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A Beverage Base From Cheese Whey and Peanut Flour

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ABSTRACT

Fluid sweet whey, defatted peanut flour, soybean oil, and corn syrup solids were processed with conventional dairy plant equipment to form a free flowing powder reconstitutable with water to form a nutritious beverage. A formulation containing 50% sweet whey solids, 20% soybean oil, 24.6% defatted peanut flour, and 5.4% corn syrup solids had a proximate composition of 20.6% protein, 5% ash, 21.6% fat, 3.5% moisture, 1% fiber, and 48.3% carbohydrate. The standardized protein efficiency ratio was 2.0 compared to casein at 2.5, and nitrogen digestibility was 80% compared to casein at 93%. The flavor quality was bland initially; however, decreased flavor scores coupled with increased peroxide values in the blend during storage were indicative of a serious stability problem.

Key Words: Peanut flour, Whey beverages, Milk replacers, and Cheese whey.

The most critical nutrition problem in much of the world today is protein-calorie malnutrition of young children, pregnant and lactating women. The basic cause is a diet which is likely to be low in protein, provide insufficient energy, and often be marginal in other nutrients.

As part of the U. S. Food-for-Peace program, nonfat dry milk and a milk replacer containing soy products and cheese whey (Holsinger et al., 1977), among other commodities and processed foods, are regularly purchased by the U. S. Department of Agriculture (USDA) for distribution as dietary supplements in child feeding programs abroad by the U. S. Agency for International Development (AID).

Several years ago, Milner (1962) pointed out the potential contributions of peanuts to dietary protein requirements in specific undernourished countries where peanuts are readily available. In the United States today there is concern in the industry about new uses and markets for peanuts. United States production of peanuts for the 1975-1976 growing season was 3.46 billion pounds, a 15% increase over 1974-1975 (USDA, 1976), and 25-35% of the crop must be diverted annually from traditional markets because of overproduction (Woodroof, 1973).

Because of the appearance of commercial sources of food quality defatted peanut flour in the United States, a dietary supplement formulation was developed with sweet cheese whey and peanut flour. Specifications previously drawn up for whey-soy drink were used to devise the new formulation (USDA, Agricultural Stabilization and Conservation Service, 1975).

The purpose of this work was to develop a prototype of a spray-dried whey-peanut powder to serve as a base for beverage type products. The production, properties, and storage stability characteristics determined by flavor and chemical measurements are described.

Materials and Methods

Ingredients

Food grade defatted peanut flour contining 57.0% protein, 0.6% fat, and 7.0% moisture was used for product preparation. The soybean oil used was refined, partially hydrogenated, and winterized. It contained methyl silicone, polysorbate 80, polyglycerides, and the antioxidants, butylated hydroxy toluene and butylated hydroxy anisole. Fluid pasteurized Cheddar cheese whey contianing 6.7% total solids was obtained from the Dairy Foods and Nutrition Laboratory, FR, SEA, USDA, Beltsville, Maryland. The corn syrup solids employed were a 42 D. E. product. The formulation selected for production of a spray-dried prototype contained 50% sweet whey solids, 24.6% defatted peanut flour, 20% soybean oil, and 5.4% corn syrup solids.

Production methods

Fifty kg lots were prepared by wet blending defatted peanut flour, soybean oil, and corn syrup solids into fluid sweet whey that had been preheated to 38-43°C. The wet blend was homogenized in two stages using pressures of 175.8 kg/cm^2 and 38.7 kg/cm^2, pasteurized by a high temperature short time procedure at 77°C for 15 sec and condensed in one pass to 41% total solids in a Harris Wiegand falling film evaporator. Preheat temperature before evaporation was 77°C and pump out temperature 30°C. The concentrate was spray dried by means of a 2.7 meter Grey Jensen dryer equipped with a 0.075 cm nozzle. The inlet temperature was 146°C and outlet temperature 93°C. Powder outlet temperature was 55°C.

Packaging and storage conditions

For storage stability studies, samples of the spray dried beverage powder were packed in No. 211 x 414 cans under nitrogen and stored at -18°C to serve as controls. Additional samples were air packed in No. 211 x 414 cans and stored in constant temperature incubators set at -18, 20, and 37°C.

