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Functional Properties of Peanut and Soybean Proteins as Influenced by Processing Method[1]

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ABSTRACT

Proteins were extracted from defatted Florunner peanuts and Cobb soybeans and dried using different methods. Freshly prepared peanut protein isolates contained 73.9 to 81.3% protein and 1.4 to 4.3% fat. The corresponding values for soybeans were 54.7 to 61.6% and 2.7 to 4.5%. Spray dried peanut protein isolate contained 69.1% protein after 36 months storage and exhibited less solubility than those stored for 24 months or freshly prepared. Freeze dried soybean isolate contained more soluble protein than the freeze dried peanut protein isolate. The reverse was true for the spray dried peanut and soybean isolates. Protein solubility, emulsifying capacity, foaming capacity and foam stability of peanut and soybean protein isolates were higher for the spray dried and freeze dried than the drum dried preparations. Heat treatment of peanuts (107°C for 20 min.) did not influence protein solubility or emulsifying capacity but decreased foaming capacity and foam stability. Storage of peanut isolates resulted in a loss of emulsifying capacity, especially for the freeze dried peanut preparation.

Key Words: peanut, soybean, peanut protein, protein functional properties, solubility, emulsifying capacity, foam ability, foam stability.

The world food supply is asymptotic to increases in world population, resulting in expected food shortages in certain parts of the world. Plant protein sources such as oilseeds and grains are in use to supplement animal protein and the demand on their use will be continually increasing. Food-grade plant protein used in the U. S. in 1970 amounted to 24% of total protein consumed and it was estimated that within several decades this amount would increase to 50-67% (Bird, 1974). Extensive technological and research developments have led soybeans to be the primary source of plant protein added to foods (Wolf, 1970; Wolf and Cowan, 1971). Recently, an interest has been developed toward the utilization of other plant proteins in foods (Ahmed and Araujo, 1978).

The successful utilization of plant proteins as ingredients of manufactured foods depends largely on such functional properties as solubility, foaming capacity, foam stability, emulsification capacity, whippability, binding ability, gelation, viscosity, water holding capacity, and fat absorption. Protein functional properties were amply reviewed by Kinsella (1976). The methods by which plant proteins are processed often play an important role in their functional properties, though some proteins are more sensitive to processing conditions than others. For example, emulsifying capacity of sunflower seed protein was not markedly affected by the type of solvent used for protein extraction (Wu et al., 1976), whereas the functional properties of protein isolates from glandless cottonseed meal processed without heat were superior to those of isolates from heated meals (Lawhon and Cater, 1971). Protein solubility was reduced when soybeans and peanuts were treated with moist heat prior to protein extraction (Wu and Inglett, 1974; Cherry and McWatters, 1975; Cherry et al., 1975; McWatters and Cherry, 1975; Kellor, 1974). This impairment in protein solubility rapidly reached a minimum followed by increases with prolonged heating (Cherry et al., 1975; Wolf, 1970; Wolf and Cowan, 1971). Peanut protein solubility was found to be more closely associated with improved quality of emulsions and foams formed than with increased quantity of oil or air incorporated in the protein mixture (McWatters and Cherry, 1977). Functional properties of defatted peanut, soybean, field pea and pecan flours were found to be sensitive to complex interactions involving amount and type of soluble protein, pH, aqueous and salt suspensions (McWatters et al., 1976; McWatters and Cherry, 1977).

Most of the studies on functional properties were conducted on oilseed meal, flour or paste and few on extracted proteins. Most dried food products prepared by the food industry are either spray or drum dried; a few are freeze dried. The objective of this study was to determine the influence of the method of drying on the functional properties of extracted peanut and soybean proteins.

