : Product ideas generated by using creative techniques.

Product	Consumer	Type of WPC	P.I.G. Method Used
Beverages			
Drinking yoghurt	Children	Soluble WPC	B
Orange juice with WPC	Children Athletes Invalids Convalescents	Soluble/Heat Stable WPC	B
Clear drink with WPC in 100 ml carton	Children Athletes Invalids University students	Soluble/Heat Stable WPC	A
Carbonated citrus juice with WPC	Children	Soluble/Heat Stable WPC	M
High protein/ calcium-vitamin-enriched drink	Athletes Convalescents Children	Soluble/Heat and Calcium Stable WPC	N
Low cholesterol/ high protein/ unsaturated fatty acids/vitamin-enriched drink	The middle-aged The aged	Soluble/Heat Stable WPC with low cholesterol	N
Low calorie, high protein/vitamin-enriched health drink	Working women Weight watchers University students	Soluble/Heat Stable WPC	N
Soya milk with WPC	Young people Weight watchers	Soluble/Heat Stable WPC	M
Egg beverages with WPC	Invalids convalescents	Soluble/Heat Stable WPC	M
Shiruko* with WPC	Children	Soluble/Heat Stable WPC	M
Baked Goods			
Dairy bread with WPC	Children	Swelling WPC Nutritional WPC	M
Dairy breakfast cereal with WPC	Children	Nutritional WPC	M

*Adzuki bean drink, normally served hot

APPENDIX 2.1 (Continued)

Product	Consumer	Type of WPC	P.I.G. Method Used
Dough mix with WPC	Industrial use for restaurants, hotels, etc.	Heat-set WPC	M
Low fat, high protein/calcium/ vitamin-enriched bread	Athletes Convalescents Children	Nutritional, emulsifying, WPC	N
Low cholesterol, high protein/ dietary fibre/ unsaturated fatty acids bread	The aged Middle-aged Convalescents	Nutritional emulsifying WPC	N
Cheese or Cheese Foods			
Cheese cakes with WPC	Office ladies	Baking WPC	B
Cheese spreads with WPC	Housewives	Milk protein concentrate	B
Sliced cheese with WPC	Children Housewives	Milk protein concentrate	B
Sweet cheese	Children	Milk protein concentrate	B
Cheese dip	Housewives	Baking WPC	B
Cheese food with WPC	Children for hiking, picnicking	High gel strength WPC	M
Cheese with low fat, high protein/ calcium/vitamins	Athletes Invalids Convalescents Children	High gel strength WPC	N
Processed cheese with low cholesterol, high dietary fibre/ vitamins/unsaturated fatty acids/ proteins	Middled-aged The aged Patients of heart diseases	Low cholesterol WPC	N

APPENDIX 2.1 (Continued)

Product	Consumer	Type of WPC	P.I.G. Method Used
Processed cheese with low calorie, high protein / vitamins	Working women University students	Nutritional, texture improving WPC	N
Cheese whip	Housewives for home cooking	Whipping WPC	B
Cream cheese sandwich with WPC	Picnickers	Whipping WPC	B
Blue cheese cake mix with WPC	Housewives for home cooking	Nutritional and baking WPC	S
Ice Cream			
Ice cream topping with WPC	Industrial use for ice cream manufacturers	Foaming, whipping WPC	B
Ice cream mixture with WPC	Industrial use for ice-cream manufacturers	Emulsifying, foaming WPC	M
Low fat, high protein/calcium/ vitamins ice-cream	Athletes Invalids Convalescents Children	Emulsifying foaming	N
Low cholesterol, high dietary fibre/ vitamins/unsaturated fatty acids/protein ice cream	The aged The middle aged	Low cholesterol WPC	N
Low calorie, high protein/vitamins ice cream	Working women University students	Emulsifying, foaming WPC	N
Yoghurt-flavoured ice cream with WPC	Young ladies Students Children	Emulsifying, foaming WPC	B
Yoghurt			
Hydrolized lactose yoghurt with WPC	Children Invalids Convalescents	Low lactose WPC	B

APPENDIX 2.1 (Continued)

Product	Consumer	Type of WPC	P.I.G. Method Used
Dry yoghurt mix	Housewives	High gel strength WPC	B
Yoghurt topping on cheese cakes	Industrial use for restaurants, hotels, etc.	Whipping WPC	B
Yoghurt with WPC	Young ladies	High gel strength WPC	M
Yoghurt pudding in a tin	Children Housewives for gifts	High gel strength WPC	B
UHT yoghurt	Children Weight watchers	Gelling WPC	B
Butter			
Extended butter with WPC	Housewives	Gelation temperature reduced WPC	B
Low calorie butter with WPC	Weight watchers Young women	High protein, low fat WPC	B
Spreadable butter with WPC	Housewives for cooking	Gelling WPC	B
Desserts			
Spreadable jelly with WPC	Children Housewives for cooking	Gelling WPC	B
Milk jelly with WPC	Housewives for cooking	Gelling WPC	B
Cream jelly with WPC	Children	Gelling WPC	B
Sweet cream with WPC	Children	Foaming/whipping WPC	B
Aseptic type desserts with WPC	Housewives for a gift	Foaming/whipping WPC	B

APPENDIX 2.1 (Continued)

Product	Consumer	Type of WPC	P.I.G. Method Used
Low fat, high protein/calcium/ vitamins, desserts with WPC	Athletes Invalids Convalescents Children	Low lactose type WPC	N
Low cholesterol, high dietary fibre/ vitamins/unsaturated fatty acids/protein dessert	The aged The middle aged	Low cholesterol	N
Low calorie, high protein/vitamins, desserts	Working women Students	High protein WPC	N
Pudding with WPC	Children	Gelling WPC	M
Uiroh	Old Persons	Gelling WPC	M
Cheese jelly	Housewives	Gelling WPC	B
Miscellaneous Foods			
Hydrolized products for sweetner	Children Convalescents	Lactose hydrol-ized WPC	B
Dairy-based salad dressing	Housewives	Low fat/ cholesterol WPC	B
Noodle with WPC	Housewives	Nutritional, gelling WPC	M
Skim milk powder with WPC	Housewives	Nutritional WPC	M
Miso soup with WPC	Housewives	Nutritional, soluble WPC	M
Chicken soup with WPC	Housewives	Soluble WPC	M
Pumpkin soup with WPC	Housewives	Soluble WPC	M
Slimming food with WPC	Women Weight watchers	Soluble WPC Heat stable WPC	M

APPENDIX 2.1 (Continued)

Product	Consumer	Type of WPC	P.I.G. Method Used
Ham and sausages with WPC	General	Gelling WPC	M
Infant formula with WPC	Infants	Soluble WPC	M
Tofu with WPC	Weight watchers	Gelling WPC	M
Kamaboko (fish)	Children	Gelling WPC	M
Fish sausages	Children	Gelling WPC	M

Key: B = brainstorming
A = attribute analysis
M = morphological analysis
N = needs analysis
L = lateral thinking

APPENDIX 2.2 : Sequential screening of product ideas generated. (Pass/fail screening).

Product Ideas	Screening Factors			
	Must Contain WPC	Must Use Present Equipment	Must not be Made by the Company at present time	Overall
Beverages				
Drinking yoghurt	P	P	P	P
Orange juice with WPC	P	P	P	P
Clear drink with WPC in a 100 ml pack	P	P	P	P
Carbonated citrus juice with WPC	P	P	P	P
High protein/calcium/ vitamin-enriched drink	P	P	P	P
Low cholesterol,high protein/unsaturated fatty acids/vitamin-enriched drink	P	P	P	P
Low calorie, high protein/vitamin-enriched health drink	P	P	P	P
Soya milk with WPC	P	P	P	P
Egg beverages with WPC	P	P	P	P
Shiruko with WPC	P	P	P	P
Baked Goods				
Dairy bread with WPC	P	F	P	F
Breakfast cereal with WPC	P	F	P	F
Dough mix with WPC	P	F	P	F
Low fat, high protein/ calcium/vitamin-enriched bread	P	F	P	F
Low cholesterol/high protein/dietary fibre/ unsaturated fatty acid-bread	P	F	P	F

APPENDIX 2.2 (Continued)

Product Ideas	Screening Factors: Must Contain WPC	Must Use Present Equipment	Must not be Made by the Company at Present Time	Overall
Ice cream mixture with WPC	P	P	P	P
Low fat, high protein/calcium/ vitamin-enriched ice cream	P	P	P	P
Low cholesterol,high dietary fibre/ vitamins/unsaturated fatty acids/ protein ice cream	P	P	P	P
Low calorie, high protein/vitamin ice cream	P	P	P	P
Yoghurt-flavoured ice cream with WPC	P	P	F	F
<u>Yoghurt</u>				
Hydrolized lactose yoghurt with WPC	P	P	P	P
Dry yoghurt mix with WPC	P	P	F	F
Yoghurt topping on cheese cakes with WPC	P	P	P	P
Yoghurt with WPC	P	P	P	P
Yoghurt pudding in a tin	P	P	P	P
UHT yoghurt	P	P	P	P
<u>Butter</u>				
Extended butter with WPC	F	P	P	F
Low calorie butter with WPC	F	P	P	F

