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FUNCTIONAL CHARACTERIZATION OF MILK COMPONENT:SOY ISOLATE BLENDS[1]

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ABSTRACT

The objective of this research was to provide an in-depth analysis of the functional properties of milk product:soy isolate blends. Blends of milk product (nonfat dry milk, sweet whey powder, electrodialyzed whey powder, whey protein concentrate and sodium caseinate) and soy isolate were evaluated in terms of several functional characteristics. Emulsion capacity, whipping ability and protein solubility were studied. The sample materials were mixed into liquid systems at various ratios and protein concentrations. The blends were subjected to a variety of treatments including pH variation, heat, addition of chemical modifiers, salts and stabilizers, homogenization and enzymatic hydrolysis. Many of these treatments improved the functionality of milk product:soy isolate blends. In general, functional properties improved as the percent milk product in the blends increased.

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مطالعه خواص مؤثر مخلوط اجزاء شیرگاو و پروتئین سویا

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خلاصه

در این پژوهش خواص موثر اجزاء شیرگاو و پروتئین سویا مورد مطالعه واقع شد. اجزاء شیرگاو

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(پودرشیربدون چربی،دونوع پودرآب پنیر ،پروتئین خالص آب پنیروکازئینات سدیم) و پروتئین خالص لوبیای سویا درچندین نسبت باآب مخلوط وفرموله شدندوخواص موء ثرآنها ازقبیل ظرفیت امولسه شدن،پف کردن وحلالیت پروتئین های مخلوط مطالعه گردید .مخلوط ساخته شده موردتغییرات وفرآیندهائی ازقبیل تغییرات پی.اچ.،حرارت ،اضافه کردن برخی از مواد تثبیت یا تعلیق کننده ونمک ها ،هموژنیزه کردن وهیدرولیزآنزیمی واقع گردیدند .بسیاری ازاین تغییرات باعث بهبودی خواص موثرفوق گردید .بطورکلی این خواص با اضافه شدن درصدهریک ازاجزاء شیرگاوبه مخلوط فرموله بهترشد .

INTRODUCTION

A great deal of effort is being directed toward finding cheaper protein sources for the food industry. Currently, animal derived ingredients and wheat are the major sources for human food, though soybean protein is becoming more popular. Animal protein foods are expensive in terms of land requirements and market price. Proteins which are to be used in food products should ideally be nutritionally adequate and economically competitive, and possess the functional properties needed in a given food system. That protein which most fully satisfies these needs will probably have the highest utilization. The common protein foods (meat, fish, eggs and dairy products) owe their wide-spread appeal to the gastronomic pleasure derived from their consumption (15). The proteins in these foods are structural components that contribute specific functional properties.

Vegetable, cereal and seed proteins are being used or investigated for roles once reserved for animal proteins. These proteins often lack functionality and nutritional adequacy. Both deficiencies can be improved by blending together appropriate amounts of animal and non-animal sources of protein. Many researchers have reported on the functionality of either milk or soy protein systems (7, 9, 13, 18, 27). Melachouris (17), Harper (6), and Kinsella (10) have recently reviewed the functionality of food protein systems. Little information has been reported concerning the functionality of blends of these different protein sources.

There are many dairy and soy protein products commercially available. The user of such products should be aware that

these differ as to functional quality. A rigorous list of quality parameters needs to be established when purchasing protein materials.

MATERIALS AND METHODS

Materials

Nonfat dry milk (NFDM), soy isolate (SI), sodium caseinate (SC), dehydrated whey protein (DWP), spray dried sweet whey (DW) and spray dried electrodialyzed whey (EDW) were obtained from commercial sources for use in these experiments. Blend samples are identified by percent milk product (i.e. NFDM/50 = 50% NFDM and 50% SI).

Preparation of Samples

To assess the functionality of the blends, dispersions were prepared at protein levels of 3.2, 5.0 and 8.0% (w/w) in ratios of 0:100, 25:75, 50:50, 75:25, and 100:0 (milk product to soy isolate). The blends were prepared in distilled water and mixed for 10 minutes at 2500 rpm. The dispersions were subjected to a variety of treatments including heating, pH modification, addition of salts and homogenization.

