CHARACTERISTICS OF FLAVORED, FLUID WHEY BASED BEVERAGES FORTIFIED WITH PEANUT AND/OR SOYBEAN SOLIDS

by

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STATEMENT BY AUTHOR

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This work is dedicated to my parents, who always supported me with their love and help throughout my studies. My thanks to them for always being beside me. To my husband George who came into my life during the last part of my research making our love an important reason for me to keep working. I would like to thank you my new friends for their support.

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ABSTRACT

Of the estimated 17 billion kilograms of annual fluid whey production only about 50% is utilized for human food or animal feed. The remainder becomes industrial waste with considerable disposal charges involved. Much whey utilization research has been directed toward the production of fractionated, condensed, dehydrated or other processed forms for use in a variety of foods. Since these approaches involve higher equipment and energy costs, it is important to consider acceptable food uses for fluid whey.

In this work, fluid cottage cheese whey was used as the major ingredient in the formulation of a chocolate flavored beverage fortified with legume solids such as peanuts. Beverage ingredient array was selected to provide a final gross composition similar to bovine milk with respect to fat, protein and carbohydrate. A considerable number of available processing variables used in preliminary trials gave generally inferior physical and sensory properties in a whey-soybean beverage. A final process was developed for a whey-peanut based, chocolate flavored beverage using a 2^3 factorial design in which the peanut content was maintained at 8% and fluid cottage cheese whey varied from 81.85% to 85.95% of the total product weight. The eight experimental formulations involved 5 and 7% sucrose, 1 and 3% cocoa and 0 and 0.1% stabilizer. Final beverage composition parameters were within the

range of calculated values. Physical and sensory properties were satisfactory.

CHAPTER 1

INTRODUCTION

It is estimated that the total annual fluid whey production in the United States is more than 17 billion kilograms (WPI Statistical Report, 1979). The similar world fluid whey production is about 72 billion kilograms (1). Both domestic and world production is increasing significantly.

About 9 Kg of cheese are produced from 100 Kg of milk. The 90 Kg difference is the byproduct whey. It has a high biological oxygen demand (BOD) and is considered as a potentially serious environmental pollutant. Several reports (2,3,4,5) indicate a growing concern about pollution, and increased emphasis on environmental control has caused cheese manufacturers to seek alternative means of whey disposal. The high acidity and lactose content of cottage cheese whey, for example, are detrimental to the biological processes involved in waste-treatment technology.

With continued increases in cheese production, disposal becomes more critical. Older, conventional methods of disposal such as diverting into streams or rivers and municipal sewage systems, feeding farm animals, spreading on fields, or processing become more inadequate.

Only about 50% of the total whey produced is utilized for human food or animal feed. The remainder becomes an industrial waste. This practice not only creates the aforementioned pollution problem but it also results in the loss of millions of kilograms of high quality proteins and other nutrients.

Considerable work has been carried out and is continuing in an attempt to find new uses for whey but completely satisfactory utilization remains a problem for the dairy industry worldwide.

Only a comparatively small fraction of the total available whey is used for human consumption. This is especially true for acid or cottage cheese whey, and it is unfortunate since whey proteins not only have high nutritional quality (6), but they also provide considerable supplementary value when combined with certain vegetable proteins of lower quality (7).

At the present time, the dairy industry faces the need to more adequately understand the broad aspects of whey utilization, especially for human food. Vajdi and Pereira (8) state that the utilization of whey in the early 1960's was largely limited to its use as a dehydrated product for use in livestock and poultry feeds. According to their report, the use of whey as a commercially available food grade product was reported in the middle 1960's. Recently, larger amounts of whey have been utilized in various dehydrated forms. Much interest has been directed to the production of whey protein concentrates (WPC). These products have high nutritional value as well as good functional or technological properties (4), however, production of these materials may be economically marginal due to excessive equipment and energy costs. They are justified mainly as alternatives to prohibitive treatment costs required to reduce whey BOD to lower levels prior to disposal as municipal sewage. In view of increasing pollution control demands there is a tendency for renewed interest in the use of whey for livestock feeding. The use of whey products in animal feeding as well as in foods has been reported (9), but more information is needed about the precise nutritional significance of whey products in human diets. In their review, Holsinger, Posati and DeVilbiss (10) consider that, in light of growing global food shortages, the most logical use might be to return whey to the human food chain in a palatable form.

Many of the available methods of whey utilization, such as production of WPC, involve selective fractionation of various whey constituents. The remaining fractions remain as a part of the problem of whey constituent utilization and disposal. These processes tend to be expensive because of escalating building, labor, equipment and energy costs.

The short supply or unavailability of animal proteins in many parts of the world has created a need to develop economical processes for incorporation of nutritionally suitable plant proteins into human diets. Research work in the United States has been directed mainly toward developing procedures for separating high-protein fractions from soybeans. Soybeans have served as an important source of proteins in Oriental diets for many centuries. However, beverage preparation from whole soybeans has been limited in other areas principally because of the undesirable "beany" or "painty" off-flavor and odor. Other legumes, such as peanuts, have received somewhat less food product research attention not because they contain protein which may be functionally or nutritionally inferior, but because of unfavorable availability or economics.

Much of the research work on whey beverages and whey-soy mixes has been directed toward production of powders that are ultimately used as a base for reconstituted beverages of increased nutritional value. Some work has been reported concerning the utilization of fluid whey in beverages, mainly in the production of fruit-flavored beverages, liquid breakfast meals and imitation milks. However, in many of these processes a final vacuum condensing/spray drying operation is involved for the production of a powdered beverage base. This represents a potentially more expensive method of utilizing whey than might be involved in utilizing fluid whey. Also, powdered whey products often displace non-fat dry milk solids (NFDMS). Under these circumstances, there are some substantial questions of economics since the more expensive NFDMS becomes a surplus product which must be disposed of as animal feed or in price support programs operated by the Commodity Credit Corporation (C.C.C.).

The purpose of this study was to investigate the possible utilization of two sources of high quality protein and other nutrients by combining fluid cottage cheese whey with certain legume solids such as peanuts or soybeans in the production of a nutritious, flavored, whey-based beverage. The intent was to closely duplicate the nutritional value of milk and to evaluate the sensory acceptability and storage properties of the product as well as to examine the economic and practical aspects of the process.

CHAPTER 2

REVIEW OF LITERATURE

Whey

Basic Properties and Production of Whey

The liquid removed after coagulation of milk in cheesemaking is known as whey. Most of the albumin, lactose, and mineral matter of the original milk remains in whey (11). The casein and fat in the coagulum or curd become cheese. Whey constitutes about 90% of the milk used in cheese manufacture, and it retains about 55% of the milk nutrients (Table 1) (2).

Whey proteins, namely lactalbumin and lactoglobulin, although present in very low concentrations, are of high nutritional quality (Table 2) (6). The essential amino acid content of whey proteins, as compared to the Food and Agriculture Organization (FAO) pattern is of interest (Table 3).

Whey from ripened cheese varieties is described as sweet with a pH of 5.9 to 6.3, while that from unripened cheeses tends to be more acid with the pH ranging from 4.4 to 4.6. Acid whey contains more lactic acid, calcium, phosphorus, and lactose. The higher acidity and saltiness tends to create consumer acceptability problems and more difficulty in overall acid whey utilization. The vitamin and mineral

Table 1. Composition of Wheys

Component	Fluid sweet whey	Fluid acid whey	Condensed acid whey	Dried sweet whey	Dried acid whey
			%		
Moisture	93.70	93.50	33.50	3.50	4.00
Lactose	4.85	4.90	34.90	75.00	67.40
Total protein	0.80	0.75	7.60	13.10	12.50
Fat	0.50	0.04	0.60	0.80	0.60
Ash	0.50	0.80	8.20	7.30	11.80
Lactic acid	0.50	0.40	12.00	0.20	4.20
Total solids	6.35	6.50	64.00	96.50	96.00

