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Utilization of Membrane-produced Oilseed Isolates in Soft-serve Frozen Desserts

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ABSTRACT

Consumption of frozen desserts in the United States has increased steadily in recent years. However, rising costs of milk solids-not-fat (MSNF) used in dessert formulas may cause manufacturers to consider less-expensive nondairy protein sources as an alternative with the resulting products labeled "nondairy". Use of soy protein isolates and concentrates as food ingredients is rapidly gaining acceptance in the United States. Glandless cottonseed and peanut protein isolates are expected to become available in the next few years. A membrane isolation process which employs ultrafiltration membranes to produce protein isolates directly from oilseed flour extracts has now been developed. Performance of these isolates in frozen desserts was assessed. Taste panel scores of dessert samples for color, odor, textures, flavor and overall acceptability were statistically analyzed. Results showed MIP soy isolate could replace MSNF (a) at the 80% level without flavor or texture loss, (b) at the 60% level without loss in overall acceptability and (c) at the 40% level without quality loss in color and odor. MIP peanut isolate replaced MSNF (a) at the 80% level without textural change, (b) at the 60% level without loss in overall acceptability or desirable flavor and odor and (c) at the 40% level without color loss. MIP cottonseed SP isolate was used to replace MSNF (a) at the 60% level without flavor loss, (b) at the 40% level with no textural changes and (c) at the 20% level without loss in overall acceptability. Based on these results, MIP oilseed isolates (especially soy and peanut) are a possible alternate source of protein for use in soft-serve frozen desserts to the replacement levels stipulated.

INTRODUCTION

Consumption of frozen desserts in the United States has increased steadily in recent years. This trend is expected to continue. However, the spiraling costs of milk solids-not-fat (MSNF) used in dessert formulas may cause manufacturers to consider less-expensive nondairy protein sources as an alternative. Products in which nondairy proteins are incorporated would have to be labeled "nondairy" since Federal standards permit only dairy proteins in ice cream, ice milk or mellorine.

Futch (1979), in a survey of frozen dessert manufacturers found that 94% of those responding considered price an important factor in maintaining frozen dessert sales (1). An analysis reported by Boehm (1976) showed household comsumption of frozen desserts to be responsive to changes in retail prices, especially in the short term (2).

The alternative to MSNF most frequently employed in frozen desserts to date has been whey solids. A number of investigations have been made to determine the effects of whey solids on ice cream and other dairy products (3-7).

In general, the investigators agreed that whey solids, especially solids from sweet wheys, could satisfactorily replace MSNF to the limits allowed by present Federal standards of identity and perhaps beyond. However, some reduction in quality was reported from loss of firmness and smoothness and from the appearance of a pinkish color when the colorant, annatto, was used in the cheese process generating the whey.

Grey (1979) cites a trend toward the use of nondairy products in the dairy industry (8). Garland et al. (1979) reported research in which defatted, glandless cottonseed flour, glandless cottonseed storage protein isolate, deglanded cottonseed flour, soy flour, soy protein concentrate and soy protein isolate were substituted for various levels of MSNF in a frozen dessert formula (9).

In the work to be described here, oilseed protein isolates produced from defatted soy, glandless cottonseed and peanut flour by industrial ultrafiltration (UF) and reverse osmosis (RO) membranes were evaluated as replacements for MSNF at levels of 20, 40, 60 and 80% in a soft-serve frozen dessert formula. A control in which none of the MSNF were replaced was also included in statistically designed experiments.

The oilseed isolates evaluated were produced by a membrane isolation process (MIP) developed by investigators at Texas A&M University's Food Protein Research and Development Center (FPRDC) (10-13). Using the MIP, protein is extracted from oilseed flours following conventional procedures. However, protein is ultrafiltered directly from the liquid extract instead of being removed by isoelectric precipitation as is conventionally done. MIP isolates possess functional and nutritional properties that differ from those of conventional isolates. Thus, the performance of MIP isolates in soft-serve frozen dessert was assessed using a sensory test panel and analytical and color measurements.