Three tests were chosen as indicators of functionality. These were emulsion capacity, whipping ability, and protein solubility. Following completion and evaluation of this first series of tests, an additional series of experiments was designed to determine if further improvements in functionality could be made. Selective protein systems were chosen as representative of the samples studied in Part I. These samples were subjected to a total of 27 different treatments. Many of these treatments resulted from combinations of variants from the first study, in addition to the inclusion of chemical modifiers, gums, emulsifiers, sweeteners, salts and enzymatic hydrolysis. Data are reported as averages determined from duplicate or triplicate determinations.

Procedure

Soluble protein. The percent soluble protein in each sample was determined on an aliquot collected after filtration through Whatman No. 42 filter paper. The Lowry modification of the Folin-Ciocaulteau colorimetric procedure (12) was used to measure soluble protein.

Emulsion capacity. Emulsion capacity was determined by a procedure similar to that of Webb *et al.* (25). An aliquot of the protein solution equivalent to 10 mg of protein, was taken from each sample. This was added to 100 ml of 1.0M NaCl solution in a 600 ml beaker and weighed. Refined corn oil was added from a 500 ml separatory funnel and delivered via tubing into the beaker at a constant rate of 0.1 ml sec^{-1}. Stirring was maintained at 3000 rpm during delivery of the oil until the emulsion inverted. The inversion point was monitored with an ohmmeter. After the break point was reached, the beaker was detached from the apparatus and reweighed to determine the amount of corn oil added. The emulsifying capacity was calculated as g of oil required to reach an infinite electric resistance minus a blank (100 ml of a 1.0M NaCl solution) divided by the amount of protein in the sample.

Whipping ability. Whipping ability was measured by whipping a sample of the protein solution (sol) at speed 8 in a Kitchen Aid Model 3-C mixer, equipped with a wire whip. A whipping time of 6 min was used. After whipping was completed, material was transferred to a tared beaker of known volume and reweighed to determine specific volume (ml g^{-1}). To determine the 1/2 stability time, the beaker was covered with a stainless steel mesh screen and inverted over a funnel. The time required for collection of liquid equal to 1/2 of the weight of the original foam was recorded. Stability times of less than 5 min were reported as zero.

RESULTS AND DISCUSSION

Solubility

Soy isolate dispersions had the lowest solubilities of any of the products tested (Table 1). Values remained essentially constant as the concentration of protein was increased. Increasing the pH of the solutions to 8.5 resulted in higher solubility, probably due to the greater net negative charge on the protein at the higher pH, which resulted in an increased affinity toward water molecules (4). The opposite effect was observed when the pH was lowered to 4.5 which is close to the isoelectric point of the protein. Addition of calcium chloride also destabilized solutions of soy protein. Calcium ions can function to neutralize charges or form crosslinks within the protein molecule, thus reducing their solubility (26). Homogenization resulted in a slight increase in solubility, probably due to physical disruption of the protein structure.

Of the milk products examined, NFDM had the lowest solubility in water (Table 1). Solubility increased at pH 8.5 and decreased as pH was lowered to 4.5. Addition of sodium phosphate, dibasic (Na_2HPO_4), caused increased solubility.

Water dispersions of sodium caseinate, electrodialyzed whey and whey protein concentrate had high solubilities (Table 1). Morr (19) found that the protein solubility of whey protein concentrates ranged from 92.3-99.9%. Lowering the pH of the sodium caseinate solutions to 4.5 or addition of $CaCl_2$ resulted in substantial reduction. The solubility of the proteins was not affected by concentration in the range studied. Morr *et al.* (20) found similar solubilities for the untreated dairy protein products as reported herein.

The solubility of sodium caseinate: soy isolate and nonfat dry milk: soy isolate blends were intermediate between those recorded for the separate systems and respective treatments (Tables 1 and 2). Soy: whey product blends had solubilities

Table 1. Protein solubility (%) of selected samples at a protein concentration of 3.2%.