Table 2. Amino Acid Composition of Dry Whey Proteins

Amino acid	Sweet-type dry whey: g/100 g protein, Mean	Sweet-type dry whey: g/100 g protein, Range	Sweet-type dry whey: g/100 g dry whey, Mean	Sweet-type dry whey: g/100 g dry whey, Range	Acid-type dry whey: g/100 g protein, Mean	Acid-type dry whey: g/100 g protein, Range	Acid-type dry whey: g/100 g dry whey, Mean	Acid-type dry whey: g/100 g dry whey, Range
Lysine	8.8	7.4 - 9.8	1.10	.91 - 1.20	10.3	9.1 - 12.5	1.24	1.13 - 1.41
Histidine	2.0	1.6 - 2.5	.25	.19 - .31	2.3	1.9 - 2.6	.28	.21 - .32
Arginine	2.6	2.4 - 2.9	.33	.29 - .36	2.8	2.7 - 2.9	.33	.30 - .36
Tryptophan	2.4	2.1 - 2.8	.30	.27 - .35	2.4	2.2 - 2.7	.29	.25 - .34
Aspartic acid	10.2	6.7 - 12.0	1.28	.82 - 1.46	10.2	9.9 - 10.7	1.23	1.11 - 1.34
Threonine	6.8	6.5 - 7.6	.85	.82 - .93	4.9	4.8 - 5.0	.59	.54 - .62
Serine	5.3	5.0 - 5.8	.66	.64 - .71	4.7	4.5 - 4.8	.56	.50 - .60
Glutamic acid	18.0	15.4 - 21.6	2.23	1.88 - 2.63	18.4	17.8 - 18.7	2.22	2.00 - 2.33
Proline	6.9	6.3 - 7.5	.85	.77 - .92	6.4	5.9 - 6.9	.77	.74 - .81
Glycine	1.9	1.8 - 2.0	.24	.23 - .25	1.7	1.6 - 1.7	.20	.18 - .22
Alanine	4.6	4.4 - 5.2	.58	.54 - .63	4.1	4.0 - 4.3	.50	.46 - .53
Cystine	2.3	2.1 - 2.4	.28	.25 - .31	2.2	1.9 - 2.4	.26	.24 - .28
Valine	5.9	5.6 - 6.4	.73	.71 - .78	5.2	5.2 - 5.3	.63	.58 - .66
Methionine	1.8	1.5 - 1.9	.22	.19 - .25	1.8	1.7 - 1.9	.21	.21 - .22
Isoleucine	5.9	5.6 - 6.6	.74	.70 - .80	5.4	5.1 - 5.9	.66	.58 - .74
Leucine	10.3	9.8 - 11.4	1.28	1.20 - 1.39	10.5	10.3 - 10.7	1.26	1.16 - 1.34
Tyrosine	2.7	2.6 - 3.0	.34	.31 - .36	3.1	2.8 - 3.3	.37	.32 - .41
Phenylalanine	3.5	3.3 - 3.7	.43	.41 - .46	3.7	3.6 - 3.7	.44	.40 - .47

Table 3. Essential Amino Acid Content of Whey Proteins[a] as Compared to the Food and Agriculture Organization (FAO) Pattern

Amino Acid	Sweet whey g/100 g protein	Acid whey g/100 g protein	FAO[b] g/100 g protein
Leucine	10.3	10.5	4.8
Lysine	8.8	10.3	4.2
Threonine	6.8	4.9	2.8
Isoleucine	5.9	5.4	4.2
Valine	5.9	5.2	4.2
Phenylalanine	3.5	3.7	2.8
Tryptophan	2.4	2.4	1.4
Methionine	1.8	1.8	2.2

a Values taken from Table 2
b From (12)

contents of sweet and acid wheys are similar except as noted (Table 4) (Whey Products Institute Report, March 1975).

Statistics show an increasing trend in annual cheese production which, in turn, results in greater volumes of fluid whey. The United States total whey production increased from 12.78 billion kilograms in 1972 to 16.98 billion kilograms in 1979 (Table 5) (WPI report). The high acidity and biological oxygen demand (BOD) of whey make it an environmental pollutant (38,000 - 46,000 ppm compared to 200 ppm for domestic sewage) (13). On the other hand, the nutritional quality of its nutrients makes it a potentially important food. These two considerations account for the seriousness of the whey disposal--whey utilization problem.

Whey Disposal Methods

Some of the reported (2) methods that have been used or proposed for whey disposal are: Spreading over fields; diverting into rivers; diverting into sewage systems; dumping in abandoned mines or holes dug for disposal; dumping in lagoons; producing fuel gas by anaerobic fermentation; returning the whey to farmers for livestock feeding, etc. These practices tend to be costly and labor-demanding for the cheese industry and have certain limitations in the overall disposal solution. Handling, transportation, and disposal costs are usually borne by the consumer in the form of higher cheese prices.

Table 4. Average Vitamin and Mineral Contents of Sweet-type Dry Whey[a]

Vitamins		Minerals	
A (I.U.)	137	Calcium (mg)	774
C (mg)	1.0	Phosphorus (mg)	1010
E (mg)	0.06	Sodium (mg)	1266
Thiamine/B_1 (mg)	0.5	Potassium (mg)	1838
Riboflavin/B_2 (mg)	2.1	Magnesium (mg)	192
Pyridoxine/B_6 (mg)	0.6	Zinc (mg)	1.7
Cobalamin/B_{12} (mcg)	2.4	Iron (mg)	0.9
Pantothenic Acid (mg)	11.6	Copper (ppm)	2.8
Biotin (mcg)	35.0	Iodine (ppm)	6.6
Niacin (mg)	1.3	Lead (ppm)	1.3
Folic Acid (mg)	0.01	Mercury (ppm)	0.02
Choline (mg)	101	Selenium (ppm)	0.06
		Cadmium (ppm)	0.11
		Arsenic (ppm)	0.65

a Values per 100 grams dry whey

Table 5. Estimated U.S. Fluid Whey and Whey Solids Production (by type) and Resulting Quantity of Whey Solids "Further Processed"

	1972	1973	1974	1975	1976	1977	1978	1979[a]
	millions of kgs							
Sweet-type Whey:								
Cheese Production:[b]	1,182.7	1,218.0	1.333.4	1,276.2	1,507.3	1,524.9	1,598.1	1,686.6
Calculated Fluid Whey:[c]	10,644.0	10,970.9	12,000.6	11,485.8	13,565.5	13,724.9	14,382.7	15,179.5
Calculated Whey Solids:[d]	691.9	713.2	779.9	746.8	881.7	892.1	934.8	986.5
Acid-type Whey:								
Cottage Cheese Production:[b]	355.9	346.4	313.3	318.3	322.8	310.5	3.214	301.5
Calculated Fluid Whey:[c]	2,135.6	2,078.4	1,879.6	1,909.5	1,936.8	1,863.2	1,874.1	1,808.7
Calculated Whey Solids:[d]	138.9	134.8	122.1	123.9	125.8	121.2	121.7	117.6
Total Whey Production	12,779.7	13,049.3	13,880.1	13,395.3	15,502.3	15,588.1	16,256.8	16,988.2
Total Equivalent Whey Solids:								
(Sweet-type + Acid-type)	830.8	848.1	902.1	870.8	1,007.4	1,013.3	1,056.5	1,104.1
Whey Solids Manufacture:								
(A) Condensed Whey Solids	31.8[e]	31.8[e]	27.7[e]	39.9	66.3	65.8	65.4	45.4
(B) Dry Whey:								
(1) Human Food	171.2	174.3	205.7	199.3	217.9	2,417	233.8	240.2
(2) Animal Feed	174.8	176.6	181.2	71.3	82.6	70.4	89.0	92.2

Table 5.--Continued

	1972	1973	1974	1975	1976	1977	1978	1979[a]
	millions of kgs							
(C) Modified Whey:								
(1) Partially Delactosed	-	-	-	64.5	58.1	65.4	75.4	62.2
(2) Partially Demineralized	-	-	-	10.0	11.8	12.7	13.6	13.6
(3) Partially Delactosed/ Demineralized	-	-	-	3.6	3.6	3.2	4.1	4.5
(D) Whey Solids in Wet Blends	-	-	-	36.8	33.6	30.9	43.6	46.8
(E) Whey Solids Utilized for Lactose[f]	64.0	83.5	95.3	100.8	77.2	79.0	83.1	79.5
Total Whey Solids Manufacture: (A) + (B) + (C) + (D) + (E)	441.7	466.3	509.8	526.2	551.2	542.1	607.9	584.3
% of Total Whey Solids Further Processed:								
Total Whey Solids Manufacture x 100 / Total Equivalent Whey Solids								

a Pending revision
b Crop Reporting Board, ESCS, USDA - Da 2-1
c Whey Production: approximately 9 lbs./1 lb. cheese produced (except Cottage)
approximately 6 lbs./1 lb. Cottage cheese produced
d Average total solids content of whey: 6.5%
e Average total solids content of condensed whey: 40%
f Approximately 1.6 lbs. whey solids utilized/1 lb. lactose produced

Whey Utilization

Utilization implies that whole whey either as a concentrate or fractionated is used for man or animals as a nutritious food or as a component of foods. In their study, Jelen and LeMaguer (14), state that the economics of processing is one of the major factors which determines whether whey will be utilized or disposed of as waste. Increasing concern for reducing environmental pollution as well as better utilization of available nutrients has caused an increase in the production of whey solids for use in human foods. A wide variety of products are involved. These include fractionated whey concentrates (partially delactosed and/or demineralized) and bulk whey concentrates (sweet whey powder and acid whey powder). These products are obtained by vacuum-concentrating-drying techniques, and separation and concentration processes such as ultrafiltration (UF), reverse osmosis (RO), electrodialysis, ion exchange, and gel filtration (Fig. 1) (15). Several researchers (2,4,1,15) have summarized the feed and food uses of whey. These applications include cheese and cheese foods, bakery and meat products, confectionary products, infant food formulations, ice cream and other frozen desserts, special dietetic foods, soups and gravies, alcoholic and non-alcoholic beverages, etc. (Fig. 2) (15).