EXPERIMENTAL PROCEDURES

Preparation of Oilseed Isolates

Soy and peanut MIP isolates were prepared following the procedure shown in Figure 1. Extractions of soy and peanut flours were made with filtered tap water (30:1 water-to-flour ratio by weight) adjusted to pH 9 and pH8, respectively, with $Ca(OH)_2$. Extraction continued for 40 min at 55 C for soy flour and 60 C for peanut flour. The flour-water slurries were subsequently centrifuged to obtain extracts for ultrafiltering.

Cottonseed storage protein (SP) isolate was prepared by first extracting the nonstorage protein (NSP) from glandless cottonseed flour with filtered tap water (18:1 water-to-flour ratio) at 28.5 C for 40 min (Fig. 2). NSP extract was separated from insoluble residue by centrifugation, pasteurized and precipitated at pH 4 using HCl. NSP curd was separated from the NSP whey by centrifugation and spray-dried.

The insoluble residue from the initial extraction was reextracted with water adjusted to pH 9.5 using NaOH. After centrifugation to remove insolubles, SP extract was combined with the NSP whey, pasteurized and prefiltered to 100 μ for ultrafiltering.

Each extract was ultrafiltered using the internally-coated tubular UF system of Abcor, Inc., Wilmington, MA. The UF system was equipped with 22 sq ft of Abcor's HFM-180 noncellulosic membrane. Feed solutions were processed at the manufacturers' recommended pressure and flow rate. Feed temperature was maintained at 65 C throughout the processing cycle to give increased flux and prevent microbial buildup. A dilution technique was applied to further purify the retentate after a 4:1 vol reduction in the original feed. Dilution consisted of adding to the concentrated feed a quantity of filtered water equal to either 3 or 4 times its vol and reconcentrating it. The UF membrane retentate was spray-dried.

Other Formula Ingredients

Foremost Edible Lactose #305 was obtained from Foremost Foods, San Francisco, CA. Nonfat dry milk solids (NFDMS), Go! Southern Special Stabilizer, ice cream color (an alkaline extract of annatto seeds) and vanilla extract were procured through Lilly Ice Cream Co., Bryan, TX. Jersey cream (containing 39% fat) was purchased from a local dairy and granulated sugar from a local supermarket.

Preparation of Blends

Each oilseed isolate was blended with lactose to give a blend with the same protein content as the NFDMS used, i.e., 35.5%. To clarify, it should be stated that NFDMS as used herein refers to the commercial nonfat dry milk powder purchased. The MSNF used refers to the total milk solids-not-fat component of the formula mix. MSNF includes NFDMS plus solids from the Jersey cream.

Preparation of Mixes

The basic formula for the frozen dessert is shown in Table I in the column headed "Control". Ingredients in formulations containing MIP isolates at different replacement levels are also given in the table. To incorporate an oilseed isolate in the formula, oilseed protein-lactose blends were substituted on a protein-for-protein basis for the desired percentage of MSNF in the formula.

Dry ingredients in each mix except the sugar were blended and then divided into 3 approximately equal parts. Each portion was then blended with 250 ml tap water at 65 C using the fastest speed of a 7-speed blender. These dispersions were then carefully transferred to a 4000-ml stainless steel beaker. All containers used were rinsed with tap water at 65 C and the rinse water added to the contents of the beaker. The remaining formula water required, the cream, coloring and flavoring were then added. Next, the sugar was

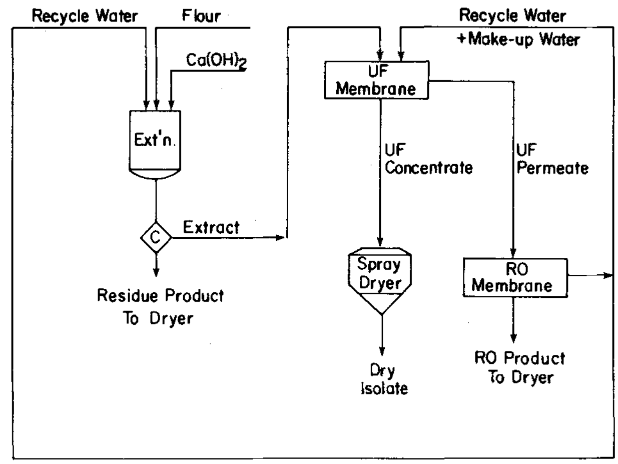

FIG. 1. Simplified flow diagram for soybean and peanut protein isolation with UF and RO membranes.