Sample[†]	Treatment						
	Control	68°C, 30'	pH 8.5	pH 4.5	0.1M $CaCl_2$	0.1% Na_2HPO_4	Homogenization
NFDM	65.6	68.8	70.1	25.0	66.2	72.2	81.2
SC	99.5	99.7	94.3	0.5	24.1	99.5	99.6
SI	57.8	58.1	60.5	4.2	7.8	58.0	62.6
DWP	96.4	94.6	99.1	99.2	92.4	91.0	99.5
EDW	99.8	95.3	96.9	98.4	99.5	99.8	98.4
DW	80.5	90.5	82.5	63.0	47.5	76.0	84.3
NFDM/50	57.9	56.0	64.5	12.2	46.5	56.3	79.7
SC/50	70.0	72.0	71.5	0.1	27.0	67.5	90.0
DWP/75	71.4	74.0	75.0	72.6	63.0	72.0	89.0
EDW/75	85.9	81.3	92.2	85.0	84.0	90.6	90.6
DW/50	67.5	62.0	71.5	44.6	66.4	67.5	71.2

[†]Samples:

NFDM = Nonfat dry milk
SC = Sodium caseinate
SI = Soy isolate
DWP = Dehydrated whey protein
EDW = Electrodialyzed whey
DW = Sweet whey
NFDM/50 = 50% nonfat dry milk, 50% soy isolate
SC/50 = 50% sodium caseinate, 50% soy isolate
DWP/75 = 75% dehydrated whey protein, 25% soy isolate
EDW/75 = 75% electrodialyzed whey, 25% soy isolate
DW/50 = 50% sweet whey, 50% soy isolate.

approaching those of the whey product (Tables 1 and 2) although the solubility of the sweet whey: soy blend was lower, possibly due to the lower pH. There was an apparent synergistic effect by the whey proteins on the soy isolate. As the proportion of whey product in the system increased, solubility of the blend increased. In whey: soy blends where soy protein predominated, elevation of the pH to 8.5 increased solubility (from 68.0 to 92.2 for electrodialyzed whey: soy isolate blends of 25:75 and 75:25 ratios respectively). Lowering the pH to 4.5 or dispersing in $CaCl_2$ did not reduce solubility proportionally when comparing the two protein systems.

Selected samples were subjected to additional treatments, the results of which are presented only in summary. Addition of sodium ethylenediamine tetracetic acid (EDTA), disodium phosphate (Na_2HPO_4) or sodium citrate to samples containing $CaCl_2$ inhibited the loss of solubility, probably by complexing the calcium. Extraction of calcium from the micelle by EDTA could result in break down of the micelle and thus increase solubility (1). The protein solubility of the whey products and the soy isolate blends were reduced by heating in 0.1M $CaCl_2$. deWit and Klarenbeek (3) also found that heating whey protein in solutions containing added calcium reduced protein solubility. Such loss could be caused by heat-salt denaturation (22). The opposite occurred when NFDM and its soy isolate blend were heated in the presence of Na_2HPO_4. Solubility increased from 57.9 to 74.4% for the NDFM: SI blends due to treatment effect (Tables 1 and 2). Sommer (24) reported that upon addition of sodium to a calcium caseinate solution, a substitution could take place resulting in a higher percent of sodium caseinate, which is more soluble. Heating solutions of NFDM, soy isolate and blends, subsequent to adjustment of the pH to 8.5, improved their solubility. Reducing agents such as L-cysteine and mercaptoethanol improved the protein solubility of several of the milk products, soy isolate and blends. This was

Table 2. Protein solubility (%) of selected samples at a protein concentration of 3.2%.