Stewart and Gilliland (16) recently reported a process to utilize whey which involves fermentation of whey by Kluveromyces fragilis to reduce the lactose level and to produce a high quality yeast-whey protein material that is used in the improvement of the nutritional value of snack foods and in the manufacture of bakery products.

Process	Product
Heat Coagulation	Denatured whey protein
	Lactose
Electrodialysis	Low ash whey protein
	Lactose
Ultrafiltration (UF)	High protein whey
	High lactose permeate
Gel Filtration	Concentrates up to 80% protein
	Lactose

Figure 1. Fractionation of Whey by Various Processes and the Resultant Products

Beverages:	Fruit juices
	Deproteinized, fermented ("Rivella")
	Cola drinks (pH 4)
	Vegetable juices (tomato)
	Soups (Cream of tomato)
Dairy Products:	Ice cream, sherbet and "Posicles"
	Process cheese and cheese spreads
	Cream sauces
	Modified milk
Bakery Products:	Cakes, cookies, crackers
	Sour dough and rye bread
	Prepared mixes
	Breading mixes for fried foods
	Pie crusts and fillings
Meat Products:	Meat loaves and spreads
	Sausages and frankfurters
Confections:	Fudge, caramel, fondants

Figure 2. Some Uses for Whey in Foods

The end uses of whey depend mainly on the unique properties of its basic components: Lactose, proteins and mineral salts. Lactose, which constitutes the major component of whey solids, is about one-fifth as sweet as sucrose and is slowly digested and absorbed from the intestine. Although in some cases, lactose in the diet may be objectionable (e.g., lactose intolerance) (17,18), in general, it is desirable. It may stimulate the growth of microorganisms which produce organic acids in the large intestine. These acids tend to inhibit the growth of undesirable bacteria and favor the increased absorption of calcium, phosphorus and magnesium. Uses of lactose are increasing (19), but more uses need to be developed because excessive whey processing costs are mainly the result of its high lactose content. High concentrations of lactose also represent a technological problem in whey drying due to its amorphous crystallization forms with high hygroscopicity that can cause caking during storage. This can be avoided by preconcentrating and crystallizing lactose prior to spray-drying. During whey processing, the Maillard reaction is likely to occur due to the combined effect of high lactose content and the free amino group of compounds such as lysine which results in a reduction of lysine availability (Table 6) (15). This reaction becomes an important parameter in whey products quality.

Whey Beverages

Holsinger, Posati and DeVilbiss (10), in their study, reviewed various aspects of whey-beverage manufacture covering most of the older

Table 6. Total and Available Lysine in High Protein Whey Powders Made by Different Processes

	Protein (%)	Total Lysine Chromatographic (g/100 g protein)	Total Available Lysine (%)
Native Whey Protein	100.0	11.4	100.0
Gel Filtration and Spray Dried	87.84	11.34	85.7
Ultrafiltration Gel Filtration and Spray Dried	80.04	10.54	93.3
Gel Filtration and Spray Dried	78.67	10.91	80.4
Roller Dried Whey	12.70	5.98	77.8
Spray Dried Whey	12.46	10.44	86.4

and more recent research. Many attempts have been made to produce beverages from whey in several countries such as Switzerland, Denmark, Germany, Brazil, Russia, etc. There are many reports in the literature concerning the use of whey in the production of beverages. Much of this research work has been directed to the use of whey powders or concentrates intended to produce a drink mix for a beverage base of increased nutritional value (20,21,22,23). Research work on the use of whey in beverage manufacture has been very prominent in Europe. Few of the many attempts to produce a satisfactory whey beverage have been as extensive or successful as the work in the 1950's in Switzerland where "Rivella" was developed. This whey beverage is one of the best-known and is a common soft drink in Switzerland (24). The process involves fermentation of deproteinized whey by lactic acid bacteria, concentration and addition of Swiss alpine herbs. The concentrate is then diluted, carbonated, bottled and pasteurized. Two types of beverages are produced: the red label Rivella (93 kcal/240 ml) and the blue lable (14 kcal/240 ml) especially formulated for diabetics.

"Whevit," a nutritious soft drink, has been developed in India by Bambha, Setty and Nambudripad (13). Other whey beverages that have been reported include whey "Champagne" and "Kwas" both developed in Poland, "Bodrost," a sparkling whey beverage has been developed in Russia; Zincica, is a special type of whey beverage produced as a by-product of ewes' milk cheese manufacture (Table 7) (25). Carbonated, flavored whey beverages are commercially available in some countries,

Table 7. Commercially Produced, Carbonated Beverages from Whey

Brand	Year Mar-keted	Country of Origin	Type
Rivella	1952	Switzerland	Nonalcoholic, herbs
Whey Champagne	1966	Poland	Alcoholic, wine-like
Whey Kwas	1966	Poland	Alcoholic, kefir-like
Bodrost	1969	Russia	Alcoholic, beer-like
Tai	1971	Brazil	Nonalcoholic, citrus

but their clear, sparkling appearance indicates that the whey has been processed and fractionated to remove proteins and lactose. Thus, the minerals and water-soluble vitamins remain as the major nutritional content of these whey products. Recent research, particularly in the United States, is directed toward utilizing whole whey in the form of nutritious beverages. Although using fluid whey may represent technological difficulties (26), several such formulations have been developed for which high consumer acceptability is claimed (Table 8) (25).

Fruit Flavored Beverages. Much of the research work in the United States has been directed to the production of fruit-flavored beverages. Acidity of whey makes it compatible with fruit juices. Demott (27) reported a simple process for producing a citrus flavored whey beverage. The process involves an optional vacuum treatment after draining whey from the cheese vat at about 54°C. The whey is cooled and the acidity increased by adding citric acid. Sweeteners and orange juice concentrate are added, and the product is cooled and packaged. Other beverage preparations involve the use of a whey concentrate or an acid whey powder (AWP) (20,28,29), which represents a more costly form of whey utilization. Nelson and Brown (30,31) reported the use of whey as a component of fruit flavored drinks.

Vajdi and Pereira (8) studied the possibility of using whey as a milk substitute in the production of several beverages. They developed strawberry-, lemon- and chocolate-flavored formulations. The whey

Table 8. Recent Research on the Production of Nutritious Whey Beverages

Beverage Use	Formulation			Protein (%)
Snack Beverage	Acid whey powder or Fluid acid or sweet whey	+	Fruit juice or Fruit juice con- centrate (orange)	0.5-1.0
Imitation Milk	Fluid acid or sweet whey	+	Vegetable hydro- colloids + Vegetable oils	1.0-1.5
Liquid Breakfast	Fluid acid or sweet whey	+	Soybean powder + citrus flavoring	2.5-3.5

content varied from 85 to 90% and the drinks were found to have good flavor, long shelf-life and were produced at a low cost.

Other Whey Uses. Other uses for whey have been reported such as a tomato-flavored beverage and an onion-flavored chip dip (32). Another food application for whey is in the production of imitation milks and breakfast meals. Brunner, Finley and Blakely (33) have developed an imitation milk (Way-Mil) formulated basically from either acid or sweet whey, vegetable oil, and stabilizer. Way-Mil contains from 2-4% fat, 1-1.5% protein, 4-5% lactose, about 0.7% ash and the water-soluble vitamins present in milk. Fat soluble vitamins, vitamin C and iron can be also added. Brunner et al. have also formulated a breakfast meal (O-Way) based on acid or sweet whey and orange juice. Holsinger et al. (10), in their review, covered whey uses in beverages from cheeses made from bacterial cultures. On the other hand, Chen, Bassette and Marshall (34), in their study, considered the possibility of using direct-acid-set (DAS) whey in the production of a milk-like beverage. Neutralized DAS cottage cheese whey has better flavor characteristics than some cultured wheys, which should make it adaptable for food uses. Chen et al. state that, "since the DAS method for making cottage cheese is increasing substantially in the United States, the need to find uses for DAS whey is important."