APPENDIX 2.2 (Continued)

Product Ideas	Screening Factors: Must Contain WPC	Must Use Present Equipment	Must not be Made by the Company at Present Time	Overall
Spreadable butter with WPC	p	p	p	p
Desserts				
Spreadable jelly with WPC	P	P	P	P
Milk jelly with WPC	P	P	F	F
Cream jelly with WPC	P	P	P	P
Sweet cream with WPC	P	P	P	P
Aseptic type desserts with WPC	P	P	P	P
Cheese jelly	P	P	P	P
Pudding with WPC and kiwifruit pulp	P	P	P	P
Uiroh	P	P	P	P
Low fat, high protein/calcium/ vitamins desserts with WPC	P	P	P	P
Low cholesterol,high dietary fibre / vitamins/unsaturated fatty acids/protein dessert with WPC	P	P	P	P
Low calorie, high protein/vitamins dessert with WPC	P	P	P	P
Miscellaneous				
Hydrolized products for sweetner	P	P	P	P

APPENDIX 2.2 (Continued)

Product Ideas	Screening Factors			
	Must Contain	Must Use Present Equipment	Must not be Made by the Company at Present Time	Overall
Dairy-based salad dressing	P	P	P	P
Noodle with WPC	P	P	P	P
Skim milk powder with WPC	P	P	P	P
Miso soup with WPC	P	P	P	P
Chicken soup with WPC	P	P	P	P
Pumpkin soup with WPC	P	P	P	P
Slimming food with WPC	P	P	P	P
Ham and sausages with WPC	P	P	P	P
Infant formula	P	P	F	F
Tofu with WPC	P	P	P	P
Kamaboko with WPC	P	P	P	P
Fish sausages with WPC	P	P	P	P

APPENDIX 2.3 : Checklist screening of product ideas remaining after sequential screening

Product Ideas	Health	Newness	Potential Growth of Market	Total
	40	32	28	100
Beverages				
Drinking yoghurt	30	25	20	75
Orange juice with WPC	30	28	25	83
Clear drink with WPC in a 100ml pack	30	29	25	84
Carbonated citrus juice with WPC (Aseptic type)	25	30	26	81
High protein/calcium/ vitamin-enriched drink	30	30	26	86
Low cholesterol,high protein/unsaturated fatty acids/vitamin-enriched drink	30	30	25	85
Soya milk with WPC	30	25	25	80
Egg beverages with WPC	30	27	25	82
Shiruko with WPC	20	25	25	70
Cheese/Cheese Foods				
Sweet cheese with WPC	30	16	16	62
Cheese dip	30	16	20	66
Cheese food with WPC	30	16	16	62
Cheese with low fat, high protein/calcium/ vitamins	30	20	20	70
Processed cheese with low cholesterol, high dietary fibre/vitamins/ unsaturated fatty acids/protein	30	20	20	70

APPENDIX 2.3 (Continued)

Product Ideas	Health	Newness	Potential Growth of Market	Total
	40	32	28	100
Processed cheese with low calorie, high protein / vitamins	30	20	20	70
Cheese whip	30	25	14	69
Cream cheese sand-wich with WPC	20	16	14	50
Blue cheese cake mix with WPC	28	25	20	73
Ice Cream				
Ice cream topping with WPC	30	25	20	75
Ice cream mixture with WPC	30	16	20	66
Low fat, high protein/ calcium/vitamins ice cream	30	16	20	66
Low cholesterol, high dietary fibre/ vitamins/unsaturated fatty acids/protein ice cream	30	16	20	66
Low calorie, high protein/vitamins ice cream	30	16	20	66
Yoghurt				
Hydrolized lactose yoghurt with WPC	30	25	20	75
Yoghurt topping on cheese cakes	30	25	20	75
Yoghurt with WPC	30	16	20	66
Yoghurt pudding in tin	30	20	25	75

APPENDIX 2.3 (Continued)

Product Ideas	Health	Newness	Potential Growth of Market	Total
	40	32	28	100
UHT yoghurt	30	28	22	80
Butter				
Spreadable butter with WPC	20	16	10	46
Desserts				
Spreadable jelly with WPC	20	20	18	58
Cream jelly with WPC	20	20	18	58
Sweet cream with WPC	20	20	20	60
Aseptic type desserts with WPC	30	20	22	72
Cheese jelly	30	30	20	80
Pudding with WPC/ kiwifruit pulp	28	25	22	75
Uiroh with WPC	28	28	20	76
Low fat, high protein/ calcium/ vitamins desserts with WPC	30	25	20	75
Low cholesterol, high dietary fibre/ vitamins/unsaturated fatty acids/protein dessert with WPC	30	25	20	75
Low calorie, high protein/vitamins dessert with WPC	30	25	20	75
Miscellaneous				
Hydrolized products for sweetner	25	25	20	70
Dairy-based salad dressing	25	25	20	70

APPENDIX 2.3 (Continued)

Product Ideas	Health	Newness	Potential Growth of Market	Total
	40	32	28	100
Noodle with WPC	25	30	20	75
Skim milk powder with WPC	30	20	16	66
Miso soup with WPC	30	30	20	80
Chicken soup with WPC	35	20	14	69
Pumpkin soup with WPC	30	25	14	69
Slimming food	35	25	25	85
Ham and sausages with WPC	30	16	20	66
Tofu with WPC	35	20	21	76
Kamaboko with WPC	35	20	23	78
Fish sausages	35	20	14	69

APPENDIX 2.4 : Probability screening of the new product ideas remaining after checklist screening: total utility = 1000

Drinking Yoghurt

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.3	.3	.2	.1	6.2	186
Healthiness	30	.2	.3	.4	.1		7.2	216
Compatibility with WPC	20	.1	.2	.3	.3	.1	5.8	116
Newness	20		.2	.3	.4	.1	5.2	104
								622

Orange Juice with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.2	.3	.3	.1	.1	6.8	204
Healthiness	30	.2	.3	.3	.1	.1	6.8	204
Compatibility with WPC	20	.2	.3	.2	.2	.1	6.6	132
Newness	20	.2	.3	.4	.1		7.2	144
								684

APPENDIX 2.4 (Continued)

Clear Drink with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.2	.3	.3	.1	.1	6.8	204
Healthiness	30	.2	.3	.3	.2		7.0	210
Compatibility with WPC	20	.2	.3	.2	.2	.1	6.6	132
Newness	20	.1	.3	.3	.2	.1	6.2	124
								670

Carbonated Citrus Juice with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.2	.2	.3	.2	.1	6.4	192
Healthiness	30	.1	.3	.3	.2	.1	6.2	186
Compatibility with WPC	20	.2	.3	.2	.2	.1	6.6	132
Newness	20	.2	.3	.3	.2		7.0	140
								650

APPENDIX 2.4 (Continued)

High Protein/Calcium/Vitamin-enriched Drink

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.2	.3	.3	.1	.1	6.8	204
Healthiness	30	.2	.3	.2	.2	.1	6.6	198
Compatibility with WPC	20	.2	.3	.2	.1	.1	6.2	124
Newness	20	.1	.2	.3	.3	.1	5.8	116
								642

Low Cholesterol, High Protein/Unsaturated Fatty Acids/Vitamins Drink

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.2	.3	.3	.1	.1	6.8	204
Healthiness	30	.2	.3	.2	.2	.1	6.6	198
Compatibility with WPC	20	.2	.3	.2	.1	.1	6.2	124
Newness	20	.2	.3	.3	.2		7.0	140
								666

APPENDIX 2.4 (Continued)

Soya Milk with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.3	.3	.2	.1	6.2	186
Healthiness	30	.2	.3	.2	.2	.1	6.6	198
Compatibility with WPC	20	.2	.3	.3	.2	.1	7.2	144
Newness	20	.1	.3	.3	.2	.1	6.2	124
								652

Egg Beverages with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.3	.3	.2	.1	6.2	186
Healthiness	30	.2	.3	.3	.1	.1	6.8	204
Compatibility with WPC	20	.2	.3	.2	.2	.1	6.6	132
Newness	20	.2	.3	.4	.1		7.2	144
								666

APPENDIX 2.4 (Continued)

Ice Cream Topping with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.2	.2	.3	.2	5.4	162
Healthiness	30	.1	.2	.3	.4		6.0	180
Compatibility with WPC	20	.2	.3	.4	.1		7.2	144
Newness	20	.1	.1	.3	.4	.1	5.4	108
								594

Hydrolized Lactose Yoghurt with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.1	.3	.3	.2	5.2	156
Healthiness	30	.2	.2	.3	.2	.1	6.4	192
Compatibility with WPC	20	.2	.2	.3	.2	.1	6.4	128
Newness	20	.1	.2	.3	.3	.1	5.8	116
								592

APPENDIX 2.4 (Continued)

Yoghurt Topping on Cheese Cakes

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.2	.2	.3	.2	5.4	162
Healthiness	30	.1	.2	.3	.2	.2	5.6	168
Compatibility with WPC	20	.2	.3	.3	.1	.1	6.8	136
Newness	20	.1	.2	.3	.2	.2	5.6	112
								578