Materials and Methods

Extraction of Protein

Raw shelled peanuts of the Florunner cultivar, obtained from Florida Peanut Company, High Springs, FL and Cobb soybeans

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obtained from the Agronomy Department, University of Florida, Gainesville, were used for all experiments. The peanuts were blanched using high pressure water, dried overnight at 50°C, ground in a Homoloid mill Model JT (Fitzpatrick Co., Elmhurst, IL), partially defatted with a hydraulic press at 40 tons pressure for 2 hrs, and the cake was ground again using a finer screen. For the moist heat (steaming) experiment, the blanched and dried peanuts were steamed at 107°C for 20 min. and dried again at 50°C overnight. Oil removal and cake grinding were carried out as for the non-heated peanuts. The soybeans were ground in a Waring blendor. The proteins were extracted using an alkaline aqueous process as suggested by Rhee et al. (1972) and adapted by Fletcher and Ahmed (1977) with the following modifications: (a) 500g of the ground material were mixed with 3500ml of distilled water and stirred for 20 min, (b) the pH was adjusted to 8.5 with 5N NaOH; the mixture was heated to 55°C and stirred for one hr, (c) the mixture was filtered through cheesecloth; the supernatant was saved and the solids were reextracted as mentioned in step b and filtered similarly, (d) the combined supernatants were centrifuged in a Westfalia Continuous Centrifuge Model SAOH-205 (Centrico, Inc., Northvale, NJ) at a bowl speed of 10,000 rpm, (e) the collected protein precipitate was dialyzed against tap water (24°C) for 36 hr was adjusted to 4.0 with 5N HCL to precipitate the protein, (g) the protein precipitate was dialyzed against tap water (24° C) for 36 hr and (h) the dialyzed protein precipitates were removed from the tubes and allowed to settle; excess water was siphoned off, and protein precipitates were placed in freezing trays for freeze drying, or suspended in water (pH 8.5) and heated to 60°C prior to spray drying or drum drying.

Drying Procedure

Protein precipitates were freeze dried (FD) at 60°C using a Virtis freeze-dryer, Model no. 25-5RC-4 (Virtis Co., Gardner, NY). Protein solutions were spray dried (SD) using an Anhydro spray drier, size no. 1 (Anhydro, Inc., North Attleboro, MA) with a gravity feed and atomization with air at pressures of 15 psi, inlet temperature of 250°C and outlet temperature of 120°C. Protein solutions were also drum dried (DD) using a Buflovak atmospheric double drum dryer (6" x 8") Model no. ALC-4 (Blaw-Knox Co., Buffalo, NY). Drying temperature was 126°C and drum speed 2.0 rpm.

Storage Study

The FD and SD peanut protein preparations were packed in glass Mason jars and stored at 24°C ant 75% RH for periods up to 36 months. The steamed peanuts and the soybean protein preparations were not included in the storage study.

Chemical Analysis

Proximate analyses were conducted according to accepted standard procedures (AOAC, 1970).

Functional Properties

Solubility. Different weights of finely ground dried samples (20 mesh), to yield 1.0 g protein, were suspended in 100 ml 0.02M sodium phosphate buffer (pH 7.0). Each mixture was stirred for 15 min. to ensure wetting the sample. The pH was adjusted to 6.0, 7.0 or 9.0 using 1.0N HCL or 1.ON NaOH. The mixture was allowed to equilibrate at 24°C for one hr with continuous stirring. Aliquots of 10 ml each were centrifuged at 24°C for 20 min, at centrifugation forces of 2000 x g and 40,000 x g. Immediately following centrifugation, the supernatant was decanted, brought up to volume, mixed with Celite and filtered to remove any cloudiness. Soluble protein determination was carried out by the Biuret method as reported by Layne (1957). Total protein was calculated from Kjeldahl nitrogen using conversion factors of 5.46 and 5.71 (Orr and Watt, 1957) for peanuts and soybeans, respectively. Protein solubility was calculated as the percent of soluble protein compared to total protein as suggested by Shen (1976).

Emulsion capacity. Emulsion capacities of peanut and soybean proteins were determined according to the method used by McWatters and Cherry (1975) with the exception of using the appropriate protein concentration, adding 50 ml of sodium phosphate buffer (pH 7.0) and 50 ml of soybean oil and blending for 30 sec. at low speed prior to the addition of the remainder of oil by the buret. Emulsifying capacities are reported as ml of oil emulsified per 100 mg of soluble protein (wet weight basis).