Organoleptic tests

For organoleptic evaluation, all taste panels were composed of trained dairy products judges selected for sensory acuity (Liming, 1966) who had received additional training in recognition of rancid and reverted soybean oil flavors. Panels averaged 14 judges with a minimum of 11 judges on one panel. Samples were withdrawn from storage at all temperatures after 25, 53, 81, 109, 137, and 165 days. The sample were reconstituted with distilled water to 15% total solids just before being tasted. The reconstituted control sample that had been stored at -18°C was divided into two parts. One part was presented to the judges as a known control, given an arbitrary score of 7, based on a quality scoring scale developed for soy products (Mustakas, 1974). On this scale, 1 equaled strong undersirable flavor, 10 equaled excellent flavor, and 6 equaled minimum acceptable flavor. A hidden control was coded and presented to the judges as one of the coded randomized sample being evaluated. The average score received by the hidden control served as the standard against which the scores received by the other samples were compared. In a limited study with 15-man panels hot flavored samples were rated for preference by using the 9-point hedonic scale of Peryam and Pilgrim (1957). After completion of each panel, statistical

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evaluations for significance were carried out by analysis of variance and Duncan's Multiple Range Test (Larmond, 1970).

Analytical and physical tests

Procedures used for the determination of total nitrogen, fat, moisture, ash, and crude fiber in the whey-peanut blend were those recommended by the AOAC (1970). Carbohydrate was determined by difference, and calorie content by calculation with the classical Atwater energy conversion factors of 4 kcal/g of food protein and carbohydrate and 9 kcal/g of food lipid (Anon., 1974).

Dispersibility of the dry samples was measured by a modification of the method of Sinnamon et al. (1957), sinkability by the procedure of Bullock and Winder (1960), solubility index by a method developed by the American Dry Milk Institute (1947), and bulk density by a procedure recommended by the USDA Agricultural Marketing Service (1970).

Amino acid analysis of the whey-peanut blend was carried out by a commercial laboratory.

Peroxide values were measured on all stored samples by the colorimetric procedure of Hills and Thiele as described by Stine et al. (1954) after the fat for analysis had been extracted from the powders. For fat extraction, lg dry sample was blended with 2 g Celite 545 and placed in a glass column, 30 cm x 1 cm I. D., equipped with a coarse sintered glass disc. The peroxide-containing fat was then eluted from the column into a 25 ml volumetric flask by use of a benzene-methanol mixture (70:30), and appropriate dilutions were made for analysis.

Animal feeding studies

Animal feeding studies were carried out at the Western Regional Research Center (WRRC), FR, SEA, USDA. The assay for protein efficiency ratio (PER) was conducted according to the AOAC (1970) procedure except that only 5 rats were used. The sample was compared to ANRC reference casein. Digestibility of the diet in percent was measured by

$$\frac{\text{feed intake - fecal weight}}{\text{feed intake}} \times 100$$

and percent nitrogen digestibility by

$$\frac{\text{nitrogen intake - fecal nitrogen}}{\text{nitrogen intake}} \times 100$$

Because only 5 rats were used in the initial study, the PER assay was repeated by researchers at the Protein Nutrition Laboratory, Beltsville, MD; 10 rats were used in the second study.

Results and Discussion

A primary requirement in the development of the new beverage powder was to use as much whey as possible in the product. The bulk of the protein was to be contributed by the peanut flour. Rao et al. (1969) pointed out that it is wasteful to provide protein concontrates as dietary supplements for young children without assuring adequate energy intake. Therefore, in order to increase the caloric density without increasing the osmotic activity of the water in the reconstituted beverage, soybean oil and 42 D. E. corn syrup solids were added to the formulation.

The proximate composition of the prototype powder is shown in Table 1. The data show that the powder is a high protein, high fat, high calorie product which simulates milk in many ways. The carbohydrate content was supplied mainly by the whey solids.

The whey-peanut blend was reconstituted easily with water for beverage use. Physical properties related to reconstitutability, shown in Table 2, resembled those of spray dried nonfat dry milk. The solubility index was somewhat high, indicating that the powder, when reconstituted, tends to settle in water, but this should not cause any usage problems. Sinkability was also increased over that of nonfat dry milk, but good sinkability is considered to be a desirable property in readily reconstitutable powders (Bullock and Winder, 1960).