Yoghurt Pudding in a Tin

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.3	.3	.2	.1	6.2	186
Healthiness	30	.2	.3	.2	.2	.1	6.6	198
Compatibility with WPC	20	.2	.3	.2	.2	.1	6.6	132
Newness	20	.2	.3	.2	.2	.1	6.6	132
								648

APPENDIX 2.4 (Continued)

UHT Yoghurt

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.2	.3	.2	.2	.1	6.6	198
Healthiness	30	.2	.2	.3	.2	.1	6.4	192
Compatibility with WPC	20	.2	.3	.2	.2	.1	6.6	132
Newness	20	.1	.2	.3	.3	.1	5.8	116
								638

Pudding with WPC/Kiwifruit Pulp

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.2	.3	.3	.1	5.8	174
Healthiness	30	.1	.2	.3	.3	.1	5.8	174
Compatibility with WPC	20	.1	.3	.3	.2	.1	6.2	132
Newness	20	.1	.3	.3	.2	.1	6.2	132
								612

APPENDIX 2.4 (Continued)

Uiroh with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
profitability	30	.1	.1	.3	.3	.2	5.2	156
Healthiness	30	.1	.2	.3	.3	.1	5.8	174
Compatibility with WPC	20	.1	.3	.3	.2	.1	6.2	124
Newness	20	.2	.3	.3	.2		7.0	140
								594

Low Fat, High Protein/Calcium/Vitamin, Dessert with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.2	.3	.3	.1	5.8	174
Healthiness	30	.1	.2	.3	.3	.1	5.8	174
Compatibility with WPC	20	.1	.2	.3	.3	.1	5.8	116
Newness	20	.1	.3	.3	.2	.1	6.2	124
								588

APPENDIX 2.4 (Continued)

Low Cholesterol, High Dietary Fibre/Vitamins/Unsaturated Fatty Acids Dessert

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.2	.3	.3	.1	5.8	174
Healthiness	30	.1	.2	.3	.3	.1	5.8	174
Compatibility with WPC	20	.1	.2	.3	.3	.1	5.8	116
Newness	20	.1	.3	.3	.2	.1	6.2	124
								588

Low Calorie, High Protein/Vitamins Dessert

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.2	.3	.3	.1	5.8	174
Healthiness	30	.1	.2	.3	.3	.1	5.8	174
Compatibility with WPC	20	.1	.2	.3	.3	.1	5.8	116
Newness	20	.1	.2	.2	.4	.1	5.6	112
								576

APPENDIX 2.4 (Continued)

Cheese Jelly

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.2	.3	.3	.1	5.8	174
Healthiness	30	.1	.2	.3	.2	.2	5.6	168
Compatibility with WPC	20	.2	.3	.2	.2	.1	6.6	132
Newness	20	.2	.3	.2	.2	.1	6.6	132
								606

Noodle with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30		.2	.3	.3	.2	5.0	150
Healthiness	30	.2	.3	.3	.1	.1	6.8	204
Compatibility with WPC	20	.2	.3	.3	.1	.1	6.8	136
Newness	20	.1	.2	.3	.3	.1	5.8	116
								606

APPENDIX 2.4 (Continued)

Miso Soup with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
profitability	30	.1	.2	.3	.3	.1	5.8	174
Healthiness	30	.2	.3	.3	.2		7.0	210
Compatibility with WPC	20	.1	.3	.3	.2	.1	6.2	124
Newness	20	.1	.2	.3	.2	.2	5.4	108
								616

Slimming Food with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.2	.3	.2	.2	5.4	162
Healthiness	30	.2	.3	.3	.2		7.0	210
Compatibility with WPC	20	.2	.3	.2	.2	.1	6.6	132
Newness	20	.2	.3	.2	.2	.1	6.6	132
								636

APPENDIX 2.4 (Continued)

Tofu with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.1	.3	.3	.2	5.2	156
Healthiness	30	.2	.3	.3	.2		7.0	210
Compatibility with WPC	20	.1	.2	.3	.3	.1	5.8	116
Newness	20	.1	.2	.3	.3	.1	5.8	116
								598

Kamaboko with WPC

Factor	Factor Weight	Level					Expected Level Weight	Contribution to Total Expected Utility
		10	8	6	4	2		
Profitability	30	.1	.1	.3	.3	.2	5.2	156
Healthiness	30	.2	.3	.3	.2		7.0	210
Compatibility with WPC	20	.1	.2	.3	.3	.1	5.8	116
Newness	20	.2	.2	.3	.2	.1	6.8	136
								618

APPENDIX 4.1 : 2^2 factorial design for the determination of acceptable orange juice and sucrose levels.

Design	% Orange Juice Solids (w/w)*	% Sucrose (w/w)
1	5.2	3.5
a	6.5	3.5
b	5.2	4.5
ab	6.5	4.5
mid-point	5.85	4.0

*Based on final product weight

APPENDIX 4.2 : Yates analysis for sweetness

Scores in Sweetness		1st Col.	2nd Col.	Mean Effect
1	3.0*	6.6	13.4	3.0
a	3.6	6.8	1.4	0.35
b	3.0	0.6	0.2	0.05
ab	3.8	0.8	0.2	0.05

*Mean scores of 5-member panel, on a 5-point scale (Score of 5 = very sweet, 3 = right blend of sweetness, 1 = not sweet)

APPENDIX 4.3 : Yates analysis for sourness

Scores in Sourness		1st Col.	2nd Col.	Mean Effect
1	3.0*	5.8	11.8	2.95
a	2.8	6.0	-1.0	-0.25
b	3.4	-0.2	0.2	0.05
ab	2.6	-0.8	-0.6	-0.15

*Mean socres of a 5-member panel, on a 5-point scale. (Score of 5 = very sour, 3 = right blend of sourness, 1 = insipid).

APPENDIX 4.4 : Yates analysis for orange flavour

Scores in Orange Flavour		1st Col.	2nd Col.	Mean Effect
1	3.0*	6.0	12.8	3.2
a	3.0	6.8	0	0
b	3.4	0	0.8	0.2
ab	3.4	0	0	0

*Mean scores of a 5-member panel, on a 5-point scale. (Score of 5 = very pronounced, 3 = recognizable, 1 = none).

APPENDIX 6.1a : Questionnaire used in the first market trial

Massey University,
Department of Food Techn

July 3, 1984

WHEY PROTEIN-ENRICHED ORANGE DRINK

Accompanying this form you will find a sample bottle of WHEY PROTEIN-ENRICHED ORANGE DRINK - a nutritious health drink.

This survey is presented to you as part of a consumer test to aid a product development project being undertaken at Massey University.

First of all, please let me briefly explain the product to assist your evaluation.

WHEY PROTEIN-ENRICHED ORANGE DRINK consists of whey protein from cow's milk, 40% strength orange juice, sucrose, natural stabilizer and buffer salts. Whey protein is part of the milk proteins derived from cheese and casein manufacture. Whey protein is a very nutritious protein because it is rich in essential amino acids and is utilized by your body very effectively. WHEY PROTEIN-ENRICHED ORANGE DRINK is fortified with this whey protein which accounts for 3% of the total weight of this product. This means that if you drink 250 ml of this product, you will get about 20% of your necessary daily intake of protein.

WHEY PROTEIN-ENRICHED ORANGE DRINK also contains 40% orange juice from which you can obtain vitamin C, natural orange flavour and carbohydrates.

In order to adjust the acidity and to prevent separation of the whey protein, citric acid and sodium citrate were added. This acid is widely used in the food industry to give the appropriate sourness and a refreshing sensation.

APPENDIX 6.1a (Continued)

A food grade natural stabilizer was added to prevent coagulation of the whey protein during heat treatment.

After all ingredients were dissolved in orange juice and water, the liquid was pasteurized using the short time and high temperature method, and aseptically bottled. Therefore it is expected that the quality of the product would be maintained for a long time at room temperature.

Although the product accompanied by this form is presented in a brown glass bottle, this can be packed in a can, a cardboard carton or a plastic bottle, depending on the consumer's preference.

INSTRUCTIONS

After tasting the WHEY PROTEIN-ENRICHED ORANGE DRINK, please fill in the questionnaire. I would like each member of your family to answer separately. If you have any children under twelve (12) years of age, please answer the last question only of this questionaire on behalf of them.

Please tick (✓) the appropriate boxes ☐ and comment where you feel necessary.

NOTE: Would you please post the questionnaire in the self-addressed envelope provided, preferably within a week?

APPENDIX 6.1a (Continued)

(1) How did you like the WHEY PROTEIN-ENRICHED ORANGE DRINK?

☐ Like extremely

☐ Like very much

☐ Like moderately

☐ Like slightly

☐ Neither like nor dislike

☐ Dislike slightly

☐ Dislike moderately

☐ Dislike very much

☐ Dislike extremely

APPENDIX 6.1a (Continued)

(2) What is your opinion of the sweetness of WHEY PROTEIN-ENRICHED ORANGE DRINK?