Variants	Sample†				
	NFDM/50	NFDM/50	SI	SC/50	SC
0.1M $CaCl_2$ - 0.1% Na_2HPO_4	59.5	40.6	51.6	26.2	4.7
0.1% Na_2HPO_4 - 68°C/30'	84.3	74.4	65.6	89.1	90.6
pH 8.5 - 68°C/30'	75.0	64.3	61.9	88.5	90.0
Maleic anhydride	82.9	71.0	67.5	75.8	80.9
Enzyme hydrolysis	70.3	63.1	79.1	70.3	66.0
5.0% NaCl	75.0	58.4	56.8	56.1	54.7
	DWP	DWP/75	EDW	EDW/75	
0.1M $CaCl_2$ - 0.1% EDTA	91.3	77.2	99.4	87.5	
pH 8.5 - 68°C/30'	93.8	81.3	99.2	89.1	
0.06% H_2O_2 - Catalase	94.4	78.1	99.8	88.1	
0.01% Mercaptoethanol	96.9	90.0	99.3	90.6	
Enzyme hydrolysis	98.4	90.6	95.4	83.8	

†Samples:

NFDM = Nonfat dry milk
SC = Sodium caseinate
SI = Soy isolate
DWP = Dehydrated whey protein
EDW = Electrodialyzed whey
DW = Sweet whey
NFDM/50 = 50% nonfat dry milk, 50% soy isolate
SC/50 = 50% sodium caseinate, 50% soy isolate
DWP/75 = 75% dehydrated whey protein, 25% soy isolate
EDW/75 = 75% electrodialyzed whey, 25% soy isolate
DW/50 = 50% sweet whey, 50% soy isolate.

probably due to disruption of disulfide bonds which resulted in depolymerization. Hydrogen peroxide (H_2O_2) treatment caused smaller, though still positive, effects on the protein solubility of soy isolate and several of its milk product blends. The solubility of the NFDM: SI blends increased from 57.9 to 69.2% due to this treatment.

The addition of succinic or maleic anhydride to the solutions improved the protein solubility of NFDM, soy isolate and blends. The protein solubilities of the whey products were not substantially affected. Cheeseman (2) reported that succinylation of milk proteins alters the electrostatic character of caseins which affects their physical properties. Succinylation of a protein converts the cationic amino groups to anionic residues (4). The increase in net negative charge alters the physico-chemical characters of proteins and can result in enhanced aqueous solubility.

Enzymatic hydrolysis for one hour markedly improved the solubility of soy isolate and its milk product blends. Other treatments (sucrose, carboxymethyl cellulose (CMC), monoglycerides, sodium hexametaphosphate (SHMP) and glycan (a yeast cell wall polysaccaride) had little effect upon the solubilities of the samples.

In general, milk products demonstrated the highest degree of protein solubility, with milk product: soy isolate blends having appreciably higher solubility than soy isolate. Many whey protein: soy isolate blends had higher solubility than what would be expected from the solubilities of individual systems. Specific treatments resulted in widely varying values, which makes it possible to achieve the desired solubility by selecting the appropriate treatment.

Emulsion Capacity

The ability of a protein to emulsify a fat is an extremely important functional characteristic. Emulsion capacities (EC) were determined for all samples at a protein concentra-

tion of 3.2%. The results are presented in Table 3. Nonfat dry milk and dehydrated whey protein had the highest EC while sweet whey and soy isolate had the lowest. The EC of milk product: soy isolate solutions decreased slightly as the amount of soy protein in the blends increased.

Moderate heating increased the EC of several samples, although at higher temperatures a reduction in EC was observed for the whey products and their soy blends due to decreased solubility. The decrease observed was proportional to the amount of soy in the mix. Adjustment of the pH to 4.5 substantially reduced the EC of soy isolate, NFDM, sodium caseinate and their blends. This was due to loss of solubility. Soluble proteins tend to form better emulsions than do insoluble ones (14). Whey product: soy isolate blends had lower EC proportional to the amount of soy in the samples. Adjustment of the pH to 8.5 resulted in an increase in EC due to enhanced solubility.