Table 1. Proximate composition of the whey-peanut blend (WPB) compared to nonfat dry milk (NDM)

Component	Percent	
	WPB	NDM[1]
Protein (total N x 6.25)	20.6	--
Protein (total N x 6.38)	--	36.2
Fat	21.6	0.8
Ash	5.0	7.9
Moisture	3.5	3.2
Fiber	1.0	0
Carbohydrate (by difference)	48.3	51.9
Calories/100g dry powder	470	362

[1]Posati and Orr, 1976.

Table 2. Physical properties of whey-peanut blend (WPB) compared to nonfat dry milk (NDM)

	WPB	NDM
Dispersibility	90.8%	97.6%
Sinkability	86.0%	48.3%
Bulk density	0.64g/cc	0.64g/cc
Solubility index	2.8 ml	0.15 ml

Proteins from various sources may lack adequate amounts of one or more of the essential amino acids. Peanut protein is deficient in lysine, methionine, tryptophan, and threonine (Milner, 1962). Whey protein, comprising about 12% of the whey solids, is a very high quality animal protein with an amino acid pattern comparable to that of egg (Posati and Orr, 1976). By blending peanut flour with whey, the amino acid content of the protein in the whey may have a synergistic effect on the amino acid profile of the protein in the peanut flour, thereby improving the overall protein quality. Table 3 lists the essential amino acid content of the peanut flour (as reported by Ayres et al., 1974), sweet whey solids (as reported by Posati and Orr, 1976), and of the new whey-peanut blend. The FAO reference protein pattern is also shown. The addition of whey protein to the peanut flour protein effected an increase of all but one of the essential amino acids in the whey-peanut blend over amounts present in the peanut flour alone. However, when compared to the FAO reference pattern (FAO, 1957, the whey peanut blend is still deficient in tryptophan and the sulfur containing amino acids. The histidine content is shown because it is required for the infant and its dispensability for adults has been questioned (Williams et al., 1974).

Table 3. Essential amino acids of peanut flour and whey-peanut blend.

Amino Acid	FAO reference[1]	Sweet whey[2]	Peanut flour[3]	Whey-peanut blend
	g amino acid/100g protein			
Lys	4.2	8.7	2.9	4.8
His	---	1.6	1.8	2.0
Thr	2.8	6.1	2.6	3.8
Cys + Met	4.2	3.5	1.9	3.1
Val	4.2	5.6	3.8	4.4
Ileu	4.2	6.0	3.2	4.2
Leu	4.8	9.8	6.4	7.4
Tyr + Phe	5.6	5.3	8.4	8.2
Trp	1.4	2.0	0.9	1.1

[1]FAO, 1957.

[2]Posati and Orr, 1976.

[3]Ayres et al., 1974.

Animal feeding studies with rats provided additional evidence that blending of whey with peanut flour improved the overall quality of the protein. The results are shown in Table 4. Ayres et al., (1974) reported the PER of the peanut flour to be 1.6. The PER of the whey-peanut blend (2.0) is comparable to the PER previously reported for whey-soy drink (2.1) (Holsinger et al., 1977) and exceeds the PER requirements (1.8) established by USDA-AID in the specifications for whey-soy drink (USDA-ASCS, 1975).

Table 4. Nutritive value of whey-peanut blend (animal feeding studies).

		Whey-peanut blend	
	Casein	5 rats WRRC assay	10 rats Beltsville assay
Standardized protein efficiency ratio	2.5	2.0	2.0
Nitrogen digestibility	93%	80%	---

Calculations based on the protein and essential amino acid requirements for very young children (Holt and Snyderman, 1965) show that the sulfur containing amino acids are the first limiting amino acids in the whey-peanut blend. For older children requiring 36g of protein per day (Williams et al., 1974), lysine is the first limiting amino acid in the blend. As the sole source of food, 1.2 liters of reconstituted blend per day would provide for the protein and essential amino acid needs of a child. However, this amount of whey-peanut blend would supply only 29% of the daily energy requirement of about 80 kcl/kg body weight (Anon., 1974). For these reasons, whey-peanut blend is suitable for use as a dietary supplement but should not be used as the sole food source except in an emergency feeding situation.

In order to be acceptable for feeding programs abroad, the blend had to show good storage stability characteristics. The average taste panel scores of the reconstituted whey-peanut blend stored at three different temperatures over a 165-day period are shown in Table 5. The results show a significant deterioration in flavor of the sample stored at 37 C after only 25 days of storage compared to the score given the hidden control. After 165 days of storage, flavor deterioration at 37 C had not changed over that observed after 81 days of storage. According to the scoring system used, the blend had an acceptable flavor only during the first month of storage. However, scores received were no different from scores received by whey-soy drink mix stored under similar conditions for the same length of time (Holsinger et al., 1978). Fluctuations in scores received by the hidden control were probably responsible for the statistically significant lower flavor scores received by the samples stored at 20 C for 81 and 165 days.