- ☐ Very sweet
- ☐ Moderately sweet
- ☐ Right level of sweetness
- ☐ Not very sweet
- ☐ Not at all sweet

(3) How would you like the sweetness?

- ☐ Much sweeter
- ☐ Sweeter
- ☐ Just the same
- ☐ Not as sweet
- ☐ Much less sweet

(4) What is your opinion of the sourness of WHEY PROTEIN-ENRICHED ORANGE DRINK?

- ☐ Very sour
- ☐ Moderately sour
- ☐ Right level of sourness
- ☐ Not very sour
- ☐ Not at all sour

APPENDIX 6.1a (Continued)

(5) How would you like the sourness?

- ☐ Much sourer
- ☐ Sourer
- ☐ Just the same
- ☐ Not as sour
- ☐ Much less sour

(6) What is your opinion of the orange flavour?

- ☐ Very pronounced
- ☐ Moderately pronounced
- ☐ Pronounced
- ☐ Weak
- ☐ Not noticeable

(7) Would you like the orange flavour to be changed, stronger or weaker? If yes,

- ☐ Much stronger
- ☐ Stronger
- ☐ Just the same
- ☐ Weaker
- ☐ Much weaker

APPENDIX 6.1a (Continued)

(8)A Can you taste any unpleasant flavour?

- ☐ Yes
- ☐ No

(8)B If yes, how strong is the unpleasant flavour?

- ☐ Very pronounced
- ☐ Moderately pronounced
- ☐ Pronounced
- ☐ Slightly detectable

If yes, please specify the unpleasant flavour

_____

(9)A If this product is available in a shop, would you buy it? Please give us an honest answer (Assuming the price is a bit higher than that of normal flavoured milk).

- ☐ Yes
- ☐ No

(9)B If yes, why would you buy this product?

- ☐ As a nutritional supplement
- ☐ Nice taste
- ☐ Absence of preservatives
- ☐ Convenience
- ☐ Because orange juice plus milk protein is a fresh combination
- ☐ Any other reasons (please specify)

_____

APPENDIX 6.1a (Continued)

(9)C If no, why would you not buy this product?

- ☐ Too sweet
- ☐ Too sour
- ☐ No orange flavour
- ☐ Unpleasant flavours
- ☐ The colour is not attractive
- ☐ There are similar products on the market
- ☐ Others (Please specify)

_____

_____

(10) If you could replace the orange flavour with other flavours, which flavour would you like? (Choose any number).

- ☐ Apple
- ☐ Grapefruit
- ☐ Kiwifruit
- ☐ Pineapple
- ☐ Passion fruit
- ☐ Lemon

Only answer questions 11-14 if you answered "yes" to question (9)A, i.e. if you would buy this product if it was commercially available.

(11) Which size container would you prefer to buy?

- ☐ 200 ml
- ☐ 250 ml
- ☐ 500 ml
- ☐ 1 litre
- ☐ Others (please specify)

APPENDIX 6.1a (Continued)

(12) How many cartons would you buy if WHEY PROTEIN ENRICHED ORANGE DRINK was sold in a 250 ml capacity carton?

- ☐ Less than one per month
- ☐ One every 3-4 weeks
- ☐ One every 2 weeks
- ☐ One every 4-7 days
- ☐ One every 2-3 days
- ☐ One per day
- ☐ Others (please specify)

_____

(13) If you could buy WHEY PROTEIN-ENRICHED ORANGE DRINK what type of packaging would you like?

- ☐ Can
- ☐ Tetra Brik (cardboard container)
- ☐ Glass bottle
- ☐ Plastic bottle
- ☐ Others (please specify)

_____

(14) If you could buy WHEY PROTEIN-ENRICHED ORANGE DRINK, what is the maximum price you would expect to pay for a 250 ml cardboard carton of this product?

(a) In New Zealand

- ☐ 45 cents
- ☐ 55 cents
- ☐ 65 cents
- ☐ 75 cents
- ☐ Others (please specify) _____

APPENDIX 6.1a (Continued)

(b) In Japan

- ☐ 90 Yen
- ☐ 100 Yen
- ☐ 110 Yen
- ☐ 120 Yen
- ☐ Others (please specify) _____

(15) Do you have any other suggestions or comments about WHEY PROTEIN-ENRICHED ORANGE DRINK?

_____

_____

(16) Could you please give the following details:

A. Which age group do you belong to?

- ☐ 13-19
- ☐ 20-29
- ☐ 30-39
- ☐ 40-49
- ☐ over 50

B. Sex

- ☐ Male
- ☐ Female

If you have any children under twelve (12) years of age, please answer the following question on behalf of them. This question should be answered only by either their mother or father.

APPENDIX 6.1a (Continued)

(17) Did they like it?

First Child	Second Child	Third Child
(_____ years old)	(____ years old)	(____ years old)
☐ Yes	☐ Yes	☐ Yes
☐ No	☐ No	☐ No

Thank you very much for your time and cooperation.

Hank Arita
Product Development Student

Food Technology Department
MASSEY UNIVERSITY

APPENDIX 6.1b : Questionnaire used in the first market trial (Japanese)

Massey University

No. 1

PALMERSTON NORTH, NEW ZEALAND

TELEPHONES, 69-099, 69-089.

In reply please quote:

ウェリントン在住の日本人の皆様へ

明治乳業　有田宏行

乳清蛋白質強化飲料（オレンジ40%）試飲のお願い

皆様方におかれましては益々御清栄のことと存じ上げます。

さて、小生は一昨年来　当国のパーマストン・ノースにありますマッセイ大学（Massey University）食品工学部で乳製品開発の研究に従事して参りました。

この度、標題のような製品「乳清蛋白質強化飲料（オレンジ40%）」を開発致しました。お手元にございますのは　本製品の試作品です。お忙しい中誠に恐縮ではございますが、本品についての御意見をおうかがい致し度　お手紙を差し上げている次第でございます。

本調査は　ウェリントン在住の日本人の方々を対象にしております。また本調査はマッセイ大学の新製品開発講座の必修事項として消費者テストを実施しようとするものでございます。

調査事項にお答えいただく前に　簡単に本品の概要について説明させていただきます。

「乳清蛋白質強化飲料（オレンジ40%）」は牛乳由来の乳清蛋白質、天然オレンジ果汁40%、砂糖、天然安定剤、それにクエン酸を原料としています。

「乳清蛋白質」というのは聞きなれない名前でしょうが、牛乳の蛋白質の一部でチーズやカゼインの製造副産物としてできるもので、非常に栄養価に富んだ蛋白質です。と言うのも必須アミノ酸に富み体内で効率良く利用されるからです。本製品はこの乳清蛋白質を全重量の3%含んでおります。

もし本製品を250ml丁飲みになると　1日に必要な蛋白質の約2割を摂取したことになります。

本製品はまた40%純度の天然オレンジ果汁を使用しておりますので　天然のオレンジフレーバー、炭水化物並びにビタミンCを摂取することができます。

乳清蛋白質の分離を防止するためと、酸味を合わせるためにクエン酸を添加しています。クエン酸は適当な酸味と壮快感を加えるために、食品工業界で広く利用されている原料の一つです。

また加熱殺菌により乳清蛋白質の凝固するのを防ぐために、天然由来の食品安定剤を添加しております。

これらの原料を水に溶解、調合した後、高温短時間法で殺菌し、更に無菌的にびん詰めしております。従いまして本製品は常温で相当長期間

にあたり品質を保持するものと期待しております。
本品は仮に褐色のガラスびんに充填しておりますが、消費者のお好みにより、茶容器、紙容器もしくはプラスチックボトルに置きかえることも可能です。

〔御記入要領〕
「乳清蛋白質酸化飲料（オレンジ40%）」を御試飲された後、下記にございます質問事項にお答えになって下さい。
質問事項には御一人様につき一部ずつ御記入下さい。
もし御家庭には3才以下のお子様がいらっしゃいましたら、質問用紙の最後の質問についてお父様又はお母様のお子様を代弁して御記入下さい。
御回答は適当な□に(レ)印を御記入下さい。また必要な箇所には御感想をお聞かせ下さい。
御記入がすべてお済みになりましたら同封の封筒にて本田まで御返送して下さいますようお願い致します。できましたら本品が届きましてから一週間以内に御返送していただきますようお願い致します。
なお、空びんは回収致しませんので、お手数をおかけますが、廃棄されますよう申し添えます。

昭和59年7月2日

No. 1

(1) 本品「乳清蛋白質強化飲料（オレンジ40%）」の御感想をお聞かせ下さい。


□ ものすごく良かった


□ 非常に良かった


□ すあまあ良かった


□ ほんの少し良かった


□ 良くも悪くもなかった


□ ほんの少し悪かった


□ 悪かった


□ 非常に悪かった


□ 極端に悪かった

(2) 本品の甘味度について御意見をお聞かせ下さい。

□ 非常に甘すぎた

□ 少し甘すぎた

□ 丁度良い甘さ

□ 少し甘さが足りなかった

□ 少しも甘くなかった

(3) それでは甘味度はどのようになればよろしいか

□ もっともっと甘くして

□ もっと甘くして

□ そのままで良い

□ 少し甘さを おさえて

□ もっともっと甘さを おさえて

No. 2

(4) 本品の酸味度（すっぱさ）についての御意見を お聞かせ下さい。

□ 非常に酸味が強すぎた
□ 酸味が少し強すぎた
□ 丁度良い酸味
□ 酸味が少し弱すぎた
□ 非常に酸味が弱すぎた

(5) それでは酸味はどのように変えればよろしいか。

□ 非常にすっぱくして
□ 少しすっぱくして
□ そのままでよい
□ 少し酸味をおさえて
□ 非常に酸味をおさえて

(6) 本品のオレンジフレーバーについての御意見を お聞かせ下さい。

□ 非常にオレンジの強い味がした
□ やや強いオレンジの味がした
□ そこそこのオレンジの味がした
□ やや弱いオレンジの味がした
□ 非常に弱いオレンジの味がした

(7) それではオレンジフレーバーの強さをどのように変えればよろしいですか。

□ もっとオレンジの味を強くして
□ 少しオレンジの味を強くして
□ そのままでよい
□ 少しオレンジの味を弱くして
□ もっともっとオレンジの味を弱くして

No. 3

(8) A. 本品について異臭をお感じになりましたか.