Foaming capacity and stability. A 2.0% protein sample in 0.02M sodium phosphate buffer (pH 7.0) was equilibrated at 24°C for one hr. A 10.0 ml aliquot was placed in a foaming apparatus consisting of a 50 ml buret equipped with a fritted glass disc. Foaming was accomplished by bubbling N_2 gas at a controlled flow rate of 10cc/min. Foam was allowed to form for one min. and the foam volume or capacity (V_0) was recorded. Results are expressed as foam capacity per 100 mg protein (wet weight basis). The decreased foam volume after 15 min. (V_f) was also recorded. Foam stability was calculated from the relationship (V_f/V_0) x 100.

Results and Discussion

Peanut protein preparations contained more protein and less moisture, fat and ash than similarly processed soybeans (Table 1). Drying method did not influence appreciably the amount of peanut protein recovered while the freeze dried soybean preparation contained higher protein content than either the spray dried or drum dried preparations. Noticeable losses were observed in protein contents of stored spray dried peanut preparations especially after 36 months storage. Losses in protein content also occurred for the freeze dried preparation stored for 18 months. These findings are in accord with the report by Nash et al. (1971) of decreased extractability of 7S and 11S fractions of soybean proteins with prolonged storage up to 200 days at 25°C.

Table 1. Proximate analysis (fresh weight basis) of peanut and soybean proteins as influenced by processing and storage treatments.

Treatment	Composition (% w/w)			
	Moisture	Fat	Protein[1]	Ash
Peanut				
SD	2.0	3.2	78.1	2.6
FD	1.4	4.3	81.3	0.8
DD	4.9	1.4	80.5	3.0
Soybean				
SD	5.2	8.0	55.0	5.2
FD	4.2	4.5	61.6	2.4
DD	6.8	2.7	54.8	5.2
SD Peanut				
Fresh	2.0	3.2	78.1	2.6
24 mo. storage	4.2	2.1	75.5	2.6
36 mo. storage	1.9	6.3	69.1	2.6
FD Peanut				
Fresh	1.4	4.3	81.3	0.8
Steamed	2.9	4.5	76.5	0.8
18 mo. storage	3.3	2.5	76.9	0.8

[1]Protein calculated from Kjeldahl N values and conversion factors of 5.46 and 5.71 for peanut and soybean, respectively.

Shen (1976) determined the solubility of soybean proteins as influenced by centrifugation forces ranging from 460 x g for 10 min to 200,000 x g for 3 hr.

He found decreased solubilities only at the extreme of the high centrifugal force. He recommended the use of centrifugation speed of 42,000 x g for 20 min. However, in the present study no statistical differences were observed between the solubility values of all protein samples prepared at low and high centrifugation speeds (Table 2). This indicates the absence of relatively large sedimenting particles in the protein preparations extracted from peanut or soybean.

Table 2. Solubility[1] (%, soluble/total) of peanut and soybean proteins as influenced by centrifugation speed and pH.

	Treatment	pH 7.0		pH 9.0	
		Centrifugation Speed			
		2000xG	40000xG	2000xG	40000xG
Peanut	SD	67.9±4.8	62.1±3.6	79.4±3.0	74.2±4.9
	FD	65.7±2.6	65.4±2.8	73.8±5.2	71.1±4.4
	DD	18.6±2.2	19.0±2.0	28.9±1.6	24.9±3.2
Soybean	SD	62.1±1.3	58.4±3.4	82.4±2.3	77.8±2.1
	FD	80.1±0.8	76.4±2.9	85.8±2.2	86.1±0.5
	DD	12.2±1.9	12.4±1.9	21.0±1.5	21.2±4.3

[1]Solubility in 0.2M sodium phosphate buffer. Percentages expressed as mean ± standard deviation.