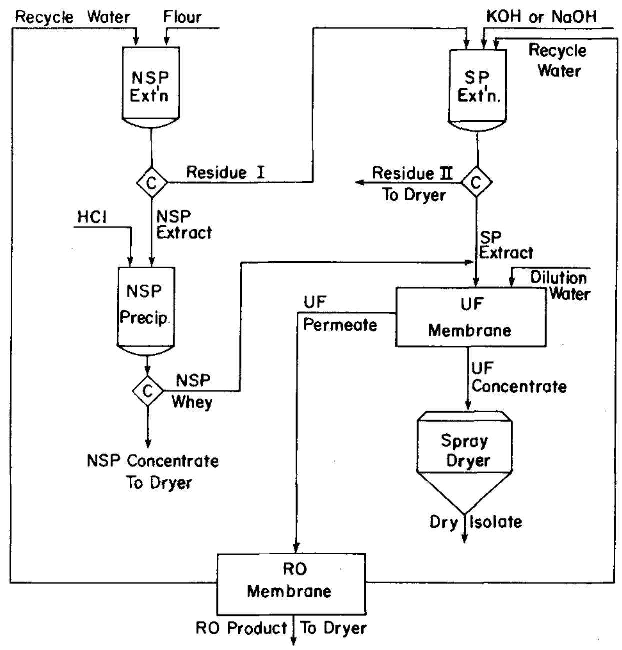

FIG. 2. Simplified flow diagram for cottonseed protein isolation with UF and RO membranes.

dissolved in the mixture.

After preparation as described, beakers with mixes were placed in a water bath at 100 C until the mixes reached 78 C. Mixes were held at 78 C for 25 sec for pasteurization. They were then cooled to 65 C in a cold water bath while being stirred by hand. The cooled mixes were homogenized at 2500 psi using a Gaulin Type 15M homogenizer. They were recooled to around 4 C with an APV heat exchanger, Type Jr. H.E. Next, they were stored in a refrigerator at 4-6 C for aging for 5-7 days.

Measurements to Evaluate Mixes

Upon completion of storage for aging, 2.4 ℓ of each mix were placed in the freezing chamber of a Swedette Model A500 soft-serve freezer and frozen until the freezer automatically stopped. The temperature of the frozen dessert at this point was -7 C. The freezer automatically maintained the dessert at approximately this temperature.

Mix viscosity was then measured at 6 C using a Brookfield Model LVT-E Viscometer equipped with T-Shaped Spindle A at 60 rpm. The pH of the mixes were subsequently read at 10 C.

Sensory evaluations were made of each frozen oilseed-protein-containing mix and the control. One mix was removed from storage, frozen and served to an 8-judge, semitrained taste panel at each session. After each mix had been scored, the series was replicated using newly prepared batches of mix. This gave 16 judgements on each dessert. Each sample was scored for texture, color (i.e., color acceptability not color difference), flavor, odor and overall acceptability, using this 5-point scale: 5-very good; 4-good; 3-fair; 2-poor; 1-very poor.

Statistical Design and Analyses

Thirteen treatment combinations (including the control) were randomized and mixes corresponding to them were prepared and stored under refrigeration. Treatment combinations were formed from 3 products (soy, glandless cottonseed SP and peanut isolate) at 4 levels (10, 40, 60 and 80%) plus a control treatment.

An analysis of variance was performed on each set of scores (odor, color, texture, flavor and overall acceptability) from the sensory evaluation. The GLM procedure of the SAS 76D package was followed in the computation (14). Sources of variation shown to be significant by analysis of variance were further tested using Duncan's New Multiple Range Test (15).

Analytical Procedures

Moisture, oil, crude fiber and ash were determined on oilseed isolates according to standard AOCS methods (16). Nitrogen was determined by the Kjeldahl method. Protein was calculated as nitrogen multiplied by 6.25. Nonprotein nitrogen (NPN) was determined as that nitrogen soluble in 10% TCA solution.

Total sugars in terms of glucose were measured colorimetrically by the Dubois et al. phenol-sulfuric acid method (17). Total phosphorus was determined by Sumner's method (18).