Peanuts

Basic Properties and Production

The peanut (*Arachis hypogeae L.*) is an annual herbaceious plant belonging to the suborder *Papilonacea* of the suborder *Leguminoseae*. The annual world production of peanuts is approximately 19 billion kilograms, and contributes over 3.5 billion kilograms to the world's protein pool for food and feed uses. Peanut is considered as the fourth most important source of edible vegetable oil and the third most important source of vegetable protein feed material.

Food Uses and Composition

In his review on the uses of peanuts, Lusas (35) states that peanuts have very important advantages over other major oilseeds such as the ease of preparation in many food forms with simple roasting and grinding processes. Also, peanut products are pleasantly flavored and do not require much refining. This is especially significant due to the present emphasis on conservation of energy and minimization of food processing costs. The United States peanut production in 1973 represented 10% of the total 18 billion kilograms world production (36). Peanut food uses include roasted and other nut products, peanut butter, peanut candies, peanut milks (Miltone), peanut protein concentrates and isolates, partially or completely defatted peanuts and peanut flours. Stability problems in peanut-based foods are due to high fat content (Table 9)(37). The control of mold development constitutes another limiting factor in the production of peanut foods.

Table 9. Average Composition of Peanut Kernel without Skin

Component	(%)	(mg/100 g)
Fat	48.4	
Protein (N x 6.25)	26.3	
Total carbohydrates (by difference)	17.6	
Moisture	5.4	
Minerals	2.3	
Crude Fiber	1.9	
Potassium		674.0
Phosphorus		409.0
Calcium		59.0
Sodium		5.0
Iron		2.0
Niacin		15.80
Thiamine		0.99
Riboflavin		0.13
Vitamin A (I.U.)		0.0

Due to the short supply of animal proteins in many parts of the world, efforts have been made to incorporate new sources of proteins into diets. Peanut proteins, for example, are considered to have good nutritional and functional characteristics. Considerable effort has been directed toward the preparation of milk-like beverages. A review on milk substitutes based on oilseeds and nuts was presented by Swaminathan and Parpia (37).

Peanuts contain about 26 to 29% protein (% N x 5.45). Approximately 10% of the proteins are water-soluble and are considered to be albumins. The remainder are globulins consisting of two major fractions, arachin and conarachin. The amino acid composition of peanut protein has been reported (Table 10)(35).

Peanut-Whey Beverage Bases

Protein-calorie malnutrition is a common and critical nutrition problem in many parts of the world. This is basically due to an imbalanced diet in protein and carbohydrates caused by the short supply of animal proteins and the lack of economical processes to include certain plant proteins into diets. Milner (38) has pointed out the potential contribution of peanuts to the dietary protein requirements in some countries where peanuts are available. United States production shows an increasing trend, and 25 to 35% of the crop is frequently diverted from traditional markets (39). A new use for peanuts was proposed by Holsinger et al. (23). Based on previous specifications for whey-soy drink bases, a beverage base from cheese whey and peanut flour was

Table 10. Amino Acid Composition of Peanut Protein, Concentrate and Isolate

Amino Acid	Peanut	Peanut Protein Concentrates	Peanut Protein Isolates
	g amino acid/16g nitrogen		
Glutamic	19.9	20.7	21.4
Aspartic	14.1	12.5	12.3
Arginine	11.3	12.6	12.8
Leucine	6.7	6.7	6.6
Glycine	5.6	4.2	4.1
Phenylanine	5.2	5.6	5.6
Serine	4.9	5.2	5.1
Valine	4.5	4.5	4.4
Proline	4.4	4.6	4.8
Alanine	4.2	4.0	3.9
Isoleucine	4.1	4.3	3.6
Tyrosine	4.1	4.4	4.3
Lysine	3.0	3.0	3.0
Threonine	2.5	2.5	2.5
Histidine	2.3	2.4	2.4
Cysteine	1.3	1.4	1.4
Tryptophan	1.0	1.1	1.0
Methionine	0.9	1.0	1.0

developed with the following formulation: 50% sweet whey solids, 24.6% defatted peanut flour, 20% soybean oil, and 5.4% corn syrup solids. Although the whey-peanut blend had a more acceptable flavor than whey-soy drink mix has, it did not show the storage stability of the whey-soy product.

Soybeans

Basic Properties and Production

Soybean (Glycine max) is also an animal herbaceous plant belonging to the suborder Leguminoseae. The annual world production has also been increasing. In 1974, the total production was about 52 billion kilograms (40). The United States soybean production represents about 60% of the world total. The potential role of soybeans as a highly economical source of nutrients has been discussed by Williams (41). According to his study, "soybeans produce far more protein per hectare than the common field crops." He also considers that, if soybeans are efficiently processed, the cost advantage of soybean protein should make soybean foods an inexpensive source of high quality protein. The cost and nutritional quality of soy flour and peanut flour was compared. Peanut flour protein was found to be inferior due to its deficiency of essential amino acids such as methionine. Williams explains that this is the reason many developing countries are more interested in soybeans to improve their diets. Much research work has been done on finding uses for soybeans. Extensive studies have been made on the preparation of soy milks and soy drink bases for beverages in an effort to improve the food crisis situation in many parts of the world.

Soy Beverages

Soybean protein offers an economical source for increasing the protein content of whey. Soy-whey mixes also provide an adequate combination according to their amino acid patterns (Table 11).

Soy-Whey Beverages. Several soy-whey "milks" have been developed. At the University of Illinois' Department of Food Science, a soy-cottage cheese whey beverage was developed (42). The beverage was reported to have a pleasant taste resembling egg nog. The characteristic strong flavor of soybean was destroyed by boiling the whole beans before they were broken. Also at the same university, a process for preparation of soy milk was developed (Illinois Process) by Nelson, Steinberg and Web (43). The process involves soaking the soybeans overnight in 0.5% $NaHCO_3$ solution followed by a blanching treatment in the same solution. It was found that such a mild alkali treatment helped to reduce the typical beany off-odor and flavor. Tsugo (44) developed a product resembling condensed milk by mixing soy "milk" with whey. The product did not have the same chemical composition as condensed milk, but it could be used for the same food purposes. Holsinger et al. (22) investigated the possibility of using cottage cheese whey in the preparation of whey-soy drink mix (WSDM), which is a nutritious beverage powder designed to be used as a dietary supplement for preschool

Table 11. Essential Amino Acid Contents of Whey[a] and Soybeans[b]

Amino Acid	Whey	Soybeans
	g/100 g protein	
Leucine	10.5	7.8
Lysine	10.3	6.4
Isoleucine	5.4	4.5
Valine	5.2	4.8
Threonine	4.9	3.9
Phenylalanine	3.7	4.9
Tryptophan	2.4	1.3
Methionine	1.8	1.3

[a]From Table 2.
[b]From (37).

children in developing countries. The ingredients in WSDM are as follows: 41% sweet whey solids, 36.9% full fat soy flour, 12.3% soybean oil, and 9.1% corn syrup solids. The study showed that formulation of WSDM with acid whey did not meet commodity specifications. This is due to the high acidity of cottage cheese whey which produces off-flavors and decreases consumer acceptability.

Soy-Whey Citrus Flavored Beverages. Due to the compatibility of whey with citrus flavors, such combinations have been used to prepare soy beverages. Guy, Vettel and Pallansch (45), developed an acceptable, low cost, citrus flavored beverage by combining soy flour with either sweet or acid whey, adding sugar, stabilizer and flavoring. The ingredients were homogenized, concentrated and shelf dried *in vacuo*. The formulation had a pH of 4.4, 16.5% total solids, and 2.7% protein. A lemon-flavored, soy protein hydrolysate which is suitable for a beverage base has been developed by Sugimoto, Van Buren and Robinson (46). They pointed out that, although soy milk is nutritious, the characteristic beany off-flavor and odor limits its world-wide acceptance. Based on the experience of other researchers, who had suggested that the components causing the off-flavor could be destroyed by treating isolated soy proteins with microbial proteases, Sugimoto et al. developed a hydrolysate by treating commercially isolated soy protein with an acid protease preparation from a higher fungus, *Trametes sanguinea*. They diluted the hydrolysate to 2% protein and the product was reported to have aroma and flavor characteristics similar to lemon juice. The addition of sugar resulted in a beverage resembling lemonade. They pointed out that, "such a beverage illustrates the possibilities of increasing the types of protein-containing drinks available to the public."