Table 5. Average flavor scores of whey-peanut blend stored at 3 temperatures for 165 days.

Sample	Storage time - days						
	Initial	25	53	81	109	137	165
Hidden Control N_2 pack, -18°C	6.56	6.91	6.76	6.92	6.81	6.46	7.13
Air pack stored -18°C	-	6.87	6.80	6.35	6.62	6.46	6.63
Air pack stored 20°C	-	6.83	6.60	6.21[1]	6.18	5.38	6.18[2]
Air pack stored 37°C	-	6.04[2]	5.70[2]	5.21[2]	5.31[2]	4.92[2]	5.22[2]

[1]Significantly different from the hidden control ($P < 0.05$) using Duncan's Multiple Range Test.

[2]Significantly different from the hidden control ($P < 0.01$) using Duncan's Multiple Range Test.

Examination of the score sheets showed that judges detected oxidized off-flavors in the blend after 53 days of storage at 37 C and scored the sample down. Therefore, peroxide values were determined on all samples as another measure of oxidative stability. The results are shown in Table 6. The data show that peroxide formation could be associated with deterioration of flavor quality in those samples stored at 37 C. Peroxide development was more rapid at 37 C in the whey-peanut blend than in whey-soy drink mix (Holsinger et al., 1978), even though the soybean oil used contained added antioxidants. No satisfactory explanation has been found for these results. It was thought that residual lipoxygenases in the peanut flour might be responsible for the more rapid peroxide development in the whey-peanut blend as the peanut flour used was manufactured under milder conditions than those used for the production of defatted soybean flour. However, according to Ayres (1975) the peanut flour processing conditions (Ayres et al., 1974) were sufficient to inactivate any lipoxygenases present. In addition, solvent extracted defatted peanut flours have been reported shelf-stable after 3 months of storage at 40 C (Harris et al., 1972).

Table 6. Peroxide values(meq O_2/kg fat) of whey-peanut blend stored at 3 different temperatures for varying lengths of time.

	Storage time - days						
Sample	Initial	25	53	81	109	137	165
Hidden control N_2 pack, -18°C	10.1	9.3	8.4	8.3	11.3	14.2	15.2
Air pack stored -18°C	-	8.9	10.4	10.9	11.4	12.4	14.2
Air pack stored 20°C	-	17.7	27.7	30.9	37.1	45.9	55.4
Air pack stored 37°C	-	19.4	32.0	38.0	57.4	74.6	82.1

A desirable feature of any beverage supplement is the possibility of it being served hot as a soup or gruel. As the whey-peanut blend had a bland taste quality initially, it was readily flavored. As shown in Table 7, when flavored with two different types of synthetic chicken flavoring and served to the judges as a soup at a temperature of 60 C, the flavored samples were preferred to an unflavored control. At 15% total solids the soup was judged to have a satisfying mouth-feel, without the use of additional stabilizers, probably because of the partial gelatinization of some of the starch in the peanut flour brought about by the wet heating used in the flour manufacturing process (Ayers et al., 1974).

Table 7. Average flavor scores on a 9-point hedonic scale of reconstituted chicken-flavored whey-peanut blend served at 60°C.

Sample	Flavor score
Control	4.7
Chicken flavor A	6.7
Chicken flavor B	5.3

Conclusions

On the basis of the data reported here, whey-peanut blend has the nutritional quality required for use in food donation programs. However, the decreased flavor scores coupled with increasing peroxide values in samples stored at 20 and 37 C over the 6 month storage period are indicative of a serious stability problem with this product which is still under investigation at present. An increase in the antioxidant level may prove beneficial.

When the storage stability problem has been solved, feasibility of the commercial development of the whey-peanut blend will depend upon cost. Based on current prices, the ingredients cost of the new blend is estimated to be 40.2 cents/kilo, compared to whey-soy drink mix at 31.9 cents/kilo. The higher cost of the whey-peanut blend is due to the cost of the peanut flour used in the formulation. For this reason, commercial development may be delayed until larger supplies of peanut flour become available.

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