Isolate color measurements were made using the Model D25D2 Hunterlab Digital Color and Color Difference Meter. Measurements were first made with isolates in a dry form and then as a wet paste prepared by adding water (5:1, water/isolate, w/w). L-Scale readings (reflecting lightness of color) were taken.

Color measurements on desserts were made after the dessert had been frozen for 60 min. Colors (L, a, b scales) were read on the Hunterlab Meter Model D25D2) used with the isolates.

RESULTS AND DISCUSSION

Analytical and color data on MIP isolates tested in experimental frozen desserts are given in Table II. The peanut isolate is shown to have a protein content in excess of 100% because the 6.25 multiplier, though commonly used, is inappropriate for peanuts (19). The soy isolate was lighter in color in a dry state than either peanut of cottonseed isolate. However, when wetted, peanut isolate maintained a lighter color. Cottonseed SP isolate was the darkest of the 3 whether dry or wet.

The ingredients of mixes containing oilseed isolates at 4 replacement levels are shown in Table I along with the ingredients of the control. Different amounts of each isolate were required because of variation in their protein contents.

Mix viscosity, color and pH measurements are shown in Table III. Mixes containing isolates were less viscous than

TABLE I

Ingredients in Soft-serve Frozen Desserts Containing MIP and a Milk Protein Control

	MIP oilseed isolates and protein replacement levels												
	Soy (%)				Cottonseed (%)				Peanut (%)				
Ingredients[a]	20	40	60	80	20	40	60	80	20	40	60	80	Control
Water (g)	3636	3631	3627	3622	3638	3634	3631	3628	3637	3633	3630	3626	3640
NFDMS (g)	617.5	458.0	298.5	139.0	617.5	458.0	298.5	139.0	617.5	458.0	298.5	139.0	777.0
Lactose (g)	97.1	194.2	291.3	388.3	98.2	196.3	294.5	392.6	103.6	207.3	310.9	414.6	—
Oilseed isolate (g)	67.2	134.3	201.4	268.6	64.7	129.4	194.1	258.7	60.1	120.1	180.2	240.3	—

[a]Ingredients and amounts common to each mix: cream-838.2 g; sugar-814.5 g; stabilizer-29.7 g; vanilla-11.6 ml; food coloring-2.6 ml.

TABLE II

Data on MIP Oilseed Isolates Used in Soft-serve Frozen Desserts

Isolates	Ash	Nitrogen Total	Nitrogen NPN	Protein (N X 6.25)	Total P	Total sugars	Crude fiber	Oil	Color (L-scale) Dry	Color (L-scale) Wet
				% Dry wt basis						
Soy	7.1	14.59	0.60	91.19	0.95	5.6	0.2	0.9	82.5	59.5
Glandless cottonseed[a]	5.0	14.94	0.63	93.36	0.88	5.6	0.5	0.4	66.7	49.8
Peanut	3.2	16.23	0.29	101.39	0.23	2.5	0.1	0.4	79.2	67.3

[a]Storage protein extract plus nonstorage protein whey.

TABLE III

Properties of Soft-serve Frozen Desserts Containing MIP Oilseed Isolates and of a Milk Protein Control

Protein replacement level (%)	Protein source	Mix viscosity, CPS (6.0 C)	Color (frozen) L	Color (frozen) a	Color (frozen) b	pH
20	Soy	162	86.8	1.9	19.3	6.96
	Glandless cottonseed	164	83.4	1.9	19.0	6.72
	Peanut	155	85.7	2.2	19.3	6.73
40	Soy	199	83.9	1.2	17.6	7.09
	Glandless cottonseed	201	82.1	1.1	18.2	6.86
	Peanut	200	87.4	1.6	17.3	6.85
60	Soy	257	85.6	1.8	18.1	7.13
	Glandless cottonseed	253	78.4	2.6	21.0	6.98
	Peanut	323	87.2	1.2	16.6	6.89
80	Soy	272	84.5	2.2	17.5	7.18
	Glandless cottonseed	330	75.7	1.5	17.5	7.12
	Peanut	325	82.7	1.2	16.7	7.06
0 (Control)	Milk-solids-not-fat	260	87.4	2.1	21.0	6.65