□ はい　　□ いいえ

B. もしお感じになられたのであれば どの程度でしたか.

□ 非常に強い異臭がした

□ 強い異臭がした

□ やや強い異臭がした

□ 何んの少し異臭がした

C. もしお感じになられたのであれば 何のニオイだと思われましたか.

---

(9) A. もし本品が店で売られていたらお買いになりますか. 遠慮しないで正直な回答をお願いします. 但し価格は通常のフレーバーミルクの類より も少し高くなるとします.

□ はい　　□ いいえ

B. もしお買いになられるとすればその理由をお聞かせ下さい. (いくつでも)

□ 栄養を補給するため

□ おいしいから

□ 保存剤を添加していないから

□ 便利だから

□ オレンジ果汁と乳清蛋白質の組み合わせが新鮮に感じるから

その他 (具体的に)

C. 本品をお買いにならないと答えた方のみ御記入して下さい. お買い上げにならない理由をお聞かせ下さい. (いくつでも)

□ 甘すぎるから

□ 酸味の強すぎるから

□ オレンジの味がしないから

No.4

□ 変なニオイがするから

□ 色がおかしいから

□ 同じような製品がすでにマーケットに出ているから

その他（具体的に）

---

(10) もしオレンジ以外のフレーバーを考えるとすればどのようなフレーバーをお好みになりますか。次の果実の中から選択して下さい（いくつでも）

□ りんご　□ キウィフルーツ　□ パイナップル

□ グレープフルーツ　□ パッションフルーツ　□ レモン

次の(11)～(14)までの質問事項については(9)Aで「はい」と答えた方のみ御記入して下さい。

(11) お買い上げになる際、容器の容量は次のいずれがよろしいですか

□ 200 ml　□ 250 ml　□ 500 ml

□ 1 l　その他（具体的に）＿＿＿＿＿＿

(12) もし本品が250 mlの容器に入って売られていたら何個お買い上げになりますか。

□ 1カ月に1個未満　□ 3～4週間に1個

□ 2週間に1個　□ 4～7日間に1個

□ 2～3日に1個　□ 毎日1個

その他（具体的に）＿＿＿＿＿＿

(13) 本品をどのような容器に入れれば良いか

□ 缶容器　□ 紙容器　□ ガラスびん

□ プラスチックボトル　その他＿＿＿＿＿＿

(14) 本品を250 mlの紙容器に入れた場合お買い上げになられる価格の上限についてお聞かせ下さい。

A. ニューデーラントでお買い上げになるとすれば

□ 45セント　□ 55セント　□ 65セント

□ 75セント　その他＿＿＿＿＿＿

No. 5

B. 日本でお買いになるとすれば

□ 90円　□ 100円　□ 110円
□ 120円　その他 _____ 円

(15) 本品について他に御意見、御批判がございましたらお聞かせ下さい。

_____

_____

(16) 御回答者御自身についてお聞かせ下さい。

A. あなたは次のどの年令層にあたりますか。

□ 13～19才　□ 20～29才　□ 30～39才
□ 40～49才　□ 50才以上

B. 性別

□ 男　□ 女

もし御家庭に12才以下のお子様がいらっしゃいましたら、次の質問については お父様もしくは お母様が お子様の代わりに御記入なさって下さい。

(17) お子様は本品をお気に召しましたか

第一子（　才）　□ はい　□ いいえ
第二子（　才）　□ はい　□ いいえ
第三子（　才）　□ はい　□ いいえ

長い時間 お手数をおかけして申し訳ありませんでした。
本調査に御協力下さいまして 本当にありがとうございました。

明治乳業　有田宏行

APPENDIX 6.2 : Acceptance scores* for whey protein-enriched orange drink (percentage distribution of consumer responses).

Type of Respondent	Total Number of Respondents	Extremely Nice (%)	Like Very Much (%)	Like Moderately (%)	Like Slightly (%)	Neither Like nor Dislike (%)	Dislike Slightly (%)	Total (%)
Men (age)								
12-19	2	50	50	0	0	0	0	100
20-29	1	0	0	0	0	0	100	100
30-39	13	0	15	77	0	0	8	100
40-49	8	0	25	62	0	0	13	100
Over 50	1	0	100	0	0	0	0	100
Men Total	25	4	24	60	0	4	8	100
Women (age)								
12-19	9	11	11	33	11	23	11	100
20-29	6	0	0	83	17	0	0	100
30-39	15	0	13	73	0	7	7	100
40-49	10	10	30	30	0	0	30	100
Women Total	40	5	15	55	5	8	12	100
Grand Total	65	5	18	57	3	6	11	100

*on a 9-point hedonic scale

APPENDIX 6.3 : Sweetness scores for whey protein-enriched orange drink (percentage distribution of consumer responses)

Type of Respondent	Total No. of Respondents (%)	Very Sweet (%)	Moderately Sweet (%)	Right Level of Sweetness (%)	Not Very Sweet (%)	Not at all Sweet (%)	Total (%)
Men (age)							
12-19	2	0	0	100	0	0	100
20-29	1	0	0	0	0	100	100
30-39	13	0	31	61	8	0	100
40-49	8	0	25	62	13	0	100
Over 50	1	0	0	100	0	0	100
Total	25	0	24	64	8	4	100
Women (age)							
12-19	9	11	33	45	11	0	100
20-29	6	0	17	50	33	0	100
30-39	15	0	33	53	14	0	100
40-49	10	0	30	70	0	0	100
Total	40	3	30	55	12	0	100
Grand Total	65	2	28	58	10	2	100

APPENDIX 6.4 : Sourness scores for whey protein-enriched orange drink (percentage distribution of consumer responses).

Type of Respondent	Total No.of Respondents	Very Sour (%)	Moder-ately Sour (%)	Right Level of Sour-ness (%)	Not Very Sour (%)	Not at all Sour (%)	Total (%)
Men (age)							
12-19	2	0	50	50	0	0	100
20-29	1	0	100	0	0	0	100
30-39	13	0	54	46	0	0	100
40-49	8	0	50	50	0	0	100
Over 50	1	0	0	100	0	0	100
Total	25	0	52	48	0	0	100
Women (age)							
12-19	9	0	33	11	56	0	100
20-29	6	0	20	80	0	0	100
30-39	15	0	53	40	7	0	100
40-49	10	0	0	90	10	0	0
Total	40	0	30	53	17	0	100
Grand Total	65	0	38	51	11	0	100

APPENDIX 6.5 : Orange flavour scores for whey protein-enriched orange drink (percentage distribution of consumer responses).

Type of Respondent	Total No. of Respondents	Very Pronounced (%)	Moderately Pronounced (%)	Pronounced (%)	Weak (%)	Not Noticeable (%)	Total (%)
Men (age)							
12-19	2	50	0	50	0	0	100
20-29	1	0	100	0	0	0	100
30-39	13	0	8	76	16	0	100
40-49	8	0	25	50	25	0	100
Over 50	1	0	100	0	0	0	100
Total	25	4	20	60	16	0	100
Women (age)							
12-19	9	0	11	33	56	0	100
20-29	6	0	33	50	17	0	100
30-39	15	0	13	60	27	0	100
40-49	10	0	10	40	50	0	100
Total	40	0	15	47	38	0	100
Grand Total	65	2	17	52	29	0	100

APPENDIX 6.6 : Percentage of the respondents who did or did not detect unpleasant flavours.

Type of Respondent	Total No. of Respondents	Respondents who detected unpleasant flavours (%)	Respondents who did not detect unpleasant flavours (%)	Total (%)
Men	25	8	92	100
Women	40	28	72	100
Total	65	20	80	100

APPENDIX 6.7 : Percentage of the respondents who would or would not buy the product.