Table 3. Solubility (%)[1] of peanut and soybean proteins as influenced by drying method and pH.

Processing method	pH 4.0	pH 7.0	pH 9.0
		Peanut	
SD	9.1±0.1	67.9±3.8	79.4±3.0
FD	4.9±2.2	65.7±2.6	73.8±3.3
DD	7.7±1.4	18.6±2.2	28.9±1.6
		Soybean	
SD	44.4±5.8	62.1±1.3	82.4±2.3
FD	13.0±1.5	80.1±0.8	85.8±2.2
DD	10.2±1.4	12.2±1.9	21.0±1.4

[1]Solubility presented as mean ± standard deviation.

Drum dried peanut and soybean protein preparations displayed lower solubility values than either spray dried or freeze dried preparations (Table 3). Solubility of all preparations was dependent on pH, with lowest values at pH 6.0 and highest values at pH 9.0. Solubility at 7.0 is of importance since most food systems utilizing plant proteins as ingredients have similar pH. Solubilities at pH 7.0 ranged 5-11% less than those at pH 9.0, with the exception of spray dried soybean protein preparation (62.1% at pH 7.0 vs 82.4% at pH 9.0). Spray dried peanut protein was more soluble at pH 7.0 than spray dried soybean protein; the reverse was true for freeze dried preparations. The reduced solubility of the drum dried preparations probably was due to the more severe heat treatment during the drying cycle (126°C for almost 30 sec.). This is contrasted with the heat treatment in spray drying 250°C for a few sec., and in freeze drying where the maximum temperature reached was 60°C.

Similar solubilities were obtained for peanuts steamed at 107°C for 20 min. prior to protein extraction and for the non-heated peanuts (Fig. 1). Apparently this additional moist heat treatment was not severe enough to cause a reduction in solubility values. Cherry and McWatters (1975) and Cherry et al. (1975) found slight changes in protein solubility when full-fat peanuts were exposed to a moist heat of 100°C for 15 min. However, a gradual decrease in solubility was observed with increased heating time from 45 to 210 min. Moist heat treatment of peanuts is a desirable process since it inactivates any trypsin inhibitor present and improves the available lysine content and protein efficiency