Textured Vegetable Proteins (TVP)

Another aspect of soybean utilization includes the manufacturing of textured foods. One of the technologies involved in this process is acid spinning, which produces protein fibers resembling meat fibers. Acid spinning involves injecting an alkaline soy protein solution through a perforated plate into an acid bath. The protein coagulates forming fibers as it reaches its isoelectric point, and the fibers are washed and further used in the production of meat analogs. Unfortunately, a high alkaline pH tends to have a detrimental effect on the nutritional value of the proteins since it destroys some amino acids, particularly cysteine and cystine. DeRham et al. (47) studied the effect of the addition of cheese whey protein to soy protein on the nutritional value of fibers made from those materials, and the losses of cysteine and cystine when the proteins were subjected to alkaline treatments. Their results showed that during manufacture of soy protein fibers at 60° C, pH 12.5 for 15 minutes, destruction of cysteine and cystine was approximately 40% of the total amino acid content. For whey protein, similar losses were found, but on absolute values, the losses in whey proteins would be higher due to the higher content of cysteine/cystine.

CHAPTER 3

MATERIALS AND METHODS

Starting Materials

Acid Whey

Fresh, acid whey containing the normal amount of fine cottage cheese curd particles was obtained from Shamrock Foods, Phoenix, Arizona. No treatment was given to the cottage cheese whey prior to its use in beverage formulation and processing.

Soybeans

Whole soybeans including hulls, variety were used.

Peanuts

Whole peanuts, including skins of the Spanish Red Skin No. 1 variety were selected for use.

Composition

The composition of the starting materials was determined as follows:

Acid Whey

Total Solids (TS). Total solids were determined in a Mojonnier Milk Tester in which a two-gram sample was weighed into a tared aluminum dish and spread in a thin film over the bottom of the dish. The dish was placed on the Mojonnier's exterior hot plate at 180°C and heated until the first traces of brown color began to appear in the residue. The dish was transferred to the vacuum oven (100°C for 10 minutes) under not less than 508 mm of vacuum, cooled in the desiccator for 5 minutes with the water circulating pump operating continuously and then the residue was weighed rapidly for % TS calculation. Determinations were made in triplicate.

Acidity. Acidity was determined by the AOAC method and expressed as % lactic acid.

Lactose. The Teles et al. method (48) was used for lactose determination. A 2-ml whey sample was transferred to a 100-ml volumetric flask and diluted to volume with distilled water. To a 2.5 ml-aliquot of the diluted whey sample in a centrifuge tube, 0.2 ml 5% zinc sulfate and 0.2 ml 4.5% barium hydroxide were added, and the samples were centrifuged one minute at 1000 rpm. One ml of the clear supernatant was transferred to a Folin blood sugar tube and 2.5 ml of Teles' reagent were added. The tubes were tightly stoppered and were immersed in a boiling water bath for 6 minutes. After cooling with tap water, the samples were diluted to 12.5 ml with distilled water and mixed. Absorbance at 520 nm was read against a similarly treated reagent blank in a Bausch and Lomb Spectronic 20 spectrophotometer. Lactose percentage was calculated using a standard curve.

Fat. Fat was measured by the Mojonnier method in which a ten-gram sample was weighed into a Mojonnier flask followed by mixing thoroughly with 1.5 ml ammonia, 10 ml ethanol, 25 ml ethyl ether, and 25 ml petroleum ether. The samples were centrifuged in the Mojonnier tester for 30 seconds and the clear supernatant was decanted into a tared aluminum dish. After evaporating the ether at 160°C, the dishes were heated in the vacuum oven (135°C/5 min at 508 mm vacuum) and then cooled in the desiccator for 7 minutes. Fat percentage was calculated by weight of extracted material.

Protein. The AOAC Kjeldahl method (49) was used for protein determination.

pH. A Fisher Accumet Model 220 instrument with combination electrode was used for pH measurement.

Peanuts and Soybeans

Proximate analyses of peanuts and soybeans were carried out according to the AOAC methods (49) for determination of moisture, ether extract, protein and ash.

Processing Techniques to Develop Whey-Peanut and Whey-Soybean Beverages

The combination of whey and legumes was calculated on the basis that the resultant fat content of the product would resemble that of bovine milk after processing (Figure 3). The ingredient proportions used were 8.7% peanuts for the whey-peanut blend, and 6.8% soybeans for the whey-soybean mixture. The legume, after being cleaned by

1.	Soybeans or peanuts	Dry, whole soybeans or whole peanuts
2.	Cleaning	Eliminate extraneous materials by hand
3.	Weighing	For 8.7% peanut and 6.8% soybean content
4.	Mixing, Blending	Mix whey and legume and blend in Waring blender. (1:2.5::soybeans: whey 1:1.5::peanuts:whey)
5.	pH Adjustment	Add 6N HCl to pH 3.5
6.	Soaking	Soak overnight at 20°C
7.	pH Adjustment	Add 6N NaOH to pH 6.8
8.	Blanching	Heat blend to 100°C for 15 minutes
9.	Homogenizing	In double stage Manton Gaulin machine Model E-200. (245/35 kg/ cm^2 at 95°C)
10.	Cooling	Cool and store at 4°C.

Figure 3. Process Number One for Whey-Peanut and Whey-Soybean Beverages.

inspecting and manually removing extraneous materials, was mixed with whey in a commercial Waring blender in the proportions shown. These were experimentally determined in order to obtain a thick, smooth slurry after blending at high speed for 10 minutes or until texture was developed. The pH was lowered to 3.5 by adding 6N HCl to inactivate lipoxygenase and prevent off-flavors. After soaking overnight, the pH was raised to 6.8 and the mix was blanched, homogenized, and cooled to 4°C. The characteristics of both peanut and soybean mixes were not satisfactory. The flavor was salty due to the sequential addition of acid and alkali for pH adjustments, which added to the mineral salt content of the ingredients. For an eight-kilogram batch of the whey-soybean slurry, the initial pH was 5.35, and 117 ml of 6N HCl were added to lower the pH to 3.5. To raise the pH to 6.8, 163 ml 6N NaOH were required. The eight-kilogram batch of whey-peanut slurry with an initial pH of 5.15, required 105 ml 6N HCl and 125 ml 6N NaOH. Although the flavor was unpleasant, particularly in the case of the soybean mix, the appearance and mouth feel were good. A second processing treatment was established (Figure 4). The proportions of legume-whey were kept the same, but the pH adjustment to 3.5 was omitted. A soaking operation was included after cleaning based on the Illinois process for preparation of soy milk (43), to prevent off-flavor. A drying, grinding and roasting operations were carried out before slurry preparation. To improve the stability of the product, 0.15% stabilizer was added after blanching the whey-peanut slurry (no stabilizer was added to the soybean blend). Also, to improve the flavor, 6% sugar

1.	Soybeans or Peanuts	Dry, whole soybeans or whole peanuts
2.	Cleaning	Eliminate extraneous materials by hand
3.	Soaking	Soak in 0.5% $NaHCO_3$ overnight (1:3::legume:solution)
4.	Rinsing, Draining	Tap water
5.	Drying	Dry at 90°C for 8 hours atmospheric oven
6.	Grinding	10 minutes at high speed in a commercial Waring blender (model 31 BL 79, CB-6)
7.	Roasting	10 minutes at 110°C
8.	Weighing	For 8.7% peanut and 6.8% soybean contents
9.	Blend	Add whey and blend for slurry preparation (1:2.5::soybean:whey) (1:1.5::peanuts:whey)
10.	Addition of Remainder Whey	
11.	pH Adjustment	Add 6N KOH pH 6.8
12.	Blanching	Heat material at 100°C/15 minutes
13.	Formulation	Add sugar, cocoa and stabilizer
14.	Weighing	Add water lost by evaporation during blanching
15.	Homogenizing	In a double stage Manton Gaulin machine (Model E-200)(245/35 kg/cm^2 at 95°C)
16.	Cooling	Cool and store at 4°C

Figure 4. Process Number Two for Plain and Chocolate-Flavored Whey-Peanut and Whey-Soybean Beverages

and 3% cocoa were added to both mixes. Four, eight-kilogram batches were made following this process (Table 12). The sensory characteristics of the whey-peanut beverages (plain and chocolate-flavored) were better than the whey-soybean beverages and were significantly improved as compared to the previous whey-soybean formulation developed through the first process. These observations led to a decision to work with a whey-peanut based beverage only. A final process was adopted (Process 3) for eight formulations (Table 13) as shown in Figure 5. The roasting operation was carried out by spreading the ground peanuts in aluminum trays (38.1 x 25.4 x 2.54 cm) in a thin layer to cover the surface of the trays which were placed in a preheated electric oven for 15 minutes (thermostat set at 160 C). During this period, the temperature fluctuations were monitored with a digital thermometer (Fluke 8024A Multimeter) (Figure 6).