Addition of monoglycerides or sodium dodecyl sulfate (SDS) resulted in higher EC, probably due to the surfactant properties of these compounds. The addition of either succinic or maleic anhydride also improved EC. This was probably due to the increased solubility of the protein (4). Improvement was also noted when the samples were dispersed in 5.0% sodium chloride. Anions may have increased the EC by enhancing the unfolding of protein molecules, thereby enlarging the effective surface area available for interfacial membrane formation (9). Enzymatic hydrolysis did not significantly alter the EC except for soy isolate, probably due to greater solubility of the partially hydrolyzed, and more soluble, protein. Addition of stabilizer salts or adjusting the pH to 8.5 also increased EC (10-20% for most samples).

Emulsification is a primary functional requirement of many food proteins. In general, the soy isolate had less EC than the milk products. Blends often had nearly as much as the milk products and nearly always more than the soy.

Table 3. Emulsion capacity measured in g oil/mg protein for selected samples at a protein concentrate of 3.2%.

Sample†	Treatment						
	Control	4.5	Anhydride	Mono-glyceride	Na_2HPO_4 - 68°C/30'	5.0% NaCl	Enzyme Hydrolysis
SI	2.4	1.0	3.0	2.7	2.2	3.0	3.1
NFDM/50	3.0	1.4	4.5	3.5	4.0	3.8	3.0
NFDM	3.5	1.7	5.1	4.6	5.3	4.3	3.5
SC/50	3.0	0.4	4.6	3.6	3.9	2.9	3.1
SC	3.2	0.1	5.2	4.1	5.1	2.4	3.5
EDW/75	2.8	3.3	4.0	4.0	3.5	3.5	2.4
EDW	2.9	4.1	4.3	4.2	4.4	4.5	2.7
DWP/75	3.3	1.7	4.2	4.3	3.2	4.1	2.6
DWP	3.7	2.9	4.4	4.2	4.7	5.1	2.8
DW/50	2.4	2.6	3.6	2.8	2.2	2.5	2.7
DW	2.6	2.6	4.3	3.2	2.6	3.1	3.1

†Samples:

NFDM = Nonfat dry milk
SC = Sodium caseinate
SI = Soy isolate
DWP = Dehydrated whey protein
EDW = Electrodialyzed whey
DW = Sweet whey
NFDM/50 = 50% nonfat dry milk, 50% soy isolate
SC/50 = 50% sodium caseinate, 50% soy isolate
DWP/75 = 75% dehydrated whey protein, 25% soy isolate
EDW/75 = 75% electrodialyzed whey, 25% soy isolate
DW/50 = 50% sweet whey, 50% soy isolate.

Whipping Ability

In this study, specific volume (SV) in ml/g was used to assess the increase in volume following whipping, while foam stability was measured by recording the one-half stability times (1/2 t) in minutes. Soy isolate, in general, had foams of low SV with zero stability times at the protein concentrations studied (Tables 4 and 5). Soy isolate solutions dispersed in $CaCl_2$ had stable foams of moderately high SV. The improvement noted may have been due to a charge effect, crosslinking or partial denaturation. Sweet whey solutions exhibited minimal foam quality. Stable foams were not produced until a protein concentration of 8% was reached, which resulted in paste-like foams of high viscosity. Sweet whey: soy isolate blends did not form stable foams, except at a protein concentration of 8% and a blend ratio containing 75% whey product.

Heating was necessary to produce stable foams from dehydrated whey protein solutions. Schmidt *et al.* (23) also reported that some controlled heating tended to improve foam quality of whey proteins. Some heat denaturation appeared to be necessary to increase the degree of protein-protein cohesion. Stability times increased at higher protein concentrations. Heating above 77°C reduced foam stability. Soy isolate: dehydated whey protein blends which were heated had stable foams with more foam quality at higher protein content. Foam quality improved as the amount of dehydrated whey protein in the blends was increased.

Protein solutions of electrodialyzed whey whipped into stable foams. Heating had little effect on foam quality, while adjustment of the pH to either 8.5 or 4.5 increased SV and 1/2 t. Kuehler and Stine (11) observed that the greater the net charge of a protein, the greater its tendency to whip. However, Kim and Kinsella (8) reported that the foam stability of bovine serum albumin was maximal near pH 5.5. Dispersing the solutions in $CaCl_2$ also increased foam stabil-

Table 4. Whipping ability as specific volume (SV) in ml/f and 1/2 stability time (1/2 t) in minutes for selected samples.