Type of Respondent	Respondents who would buy it		Respondents who would not buy it		Total	
Men (age)	No.	(%)	No.	(%)	No.	(%)
12-19	2	100	0	0	2	100
20-29	0	0	1	100	1	100
30-39	10	77	3	23	13	100
40-49	5	63	3	37	8	100
Over 50	1	100	0	0	1	100
Total	18	72	7	28	25	100
Women (age)	No.	(%)	No.	(%)	No.	(%)
12-19	5	56	4	44	9	100
20-29	4	67	2	33	6	100
30-39	14	93	1	7	15	100
40-49	5	50	5	50	10	100
Total	28	70	12	30	40	100
Grand Total	46	71	19	29	65	100

APPENDIX 6.8 : Consumer reasons for buying the product (percentage of consumers who would buy product).

Type of Respondent	No. of Respondents Buying	Reasons for Buying: Nutritious Supplement	Nice Taste	Absence of Preservatives	Convenience	Fresh Combination of milk protein + orange juice	Others	Total
		(% of people buying)						
Men (age)								
12-19	2	0	50	0	0	50	0	100
20-29	0	0	0	0	0	0	0	
30-39	10	20	27	0	13	40	0	100
40-49	5	43	14	0	0	29	14 *	100
Over 50	1	0	100	0	0	0	0	100
Total	18	24	28	0	8	36	4	100
Women (age)								
12-19	5	20	40	0	0	40	0	100
20-29	4	66	0	17	0	17	0	100
30-39	14	41	23	18	0	18	0	100
40-49	5	37	13	13	0	37	0	100
Total	28	41	20	15	0	24	0	100
Grand Total	46	34	23	9	3	29	2	100

*As a possible agent for keeping bowels in good conditions.

APPENDIX 6.9 : Percentage distribution of flavour preferences of the consumers.

Type of Respondent	Total No. of Respondents	Apple (%)	Pine-apple (%)	Grape-fruit (%)	Passion fruit (%)	Lemon (%)	Kiwi fruit (%)
Men	25	19	29	13	10	16	13
Women	40	21	17	17	13	19	13
Total	65	20	21	15	12	19	13

APPENDIX 6.10 : Frequency and rank of the container type wanted by the consumers.
(% of consumers saying they would buy the product)

Type of Respondent	No. of Consumers Buying Product	Can		Cardboard Carton		Glass Bottle		Plastic Bottle		Others	
		No.	%	No.	%	No.	%	No.	%	No.	%
Men	17	1	6	14	82	3	18	2	12	0	0
Women	26	1	4	16	62	2	8	10	38	1 *	4
Total	43**	2	5	30	70	5	12	12	28	1	2
Rank		4		1		3		2		5	

*Container of yoghurt type

**Those respondents who would not buy did not answer the question; percentage calculated on respondents who answered question, 3 people did not answer the question.

APPENDIX 6.11 : Price of the product-percentage distribution of consumers who would buy product.

NEW ZEALAND DOLLARS

Type of Respondent	No. of Respondents Buying	45 cents (%)	55 cents (%)	65 cents (%)	75 cents (%)	Total (%)
		% of respondents buying				
Men	17	0	28	61	11	100
Women	26	4	39	43	14	100
Total	43*	2	35	50	13	100

JAPANESE YEN

Type of Respondent	No. of Respondents Buying	90 Yen (%)	100 Yen (%)	110 Yen (%)	120 Yen (%)	Total (%)
		% of respondents buying				
Men	17	17	67	0	16	100
Women	26	18	54	4	24	100
Total	43*	17	59	2	22	100

*3 respondents did not answer; percentage calculated on people answering.

APPENDIX 6.12 : Overall comments and criticism of the product.

Male, 12-19 years of age

* I don't like the colour. If milk is a base, the colour should be white.

Male, 30-39 years of age

* There's no special taste, I suppose. It is similar to the taste of Japanese popular drinks, so no character can be seen.

* It seems easy to mix orange with milk even at home. More definite sales points are necessary when sold as a consumer product.

* It is too sour to drink much at a time.

* My first impression was that it was like an instant juice powder which was available in Japan many years ago. In other words, it tasted a bit like medicine.

Male, 40-49 years of age

* I don't want a fruit juice mixture.

* There was nothing advantageous.

* I would prefer a thicker drink.

Male, over 50 years of age

* I tasted it chilled. I wonder how it changes when served ambient. Or what about being served hot? I noted a refreshing sensation because of citric acid. That's for sure.

Female, 12-19 years of age

* Good drink.

* I don't like that indescribable colour. It's something like that of a medicine.

APPENDIX 6.12 (Continued)

Female, 20-29 years of age

* It seems nutritious. I suggest you pack it in a small container like 'Yakult'.

* It tasted like 'Yakult' in Japan. It's a good idea to combine Yakult with fruit (orange). It was my children who liked it most.

* It tasted like milk very much. For those who don't like milk, it seems difficult to drink much at a time. It's better if you pack it in a small container, then.

* I know my family do not tend to like sweet foods very much. Nevertheless, I felt it not sweet enough. I want it to be a little more sweet. It was all the more so because the orange caused a sourness which was a little too intense, although I like this kind of sourness.

Female, 30-39 years of age

* As it tasted thick, it can be more convenient and handy to give my children if you pack it in a small container.

* It tasted too light, so that it was not worth drinking. In fact, I wanted more lactic bacteria flavour.

* It encouraged me to try to drink it, more than soya milk did. I suggest you sell it as a cold drink. I don't think it sells well if the serving temperature is ambient. I thought it good for my skin-care too if I drank daily. Once it is sold, I am ready to drink every day as a health food rather than as a favourite food.

* The colour is my children's favourite. I think it a good idea if you pack it in a transparent container so that everybody can see it.

* I suggest the appearance would be better if the colour was a little more orangey.

APPENDIX 6.12 (Continued)

* I thought it good for the first mouthful, but soon I noted an unpleasant flavour and gave it up.

* It was very nice, but I like the cold one cooled in a refrigerator better than the ambient one (this is possibly because I don't like cow's milk very much).

* I think it very refreshing. When my children lose their appetite I will feed them. So I think it convenient.

Female, 40-49 years of age

* The impression of the product which was chilled in a refrigerator and tasted in a warm room was 'super'. I like its refreshing 'aftertaste'. I wonder how it might change in taste if I try it without chilling. Anyway, sourness and sweetness are just about right.

* As this was a bit too thick, it would be better if you dilute it.

* I thought it very handy and nice in taste. I suggest you pack it in a plastic bottle or glass bottle so that you can see the colour of the product.

APPENDIX 6.13 : Japan's population by age groups.
(estimates as of October 1, 1981)

	Number (in thousands)		
Age Group	Male	Female	Total
0 - 4	4,211	3,998	8,209
5 - 9	5,073	4,821	9,894
10 - 14	4,874	4,626	9,500
15 - 19	4,168	3,984	8,152
20 - 24	3,953	3,857	7,810
25 - 29	4,326	4,278	8,604
30 - 34	5,712	5,637	11,350
35 - 39	4,372	4,375	8,748
40 - 44	4,241	4,263	8,504
45 - 49	4,101	4,124	8,225
50 - 54	3,648	3,732	7,381
55 - 59	2,734	3,218	5,952
60 - 64	1,958	2,588	4,546
65 - 69	1,767	2,266	4,034
70 - 74	1,374	1,807	3,182
75 - 79	857	1,200	2,057
80 - 84	446	721	1,167
85 -	185	384	569
Total	58,002	59,882	117,884

Source: Tsuneta Yano Memorial Society, (1983).

APPENDIX 6.14 : Frequency of use of the product (percentage distribution by age groups who would buy product).

Age Group (Men and Women)	One Every 3-4 Weeks	One Every 2 Weeks	One Every 4-7 Days	One Every 2-3 Days	One Every Day	Total
	0.29 packs per week	0.50 packs per week	1.27 packs per week	2.80 packs per week	7 packs per week	
12 - 19	14	28	14	14	30	100
20 - 29	25	-	50	-	25	100
12 - 29 Total	18	18	28	8	28	100
30 - 39	9	4	43	39	5	100
Over 40	11	11	22	11	45	100
Grand Total	12	9	35	26	18	100

APPENDIX 9.1a : Questionnaire used in the second market trial (English)

To every Japanese person who resides in Wellington

Dear Sir,

I would like to express my thanks to all of you who helped me with the survey concerning 'Whey Protein-Enriched Orange Drink'. It is my conclusion that the product quality should be changed after I collected and studied your valuable opinions.

Accompanying this letter you will find two (2) sample bottles of 'Whey Protein-Enriched Orange Drink' which was prepared and pasteurised afresh at Massey University. I would greatly appreciate it if you could help me again with the present survey regarding the drink.

Please fill in the questionnaire, ticking (✓) the appropriate boxes and giving any comments where you feel necessary.

Please post the questionnaires in the self-addressed envelope provided within a week if you could.

Yours sincerely,

H. ARITA

Representative,
Meiji Milk Products Co. Ltd.

(1) How did you like the 'Whey Protein-Enriched Orange Drink'?

671	561	
☐	☐	Like extremely
☐	☐	Like very much
☐	☐	Like moderately
☐	☐	Like slightly
☐	☐	Neither like nor dislike
☐	☐	Dislike slightly
☐	☐	Dislike moderately
☐	☐	Dislike very much
☐	☐	Dislike extremely

(2) A. Can you taste unpleasant flavours?