TABLE IV

Mean Sensory Scores Assigned to Soft-serve Frozen Desserts Containing MIP Oilseed Isolates and to a Milk Protein Control[a]

Protein replacement level (%)	Protein source	Taste panel scores: Color means	Odor means	Texture means	Overall acceptability means	Flavor means
20	Soy	$4.02^{b,c}$	$3.90^{b,c}$	$3.92^{b,c}$	$3.96^{b,c}$	$3.81^{b,c,d}$
	Glandless cottonseed	3.63^{c}	3.63^{c}	$3.88^{b,c,d}$	$3.69^{b,c,b}$	$3.63^{b,c,d}$
	Peanut	$4.08^{b,c}$	$3.95^{b,c}$	$3.76^{b,c,d}$	$3.95^{b,c,d}$	$4.20^{b,c}$
40	Soy	$3.88^{b,c}$	$3.69^{b,c}$	$4.00^{b,c}$	$3.75^{b,c,d}$	$3.69^{b,c,d}$
	Glandless cottonseed	3.63^{c}	$3.75^{b,c}$	$3.63^{b,c,d}$	$3.31^{d,e}$	$3.31^{b,c,d}$
	Peanut	$3.81^{b,c}$	$3.75^{b,c}$	$4.06^{b,c}$	$3.94^{b,c,d}$	$3.56^{b,c,d}$
60	Soy	3.74^{c}	$3.56^{c,d}$	$3.80^{b,c,d}$	$3.86^{b,c,d}$	$3.42^{b,c,d}$
	Glandless cottonseed	2.94^{d}	$3.56^{c,d}$	$3.50^{c,d}$	$3.38^{c,d,e}$	$3.50^{b,c,d}$
	Peanut	3.71^{c}	$3.73^{b,c}$	$3.75^{b,c,d}$	$3.77^{b,c,d}$	$3.40^{b,c,d}$
80	Soy	3.68^{c}	3.63^{c}	$3.75^{b,c,d}$	$3.42^{c,d}$	$3.23^{b,c,d}$
	Glandless cottonseed	2.56^{d}	3.06^{d}	3.25^{d}	2.79^{e}	2.96^{d}
	Peanut	3.62^{c}	$3.55^{c,d}$	$3.55^{b,c,d}$	$3.35^{c,d,e}$	$3.08^{c,d}$
0 (Control)	Milk solids-not-fat	4.38^{b}	4.19^{b}	4.19^{b}	4.13^{b}	4.31^{b}

[a]Means of ca. 16 judge scores.

[b-e]Means with the same letter are not significantly different at the 5% level of significance.

the control at the 20, 40 and 60% replacement levels with the exception of the mix with peanut at the 60% level. Mixes containing peanut isolate were essentially equal in color to the control at the 40 and 60% replacement levels. Other mixes with isolates were not as light-colored as the control. The SP cottonseed product adversely affected color to a greater degree than did soy or peanut isolates. The presence of oilseed isolates in mixes tended to raise their pH slightly.

Mean sensory scores assigned to frozen desserts by panel members are presented in Table IV. Statistically analyzed mean scores are shown for color, odor, texture, flavor and overall acceptabiltiy.

The data show that up to 40% of the MSNF could be replaced with MIP soy or peanut isolates without loss of color lightness. Glandless cottonseed SP isolate measurably lowered the color even at the 20% replacement level. Odor scores indicate that soy-containing desserts did not significantly differ from the control through the 40% replacement level and that peanut-containing desserts equaled the control through the 60% replacement level. Odor scores for desserts with cottonseed were unexplainably higher at the 40% level than at the 20% level. No textural changes occurred in desserts having soy or peanut replacements through the 80% level. Cottonseed isolate affected texture adversely beyond the 40% replacement level.

Flavor scores show dessert flavor was unaffected by using soy through the 80% replacement level. Cottonseed and peanut flavor scores were not significantly different through the 60% level of replacement. The data also show that samples containing soy and peanut isolates at levels through 60% did not differ in overall acceptability from 0% replacement control samples. The cottonseed storage protein isolate did not affect overall acceptabiltiy at the 20% replacement level. Based on these results, MIP oilseed isolates are a possible alternate source of protein for use in frozen desserts when incorporated at replacement levels shown not to cause loss of acceptability.

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