Sample[†]	Protein level 3.2 SV	3.2 1/2 t	5.0 SV	5.0 1/2 t	8.0 SV	8.0 1/2 t
NFDM	7.5	35	7.1	48	6.8	65
SC	8.7	17	8.2	10	8.1	8
SI	2.5	0	2.4	0	2.1	0
EDW	6.4	30	7.3	28	3.1	150
DWP[‡]	10.3	19	7.0	23	7.9	45

	Variant: Control SV	Control 1/2 t	77°C/NH SV	77°C/NH 1/2 t	pH 4.5 SV	pH 4.5 1/2 t	0.1M $CaCl_2$ SV	0.1M $CaCl_2$ 1/2 t	Na_3 Citrate SV	Na_3 Citrate 1/2 t
NFDM/50	8.7	27	8.6	25	2.0	0	5.3	12	8.9	32
SC/50	8.2	8	8.2	10	1.9	0	9.5	28	8.3	10
EDW/75	6.4	27	6.0	24	5.1	6	6.8	41	6.4	37

[†]Samples:

NFDM = Nonfat dry milk
SC = Sodium caseinate
SI = Soy isolate
DWP = Dehydrated whey protein
EDW = Electrodialyzed whey
DW = Sweet whey
NFDM/50 = 50% nonfat dry milk, 50% soy isolate
SC/50 = 50% sodium caseinate, 50% soy isolate
DWP/75 = 75% dehydrated whey protein, 25% soy isolate
EDW/75 = 75% electrodialyzed whey, 25% soy isolate
DW/50 = 50% sweet whey, 50% soy isolate.

[‡]Heated at 68°C/30 min.

Table 5. Whipping ability as specific volume (SV) in ml/g and 1/2 stability time (1/2 t) in minutes for selected samples at a protein level of 3.2%.

	Sample†							
	DWP		DWP/75		DW		DW/75	
Variant	SV	1/2 t	SV	1/2 t	SV	1/2 t	SV	1/2 t
0.1m $CaCl_2$-0.1% Na_3 Cit.	7.7	17	7.1	14	2.2	0	3.4	0
0.1% Na_2HPO_4-68°C/30'	7.2	47	8.4	43	5.7	37	4.0	5
pH 8.5 - 68°C/30'	9.0	16	9.0	36	6.3	35	5.2	12
H_2O_2 - 68°C/30'-Catalase	8.2	18	7.2	18	5.6	40	4.3	5
0.5% SHMP	8.8	30	6.5	22	4.9	0	4.1	0
0.1% CMC	5.3	5	3.5	0	5.2	24	4.3	12
3.5% glycan-homog.	4.6	5	4.0	0	3.4	0	2.7	0
Enzyme hydrolysis	10.6	47	10.1	19	4.8	5	5.2	5

	EDW		EDW/75	
	SV	1/2 t	SV	1/2 t
H_2O_2	7.1	35	5.8	14
0.1% CMC	5.7	47	5.3	43
0.5% CMC	3.0	338	4.5	140
3.5% glycan-homog.	4.1	240	4.1	65

†Samples:

NFDM = Nonfat dry milk, SC = Sodium caseinate, SI = Soy isolate, DWP = Dehydrated whey protein, EDW = Electrodialyzed whey, DW = Sweet whey, NFDM/50 = 50% nonfat dry milk, 50% soy isolate, SC/50 = 50% sodium caseinate, 50% soy isolate, DWP/75 = 75% dehydrated whey protein, 25% soy isolate, EDW/75 = 75% electrodialyzed whey, 25% soy isolate, DW/50 = 50% sweet whey, 50% soy isolate.

ity, probably due to partial denaturation or crosslinking. Foam stability dramatically improved at 8.0% protein, though the paste-like foams had low SV. Electrodialyzed whey: soy isolate blends formed less stable foams than those from dehydrated whey protein. As the amount of whey product in the blends increased, SV and 1/2 t increased. Adding $CaCl_2$ or adjustment of the pH to 4.5 improved foam stability.