Sample No.

674 ☐ Yes ☐ No

561 ☐ Yes ☐ No

B. If yes, please describe them.

Sample No.

674 _____

561 _____

(3) What is your opinion of the colour?

Sample No. 674	Sample No. 561	
☐	☐	Orange
☐	☐	Whitish orange
☐	☐	Brownish orange
☐	☐	Pinkish orange
☐	☐	Yellow
☐	☐	Whitish yellow
☐	☐	Brownish yellow
☐	☐	Pinkish yellow

(4) How would you like the colour?

Sample No. 674	Sample No. 561	
☐	☐	More orangey
☐	☐	More whitish
☐	☐	More pinkish
☐	☐	More yellowish
☐	☐	More brownish
☐	☐	Just the same

(5) How would you compare them with the last sample in general?

Sample No. 674	Sample No. 561	
☐	☐	Better
☐	☐	Just the same
☐	☐	Worse

(6) A. Which sample would you like better, 674 or 561?

- ☐ 674 was extremely better than 561
- ☐ 674 was much better than 561
- ☐ 674 was slightly better than 561
- ☐ Same
- ☐ 674 was slightly worse than 561
- ☐ 674 was much worse than 561
- ☐ 674 was extremely worse than 561

B. In what way would you think one was better than the other if you had to choose between them?

_____

_____

(7) Would you have any other suggestions or comments?

_____

_____

(8) Could you please give the following details:

A. Which age group do you belong to?

- ☐ 13 - 19
- ☐ 20 - 29
- ☐ 30 - 39
- ☐ 40 - 49
- ☐ Over 50

B. Sex:

- ☐ Male
- ☐ Female

If you have any children under twelve (12) years of age, please answer the following questions on behalf of them. These questions should be answered only by either their mother or their father.

(9) Did they like the drinks?

	Sample No.		
First child	674	☐ Yes	☐ No
(___years old)	561	☐ Yes	☐ No
Second child	674	☐ Yes	☐ No
(___years old)	561	☐ Yes	☐ No
Third child	674	☐ Yes	☐ No
(___years old)	561	☐ Yes	☐ No

(10) Your child would prefer:

First child	☐	674
	☐	561
	☐	Equally
Second child	☐	674
	☐	561
	☐	Equally
Third child	☐	674
	☐	561
	☐	Equally

Thank you very much for your time and cooperation.

Representative,
Meiji Milk Products,
H. Arita

APPENDIX 9.1b : Questionnaire used in the second market trial (Japanese).

Massey University

PALMERSTON NORTH, NEW ZEALAND TELEPHONES, 69-099, 69-089.

In reply please quote:

ウェリントン在住の日本人の皆様へ

明治乳業　有田宏行

皆様方におかれましては益々御清栄のことと存じ上げます。
先日は お忙しいところ乳清蛋白質強化飲料」の調査に御協力いただきありがとうございました。
皆様方からいただいた貴重な御意見を集約しましたところ、品質を変更した方がよいという結論になりました。お手元にございますのは マッセイ大学で今回 あらたに調合殺菌した製品の試作品(2本)です。
お忙しい中恐縮ですが 再度 本調査に御協力下さいますよう お願い致します。
記入方法は 前回同様 質問用紙の適当と思われる口に(レ)印をつけて下さい。また必要な箇所には 御感想をお聞かせ下さい。
御記入が お済みになりましたら 同封の封筒にて できましたら一週間以内に有田まで 返送して下さいますよう お願い致します。

昭和59年 8月 14日

No. 1

(1) 本品 乳清蛋白酸化飲料 (オレンジ 40%) の御感想をお聞かせ下さい。

	サンプル番号 674	サンプル番号 561	
	□	□	非常に良かった
	□	□	非常に良かった
	□	□	良かった
	□	□	少し良かった
	□	□	良くも悪くもなかった
	□	□	少し悪かった
	□	□	悪かった
	□	□	非常に悪かった
	□	□	極端に悪かった

(2) A. 本品について不快な臭いをお感じになりましたか。

サンプル番号		
674	□ はい	□ いいえ
561	□ はい	□ いいえ

B. もしお感じになられたのであれば何のニオイだと思われましたか。

サンプル番号

674 _____

_____

561 _____

_____

No. 2

(3) 本品の色は次のどれに当たりますか

サンプル番号 674	サンプル番号 561	
□	□	オレンジ色
□	□	白味がかったオレンジ色
□	□	茶系のオレンジ色
□	□	ピンク系のオレンジ色
□	□	黄色
□	□	白味がかった黄色
□	□	茶系の黄色
□	□	ピンク系の黄色

(4) 本品の色はどのようになればよろしいか

サンプル番号 674	サンプル番号 561	
□	□	もっとオレンジ色を強く出して
□	□	もっと白色系にて
□	□	もっとピンク系にて
□	□	もっと黄色くして
□	□	もっと茶系にて
□	□	そのままでよい

(5) 本品は総合的な印象の点で前回の試作品と比べてどうでしたか。

サンプル番号 674	サンプル番号 561	
□	□	良くなった
□	□	変わらない
□	□	悪くなった

No. 3

(6) A サンプル674とサンプル561を比べてどちらがお口に合いましたか

□ 674の方が561よりもものすごく良かった

□ 674の方が561よりも非常に良かった

□ 674の方が561よりも少し良かった

□ 同じ

□ 674の方が561よりも少し悪かった

□ 674の方が561よりも非常に悪かった

□ 674の方が561よりも極端に悪かった

5. [illegible]ですか

____

____

(7) 本品について他に御意見、御批判がございましたらお聞かせ下さい

____

____

____

(8) 御回答者御自身についてお聞かせ下さい

A. あなたは次のどの年令層にあたりますか

□ 13～19才　□ 20～29才　□ 30～39才

□ 40～49才　□ 50才以上

B. 性別

□ 男　□ 女

No. 4

もし御家庭に12才以下のお子様がいらっしゃいましたら次の質問については
お父様もしくはお母様がお子様の代わりに御記入なさって下さい

(9) お子様は本品をお気に召しましたか

	サンプル番号		
第一子（　才）	674	□ はい	□ いいえ
	561	□ はい	□ いいえ
第二子（　才）	674	□ はい	□ いいえ
	561	□ はい	□ いいえ
第三子（　才）	674	□ はい	□ いいえ
	561	□ はい	□ いいえ

(10) お子様はどちらのと言えば

第一子	□	674の方を好んだ
	□	561の方を好んだ
	□	同じ
第二子	□	674の方を好んだ
	□	561の方を好んだ
	□	同じ
第三子	□	674の方を好んだ
	□	561の方を好んだ
	□	同じ

長い時間、お手数をおかけして申し訳ありませんでした。
本調査に御協力下さいまして本当にありがとうございました。

明治乳業　　有田宏行

APPENDIX 9.2a : Consumer acceptability of whey protein-enriched orange drink with s-WPC 80 (distribution of the number of respondents by sex and age) in the second survey.

Sex	Age	No.	Like Extremely	Like Very Much	Like Moderately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moderately	Dislike Very Much	Dislike Extremely
		No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Men	13-19	2	1	0	0	0	0	1	0	0	0
	20-29	0	0	0	0	0	0	0	0	0	0
	30-39	10	0	2	4	0	3	0	1	0	0
	40-49	5	0	2	1	2	0	0	0	0	0
	Total	17	1	4	5	2	3	1	1	0	0
Women	13-19	7	1	1	3	2	0	0	0	0	0
	20-29	2	0	0	2	0	0	0	0	0	0
	30-39	11	0	2	4	3	2	0	0	0	0
	40-49	4	0	2	1	1	0	0	0	0	0
	Total	24	1	5	10	6	2	0	0	0	0
	Grand Total	41	2	9	15	8	5	1	1	0	0

APPENDIX 9.2b : Consumer acceptability of whey protein-enriched orange drink with 1-WPC 75 (distribution of the numbers of the respondents by sex and age) in the second survey.

Sex	Age		Like Extremely	Like Very Much	Like Moderately	Like Slightly	Neither Like nor Dislike	Dislike Slightly	Dislike Moderately	Dislike Very Much	Dislike Extremely
		No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Men	13-19	2	0	1	0	0	0	1	0	0	0
	20-29	0	0	0	0	0	0	0	0	0	0
	30-39	10	0	4	1	1	3	1	0	0	0
	40-49	5	0	2	0	1	1	1	0	0	0
	Total	17	0	7	1	2	4	3	0	0	0
Women	13-19	7	0	1	1	1	1	3	0	0	0
	20-29	2	0	2	0	0	0	0	0	0	0
	30-39	11	0	2	6	2	1	0	0	0	0
	40-49	3	0	0	2	0	1	0	0	0	0
	Total	23*	0	5	9	3	3	3	0	0	0
	Grand Total	40	0	12	10	5	7	6	0	0	0

*One woman did not answer

APPENDIX 9.3 : Acceptability of the two drinks by children under 12 years of age (distribution of the numbers of children by age).