Beverage formulations were based on a 2^3 factorial design with three ingredients each at two concentrations with the following sample identities:

	Sugar/Stabilizer (%)			
Cocoa (%)	5/0	5/0.1	7/0	7/0.1
1	A	B	C	D
3	E	F	G	H

Table 12. Composition of Beverages Obtained through Process 2

Formulation	Composition	(%)
Whey-Soybean (unflavored)	Cottage cheese whey	93.2
	Soybeans	6.8
Whey-Soybean (flavored)	Cottage cheese whey	84.2
	Soybeans	6.8
	Sucrose	6.0
	Cocoa	3.0
Whey-Peanut (unflavored)	Cottage cheese whey	91.15
	Peanuts	8.70
	Stabilizer	0.15
Whey-Peanut (flavored)	Cottage cheese whey	82.15
	Peanuts	8.70
	Sugar	6.00
	Cocoa	3.00
	Stabilizer	0.15

Table 13. Whey-Peanut Based Final Formulations

Sample	Whey	Peanuts	Sugar	Cocoa	Stabilizer	Emulsifier	TS
	%						
A	85.95	8.0	5.0	1.0	0.0	0.05	19.85
B	85.85	8.0	5.0	1.0	0.1	0.05	19.34
C	83.95	8.0	7.0	1.0	0.0	0.05	21.12
D	83.85	8.0	7.0	1.0	0.1	0.05	21.21
E	83.95	8.0	5.0	3.0	0.0	0.05	21.07
F	83.85	8.0	5.0	3.0	0.1	0.05	21.16
G	81.95	8.0	7.0	3.0	0.0	0.05	22.77
H	81.85	8.0	7.0	3.0	0.1	0.05	22.82

1.	Peanuts	Whole peanuts including skins (Spanish Red Skin No. 1 variety) were used.
2.	Cleaning	Extraneous materials removed by hand
3.	Soaking	16 hrs/4°C in 0.5% $NaHCO_3$ (1:3:: peanuts:solution)
4.	Draining, Rinsing	Tap water
5.	Drying	7-8 hours at 90°C (atmospheric oven)
6.	Grinding	10 minutes at high speed in a commercial Waring blender (model 31 BL 79, CB-6)
7.	Roasting	15 minutes at 160°C
8.	Weighing	For an 8% peanut content
9.	Blending	5-10 minutes to prepare slurry (1:1.5::peanuts:whey) with Waring blender
10.	pH Adjustment	6N KOH was added to adjust the pH to 6.8
11.	Blanching	The material was blanched for 15 minutes at 100°C in a double jacketed steam kettle (Model D-30 SP, Groen Mfg. Co.)
12.	Weighing	Final product weight was adjusted by the addition of distilled water to account for that lost by evaporation during blanching
13.	Formulation	Sugar, cocoa, stabilizer, and emulsifier were added and dispersed by mixing
14.	Homogenizing	A double stage Manton Gaulin machine (Model E 200) was used for this treatment (245/35 kg/cm^2 at 95°C)
15.	Addition of Vanilla and Diacetyl	These flavoring ingredients were added at the rates of 13.3 ml vanilla/8 kg and 1.33 ml diacetyl/8 kg
16.	Cooling	The products were cooled immediately to 4°C and stored at this temperature for further studies

Figure 5. Process Number Three for Eight Whey-Peanut Chocolate-Flavored Experimental Beverages

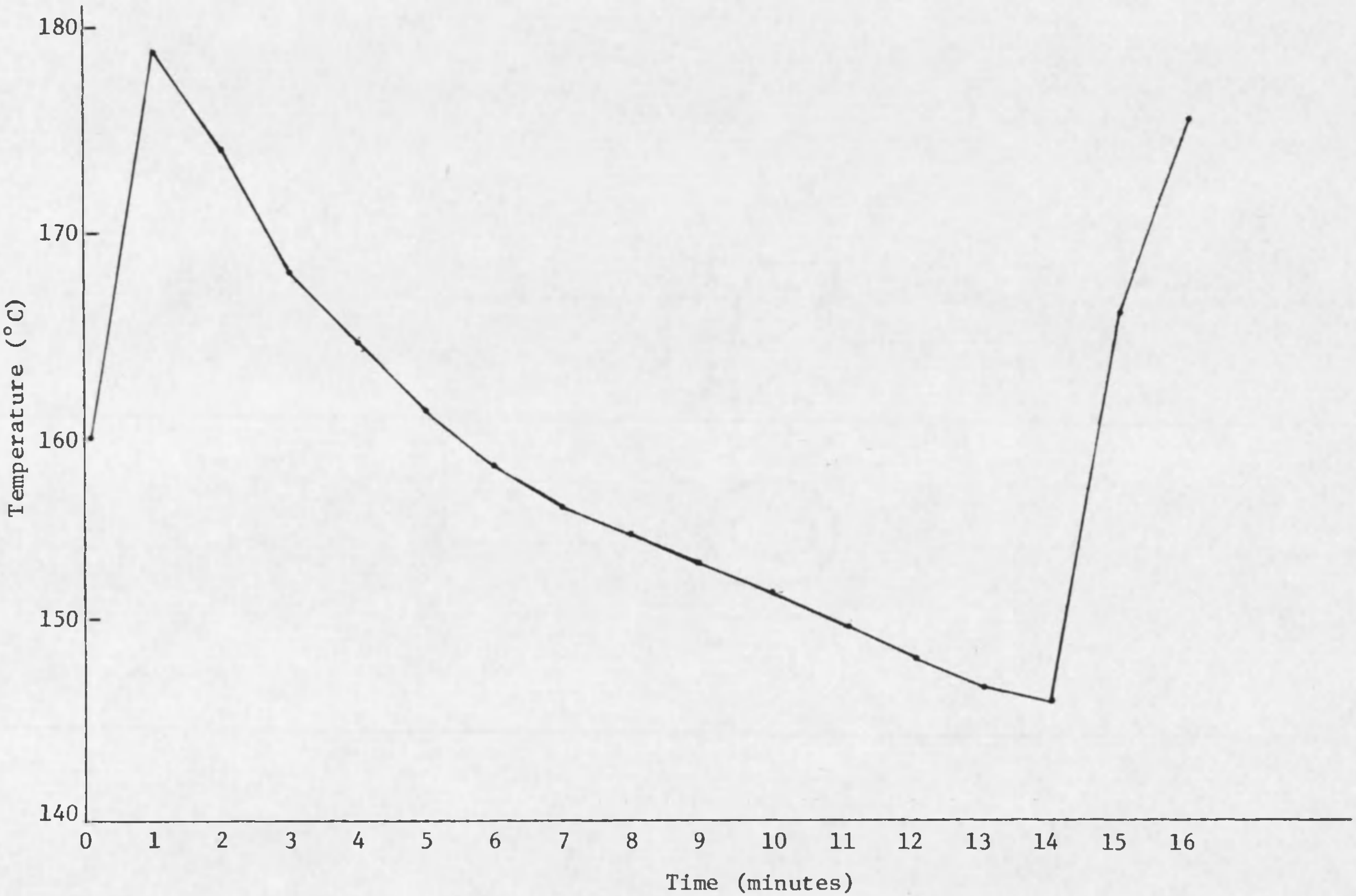

Figure 6. Changes in Temperature during Roasting of Ground Peanuts

Experimental

Analysis of Eight Formulations

Total Solids (TS). Total solids were determined by the Mojonnier method as described for TS in cottage cheese whey.

Fat. Various fat determination methods were used, namely: Mojonnier, Babcock, TESA, and the Chloroform-methanol extraction by Bligh and Dyer (50). The latter proved to be the most effective.

Lactose. Lactose was determined by the Feitosa Teles et al. method (48).

Protein and Ash. These constituents were determined by the AOAC methods (49).

Viscosity. The viscosities of the beverages were determined with a Brookfield Synchro-Lectric Viscosimeter (Model RVT, Brookfield Engineering Laboratories, Inc.).

Peanut Soaking Water Analysis

Total solids, protein and ash contents of the soaking water were determined by the same methods as used for beverage analysis.