Sodium caseinate solutions whipped into stable foams at all protein concentrations tested. Samples subjected to high temperature treatment had foams of reduced SV and 1/2 t, whereas other heat treatments had little effect. No foams were formed when the pH was reduced to 4.5, while added $CaCl_2$ resulted in marked improvement. Since both treatments lowered the solubility, the increase may have been due to crosslinking with calcium ions. Sodium caseinate: soy isolate blends produced low stability foams at all protein concentrations. Dispersion in $CaCl_2$ markedly improved foam quality and stability.

NFDM foams had the longest 1/2 t of the products tested which improved as the percent protein increased. Whipping properties were reduced when either high temperature heating was employed or pH was lowered to 4.5. Addition of stabilizer salts improved foam quality. Foams from NFDM: soy isolate blends had less stability, although approximately the same SV as NFDM foams. Foam stability improved as the percent NFDM in the blends increased and as the total protein content increased. The stability of these foams was greater than for any other milk product: soy isolate blend.

The whippability of dehydrated whey protein and dehydrated whey protein: soy isolate blends were improved by adding stabilizer salts or EDTA to solutions dispersed in 0.1M $CaCl_2$. Addition of sodium hexametaphosphate (SHMP) markedly improved foam quality. Peltonen-Shalaby (21) found that ash content was positively correlated to the foam quality of whey protein concentrates. Calcium and phosphate prepara-

tions both exhibited good foam properties. Melachouris (16) observed that whey protein acts as a cation while SHMP acts as an anion. Under the proper conditions they bind and form aggregates which can increase protein-protein cohesion.

The foams produced from dehydrated whey protein, sweet whey and soy isolate blends were improved by heating samples containing stabilizer salts and by adjusting the pH to 8.5. Heating following hydrogen peroxide (H_2O_2) treatment improved the whipping properties of many of the whey products and soy isolate blends. Hansen and Black (5) reported that H_2O_2 caused definite changes in whey proteins, probably important in the improvements noted. Greater foam stability and expanded SV were noted for many of the solutions when reducing agents, such as L-cysteine or mercaptoethanol were used, probably due to their effect on disulfides. A marked improvement was achieved when succinic or maleic anhydride was added to soy solutions. Succinylation can enhance in solubility (4).

Addition of carboxymethyl cellulose (CMC) to samples resulted in improved foam quality for almost all solutions, with heating further enhancing foam stability. Harper (6) reported that addition of CMC improved the stability of a whipped topping. Glycan was blended into the samples by homogenization, which improved the stability of many of the foams.

Enzymatic hydrolysis improved the foam quality of the solutions except for sodium caseinate and its soy isolate blend. For these two samples, SV and 1/2 t were essentially unchanged from the controls. Kuehler and Stine (11) postulated that the increased foamability of enzymatically treated protein solutions was probably due to the larger polypeptide content which enlarges the available surface area. Extensive hydrolysis resulted in a greater number of small peptides which lacked the ability to maintain the protein membrane.

In general, stable foams were produced from NFDM, sodium

caseinate, electrodialyzed whey and their soy isolate blends. Sols of whey protein concentrate also produced stable foams when subjected to specific treatments. Blends of these products with soy isolate produced foams of similar SV with slightly shorter 1/2 t. By utilization of the appropriate treatment it was possible to substantially improve whipping properties.

CONCLUSIONS

In general, the common functional characteristics of single cell proteins and vegetable protein isolates are inferior to animal proteins such as meat, egg and milk. This was corroborated by the research reported in this paper with milk protein: soy isolate blends. Based on the functional tests employed herein, the performance of the milk proteins was diminished by the incorporation of soy isolate.

However, if a vegetable protein is to be used as a protein additive to a food system where protein functional performance is needed, milk protein will definitely enhance such properties. As non-animal proteins become more widely used in the future, and animal proteins become more expensive, such blends will become more widely used and information concerning the effects of processing on protein-protein interactions and resultant functionality will be needed.

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