Age *		s-WPC		l-WPC	
		Like	Dislike	Like	Dislike
	No.	No.	No.	No.	No.
2	5	4	1	5	0
3	2	2	0	2	0
4	6	6	0	4	2
5	2	2	0	2	0
6	1	0	1	1	0
Total	16	14	2	14	2
9	2	2	0	2	0
10	2	1	1	1	1
11	1	1	0	1	0
12	2	2	0	2	0
Total	7	6	1	6	1
Grand Total	23	20	3	20	3

*No 7, 8 year old children

APPENDIX 9.4a : Colour of the drink with s-WPC 80 (distribution of the numbers of the respondents by sex and age) in the second survey.

Sex	Age		Orange	Whitish Orange	Brownish Orange	Pinkish Orange	Yellow	Whitish Yellow	Brownish Yellow	Pinkish Yellow
		No.	No.	No.	No.	No.	No.	No.	No.	No.
Men	13-19	2	0	2	0	0	0	0	0	0
	20-29	0	0	0	0	0	0	0	0	0
	30-39	10	1	8	0	0	0	1	0	0
	40-49	5	1	3	0	0	0	1	0	0
	Total	17	2	13	0	0	0	2	0	0
Women	13-19	6	0	6	0	0	0	0	0	0
	20-29	2	1	1	0	0	0	0	0	0
	30-39	11	3	8	0	0	0	0	0	0
	40-49	4	1	3	0	0	0	0	0	0
	Total	23*	5	18	0	0	0	0	0	0
Grand Total		40	7	31	0	0	0	2	0	0

*One respondent did not answer

APPENDIX 9.4b : Colour of the drink with 1-WPC 75 (distribution of the numbers of the respondents by sex and age) in the second survey.

Sex	Age	No.	Orange	Whitish Orange	Brownish Orange	Pinkish Orange	Yellow	Whitish Yellow	Brownish Yellow	Pinkish Yellow
			No.	No.	No.	No.	No.	No.	No.	No.
Men	13-19	2	1	1	0	0	0	0	0	0
	20-29	0	0	0	0	0	0	0	0	0
	30-39	10	1	8	0	0	1	0	0	0
	40-49	5	1	4	0	0	0	0	0	0
	Total	17	3	13	0	0	1	0	0	0
Women	13-19	7	0	7	0	0	0	0	0	0
	20-29	2	1	1	0	0	0	0	0	0
	30-39	10	4	6	0	0	0	0	0	0
	40-49	4	0	4	0	0	0	0	0	0
	Total	23*	5	18	0	0	0	0	0	0
Grand Total		40	8	31	0	0	1	0	0	0

*One respondent did not answer

APPENDIX 9.5a : Colour change preference with s-WPC 80 (distribution of the number of the respondents by sex and age).

Sex	Age		More Orangey	More Whitish	More Pinkish	More Yellowish	More Brownish	Just the Same
		No.	No.	No.	No.	No.	No.	No.
	13-19	2	1	0	0	0	0	1
	20-29	0	0	0	0	0	0	0
Men	30-39	10	3	0	0	0	0	7
	40-49	5	1	1	0	0	0	3
	Total	17	5	1	0	0	0	11
	13-19	6	2	2	0	0	0	2
	20-29	2	0	1	0	0	0	1
Women	30-39	11	3	1	0	0	0	7
	40-49	4	1	0	0	0	0	3
	Total	23*	6	4	0	0	0	13
Grand Total		40	11	5	0	0	0	24

*One respondent did not answer

APPENDIX 9.5b : Colour change preference with 1-WPC 75 (distribution of the numbers of the respondents by sex and age).

Sex	Age		More Orangey	More Whitish	More Pinkish	More Yellowish	More Brownish	Just the Same
		No.	No.	No.	No.	No.	No.	No.
Men	13-19	2	1	0	0	0	0	1
	20-29	0	0	0	0	0	0	0
	30-39	10	3	0	0	0	0	7
	40-49	5	1	1	0	0	0	3
	Total	17	5	1	0	0	0	11
Women	13-19	7	3	2	0	0	0	2
	20-29	2	0	1	0	0	0	1
	30-39	10	2	1	0	0	0	7
	40-49	4	0	0	0	0	0	4
	Total	23*	5	4	0	0	0	14
Grand Total		40	10	5	0	0	0	26

*One respondent did not answer

APPENDIX 9.6 : Comparison of the two drinks with the previous sample from the first market trial (distribution of the numbers of the respondents by sex and age).

		Better		Just the Same		Worse	
		s-WPC No.	l-WPC No.	s-WPC No.	l-WPC No.	s-WPC No.	l-WPC No.
Men	13-19	2	2	2	2	0	0	0	0
	20-29	0	0	0	0	0	0	0	0
	30-39	10	10	6	4	3	5	1	1
	40-49	4	4	3	2	1	2	0	0
	Total	16*	16*	11	8	4	7	1	1
Women	13-19	6	7	4	1	1	5	1	1
	20-29	2	2	2	2	0	0	0	0
	30-39	11	10	8	4	2	5	1	1
	40-49	4	4	4	2	0	2	0	0
	Total	23*	23*	18	9	3	12	2	2
Grand Total		39*	39*	29	17	7	19	3	3

*Two respondents did not answer

APPENDIX 9.7 : Comparison of the two drinks with each other, showing the extent of preference by the respondents (distribution of the numbers of the consumers by sex and age).

Sex	Age		s-WPC was extremely better than 1-WPC	s-WPC was much better than 1-WPC	s-WPC was slightly better than 1-WPC	Just the same	s-WPC was slightly worse than 1-WPC	s-WPC was much worse than 1-WPC	s-WPC was extremely worse than 1-WPC
		No.	No.	No.	No.	No.	No.	No.	No.
	13-19	2	0	0	2	0	0	0	0
	20-29	0	0	0	0	0	0	0	0
Men	30-39	10	0	1	3	1	4	1	0
	40-49	5	0	1	3	1	0	0	0
	Total	17	0	2	8	2	4	1	0
	13-19	7	2	3	1	1	0	0	0
	20-29	2	0	0	0	0	2	0	0
Women	30-39	11	0	1	4	1	5	0	0
	40-49	4	1	2	1	0	0	0	0
	Total	24	3	6	6	2	7	0	0
Grand Total		41	3	8	14	4	11	1	0

APPENDIX 9.8 : The reasons for preference of one drink over the other.

The Respondents who Preferred 674 to 561

* The flavour was better in 674 than in 561 (M:30, M:40, W:40 and W:40).
* 674 was less sour, which was good (W:10, M:30 and W:30).
* 674 was more tasteful (W:40, M:10 and M:40).
* 674 was easier to drink (M:10).
* 674 was sweeter, which was good (W:10).
* Mouthfeel was smooth in 674 and the sweetness was about right (W:40).
* 674 was more refreshing (M:30 and W:30).
* There was better aftertaste in 674 (M:40).
* There was sourness left in the mouth after drinking 561 (M:30 and W:30).

The Respondents who preferred 561 to 674

* 674 was too sour (M:30, W:20 and W:30).
* There was not enough sourness in 674 (M:30 and W:30).
* 561 was easier to drink (W:20).
* 561 was milder (M:30 and W:30).
* 561 was more refreshing (W:30 and W:30).
* There was an unpleasant flavour in 674 (M:30 and W:30).
* There remained astringency in the mouth after drinking 674 (M:40).

KEY: 674 = The drink with s-WPC 80.
561 = The drink with l-WPC 75.
M:30 = Men in their thirties, etc.

APPENDIX 9.9 : Preference for one drink over the other, being tasted by children under 12 years of age (distribution of the numbers of children by age).

Age		Children Preferred s-WPC	Children Preferred l-WPC	Children Had No Preference
	No.	No.	No.	No.
2	5	0	2	3
3	2	0	1	1
4	6	2	1	3
5	2	1	0	1
6	1	0	1	0
Total	16	3	5	8
9	2	1	1	0
10	1	0	1	0
11	1	0	1	0
12	2	2	0	0
Total	6	3	3	0
Grand Total	22*	6	8	8

*One child did not answer

APPENDIX 9.10 : Overall comments on products made in the second survey.

Comments Regarding Flavours

* There was bitterness in 561, I suppose (W:40).

* Taste needs to be improved (M:10).

* They got better in taste than the previous sample, that's for sure (W:20).

* I did not become refreshed after I drank them. There were unpleasant aftertastes (M:30).

* There were neither enough orange nor sour flavours in 674, but 674 would be better if you wished to drink a greater volume (W:30).

* There remained sour flavour in the mouth after I drank 674 (W:30).

* There was less sourness in the present samples than in the previous one. So they were easier to drink (M:30).

* I felt an unpleasant milky flavour (M:30).

Comments Regarding Thickness

* I would like them to be thinner as I thought it a bit too thick and felt like becoming full (W:30, W:30 and M:40).

* Both the drinks were too thick. When I tried to drink them with carbonated water blended, I got the right thickness (M:30).

* As they were a little too powdery, they got to be slightly more smooth (M:30).

APPENDIX 9.10 (Continued)

Comments Regarding Colour

* Please indicate the shelf-life in order to know the possible colour change after a certain storage.