CHAPTER 4

RESULTS AND DISCUSSION

The composition of the starting materials was within expected values. Cottage cheese whey total solids content was slightly higher than the reports in the literature indicate. (Table 14). In the peanuts and soybeans the water content was slightly lower than reported values (Table 15). This was probably due to lower relative humidity in the storage environment. The constituent concentration in the preliminary batches was within expected values (Table 16). In process No. 1, the ash content was higher than calculated due to the addition of hydrochloric acid and sodium hydroxide. In process No. 2, the chocolate-flavored beverages had higher total solids contents due to the addition of 6% sucrose, 3% cocoa, and in the case of the whey-peanut beverage, 0.15% stabilizer. Protein, fat and ash values tend to be higher in the chocolate-flavored products due to the contribution of these constituents from cocoa. Sensory properties of the beverages improved from process number one to number two. Stability proved to be a problem in the first whey-peanut product. In the second trial, the addition of 0.15% stabilizer was effective. The whey-peanut beverages, both plain and chocolate flavored, had better flavor and mouth feel, therefore, the decision made to proceed with the processing of peanuts only since the

Table 14. Composition of Cottage Cheese Whey.

Component	Cottage cheese whey (curd particles included) (%)
Water	93.100
Lactose	5.000
Protein	0.740
Ash	0.730
Lactic acid	0.420
Fat	0.037
Total Solids	6.93

Table 15. Composition of Peanuts and Soybeans.

Component (% by weight)	Peanuts Spanish Red Skin No. 1	Peanuts[a]	Soybeans	Soybeans[a]
Fat	48.14	48.40	18.35	17.70
Protein	29.68	26.30	37.75	34.10
Total carbohydrate (by difference)	15.42	17.60	32.94	33.50
Water	4.68	5.40	6.31	10.00
Ash	2.08	2.30	4.65	4.70

[a]USDA 1963. Composition of Foods. ARS Agricultural Handbook No. 8

Table 16. Composition of Beverages Produced through Processes No. 1 and No. 2.

Component (%)	Whey-peanut (unflavored)	Ex-pected	Whey-Peanut (chocolate)	Ex-pected	Whey-Soybean (unflavored)	Ex-pected	Whey-Soybean (chocolate)	Ex-pected
Process No. 1								
Water	85.46	85.76			87.35	87.25		
Lactose	4.60	4.57			3.98	4.75		
Fat	3.84	4.22			1.35	1.28		
Protein	3.33	3.26			3.58	3.21		
Total carbohydrates (by difference)	1.64	1.34			2.15	2.24		
Ash	1.13	0.85			1.59	1.27		
Total solids	14.54	14.24			12.65	12.75		
Process No. 2								
Water	84.20	85.62	76.66	77.21	87.07	87.25	73.89	79.15
Lactose	4.30	4.56	4.00	4.11	4.70	4.66	3.90	4.21
Fat	3.98	4.22	4.30	4.22	1.27	1.28	1.33	1.28

Table 16.--Continued

Component (%)	Whey-peanut (unflavored)	Expected	Whey-Peanut (chocolate)	Expected	Whey-Soybean (unflavored)	Expected	Whey-Soybean (chocolate)	Expected
Protein	3.50	3.26	3.70	3.19	3.46	3.26	3.50	3.19
Total carbohydrate (by difference)	2.88	1.34	0.72	1.34	2.26	2.24	2.30	2.24
Ash	1.14	0.85	1.47	0.78	1.24	1.00	2.02	0.93
Total Solids	15.80	14.38	23.34	22.79	12.93	12.75	26.11	20.85

"beany" off-flavor of the soybean product was difficult to adequately mask.

The composition of the final experimental beverages was also within calculated values (Table 17). Each component concentration was within the range of expected values. Total solids were slightly higher than expected due to approximations in the addition of water to adjust to the calculated solids content. Higher total solids content gave the beverages a viscosity within the range of shake-type beverages (Table 18).

Color, appearance, and stability were acceptable. The color was more desirable in the case of formulations E, F, G and H which contained the higher level of cocoa (3%). Stability of the beverage was fairly good although it varied slightly for each formulation. A sample of each batch was placed in a 100-ml graduated cylinder and stored at 4°C to observe surface liquid separation and rate of settling. Batch H showed the highest instability and some settling. No settling occured in the others, and only an aqueous, yellowish surface layer separated. Samples B, D, F and H were expected to be more stable because of the use of 0.15% stabilizer. Beverages C and D showed the highest stability (Figure 7). Their surface layer values for the 8, 16 and 31-day intervals were always lower as compared to the other formulations. Beverage H showed marked differences in physical and sensory properties. This was probably due to slightly different processing conditions since this batch was processed a day after the others using smaller equipment.

Beverage acceptability was tested based on the Theory of Signal Detection (TSD) by an untrained panel of 15 persons. The use of this

Table 17. Calculated and Determined Beverage Percentage Composition Values

Constituent	Sample: A		B		C		D		E		F		G		H	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
Lactose	4.30	4.20	4.29	4.30	4.20	4.10	4.19	4.10	4.20	4.10	4.19	4.10	4.10	4.10	4.09	4.10
Fat	4.12	4.15	4.12	4.13	4.12	4.14	4.12	4.15	4.59	4.50	4.59	4.60	4.38	4.57	4.38	4.59
Protein	3.18	3.97	3.18	4.21	3.16	4.30	3.16	4.21	3.49	4.58	3.49	4.73	3.48	4.8	3.48	2.98
Total carbohydrates (by difference)	1.76	2.01	1.76	2.43	1.76	2.01	1.76	2.60	2.81	3.37	2.81	3.31	2.81	5.0	2.81	3.51
Ash	0.84	1.15	0.84	1.19	0.83	1.16	0.83	1.15	0.93	1.17	0.93	1.24	0.91	1.25	0.91	1.25
Total Solids	19.25	20.53	19.34	21.41	21.12	22.76	21.21	23.36	21.07	22.77	21.16	23.13	22.73	26.77	22.82	23.58
Sucrose	5.0	---	5.0	---	7.0	---	7.0	---	5.0	---	5.0	---	7.0	---	7.0	---
Coca	1.0	---	1.0	---	1.0	---	1.0	---	3.0	---	3.0	---	3.0	---	3.0	---
Emulsifier	0.05	---	0.05	---	0.05	---	0.05	---	0.05	---	0.05	---	0.05	---	0.05	---
Stabilizer	0.0	---	0.1	---	0.0	---	0.1	---	0.0	---	0.1	---	0.0	---	0.10	---

[a]Calculated

[b]Determined

Table 18. Viscosity of Chocolate-flavored Whey-Peanut Beverages

Beverage	Viscosity (cps)
A	97.5
B	235.0
C	148.5
D	170.0
E	117.5
F	182.5
G	225.0
H	177.5

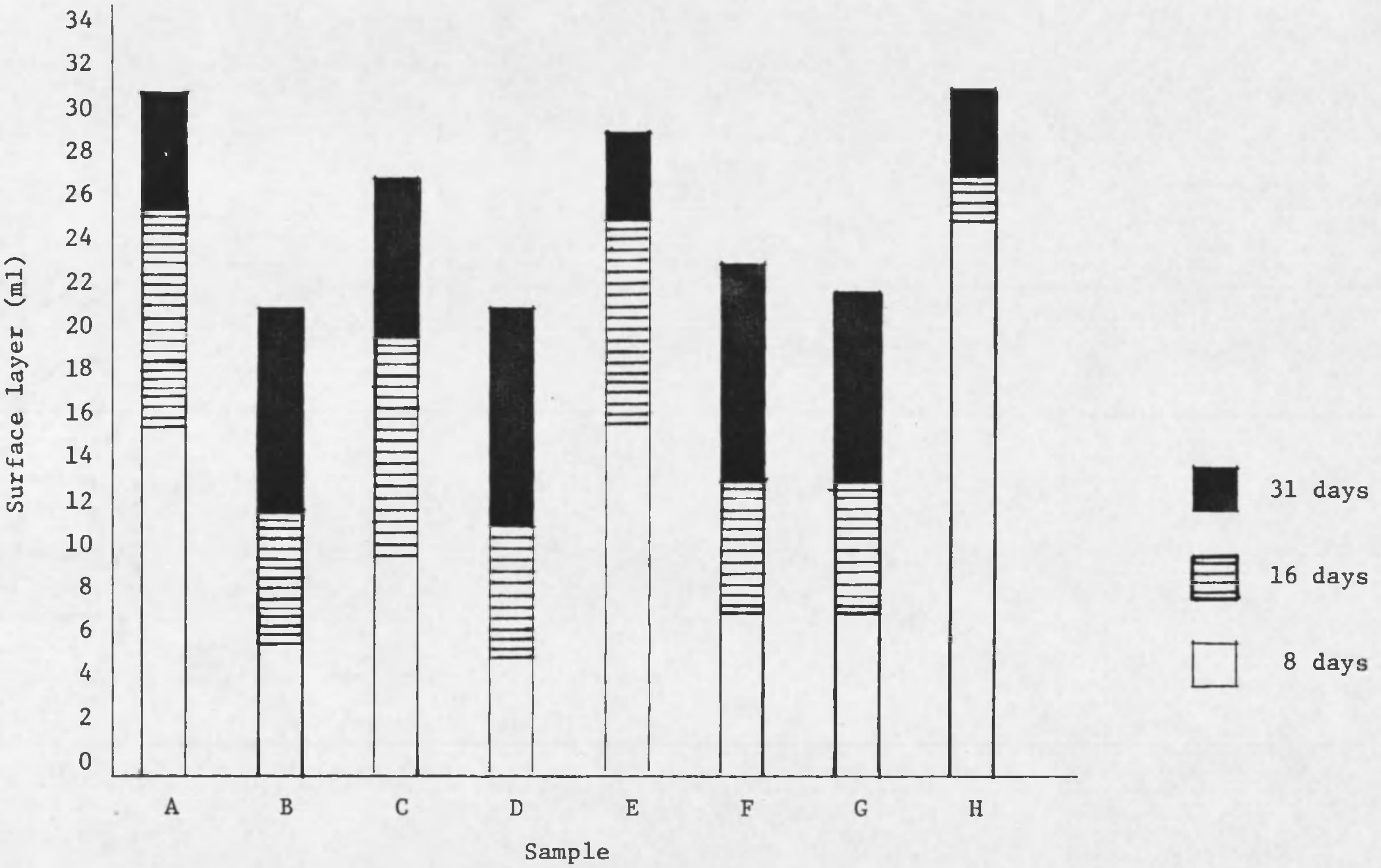

Figure 7. Beverage Stability

method to evaluate the acceptability of fluid cottage cheese whey-based products has been reported (51,52,53). The panel included 8 female and 7 male persons graduate and undergraduate students and university professors. The panelists were instructed regarding tasting and scoring procedures and were seated in individual booths where they received a small amount of each beverage in a random-numbered cup at intervals of about one minute. The test was replicated on three consecutive days. Each day, the panelists tasted three sets of eight samples each and recorded their decisions based on a 0 to 9 hedonic scale. Each number indicated a specific "like" or "do not like" reaction; zero corresponding to "I am absolutely certain that I do not like the beverage," and nine meaning, "I am absolutely certain that I like the beverage."

At the lower cocoa concentration (1%), there is no significant change in preference produced by the higher concentration of sucrose (7% vs 5%) at either stabilizer levels (0 vs 0.1%) (Figure 8). Therefore, there was no acceptability interaction between sucrose and stabilizer. In the case of the higher cocoa concentration (3%), there is a cross-over effect indicating a possible interaction between sucrose and stabilizer. This is a relatively weak interaction since the effect of sucrose at either stabilizer level is practically the same:

	0% Stabilizer	0.1% Stabilizer
	Rating	Rating
7% Sucrose	2.9	2.6
5% Sucrose	2.5	2.3
Difference	0.4	0.3

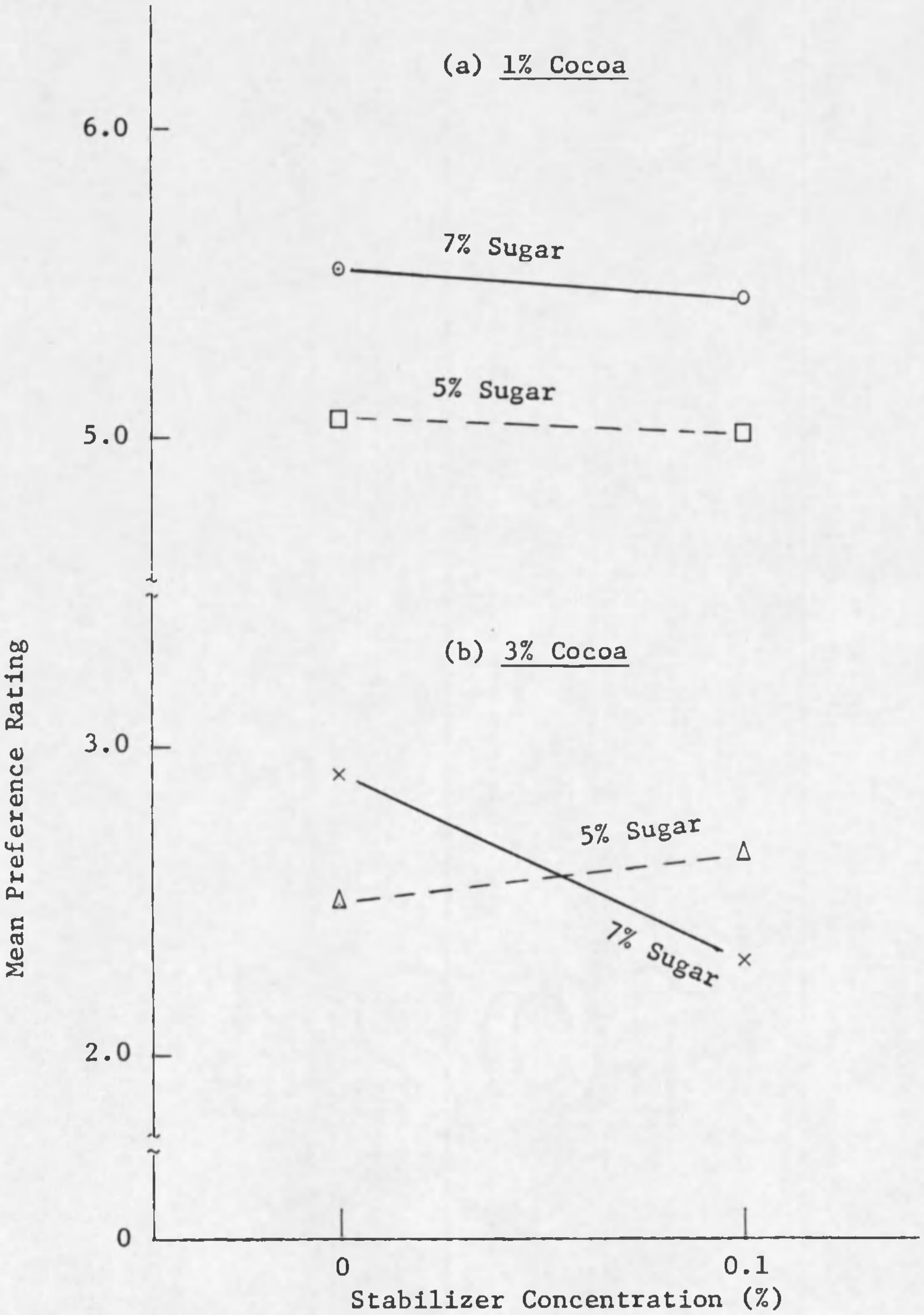

Figure 8. Preference vs Stabilizer: Sugar

Results showed that the lower cocoa level (1%) was definitely preferred to the higher concentration.

The nutritional quality of the beverage protein was calculated on the basis of the essential amino acid pattern of the products as compared to the Food and Agriculture Organization (FAO) recommendations (Table 19). All formulations have a comparatively good amino acid pattern and only methionine is slightly deficient as compared to the FAO pattern.

Analyses showed a relatively low solids loss during soaking with a total solids content of 1.19%, protein 0.22% and ash 0.25%. Other constituents were not determined.

Table 19. Essential Amino Acid Content of Whey-Peanut Chocolate Flavored Beverages as Compared to the FAO Pattern

Amino Acid	A, B	C, D, E, F	G	H	FAO
	g/100g protein				
Leucine	9.51	9.31	9.10	9.09	4.8
Lysine	9.10	8.90	8.69	8.68	4.2
Isoleucine	4.90	4.79	4.68	4.67	4.2
Valine	4.80	4.70	4.59	4.58	4.2
Threonine	4.44	4.34	4.24	4.23	2.8
Phenylalanine	3.58	3.50	3.43	3.42	2.8
Tryptophan	2.15	2.16	2.06	2.05	1.4
Methionine	1.64	1.60	1.57	1.56	2.2

CHAPTER 5

CONCLUSIONS

This study shows a possibility for the use of fluid whey as the main ingredient in the production of a nutritious beverage through a comparatively simple process involving conventional equipment. Processing and ingredient costs will depend upon the availability of peanuts and the handling and transportation costs of cottage cheese whey.

Acceptability tests showed a higher preference for the low cocoa (1% vs 3%) with little or no difference between sugar (5% vs 7%) and stabilizer (0 vs. 0.1%).

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