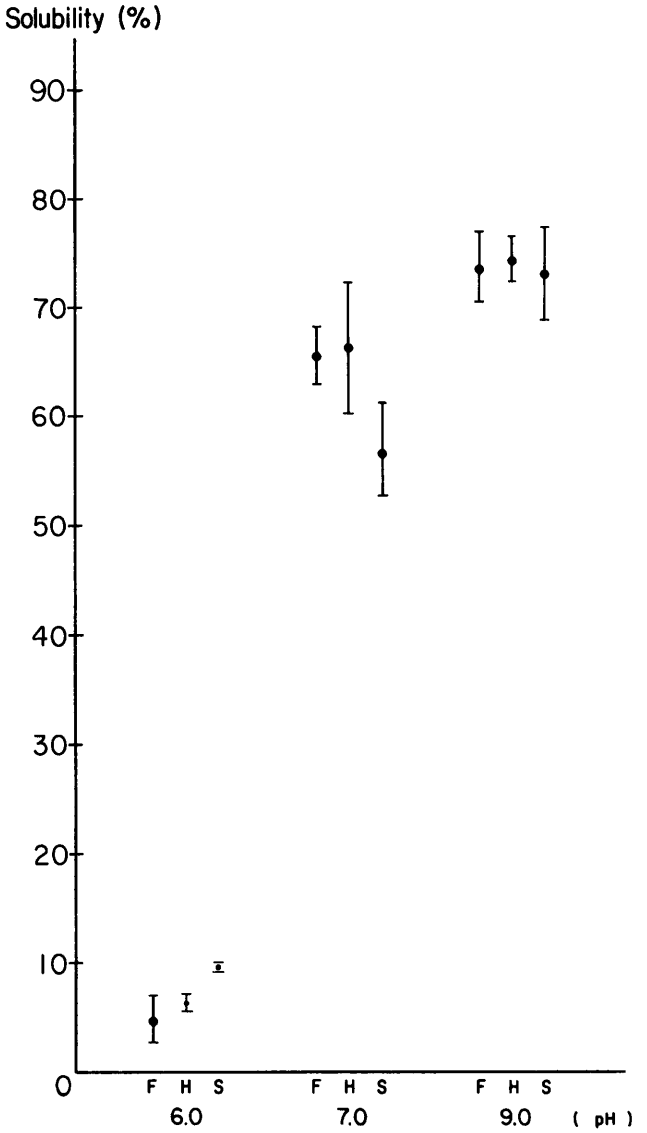

Fig. 1. Effect of moist heat treatment (107°C for 20 min.) and storage at 24°C on solubility (%) of FD peanut protein preparations. Results are expressed as means ± standard deviation, F=fresh, H = moist heat, S = 18 mo storage.

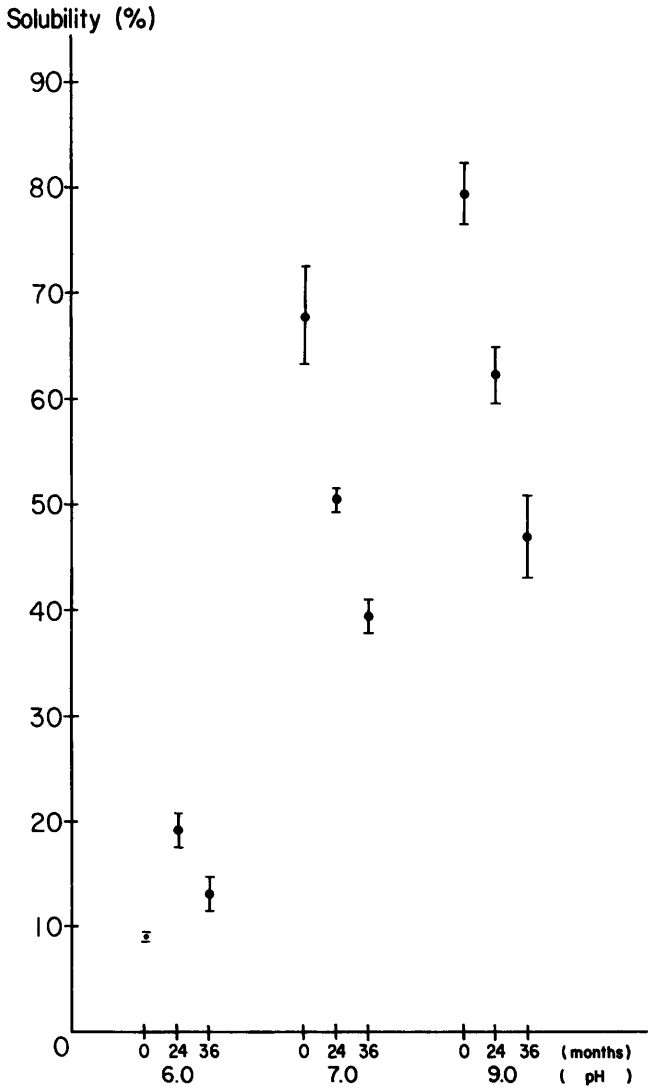

Fig. 2. Solubility (%) of SD peanut protein preparations as influenced by pH and storage at 24°C. Results expressed as means ± standard deviation.

ratio of peanuts (Neucere et al., 1972). The solubility at pH's 7.0 and 9.0 of the stored FD peanut protein were similar to the freshly prepared peanut preparation (Fig. 1). However, at pH 6, the stored product shows higher solubility than either the fresh or steamed peanut preparations.

Spray dried peanut protein preparations stored for 24 and 36 months had less soluble protein than the freshly prepared product (Fig. 2) at each pH used. The 36-month storage resulted in proteins with less solubility than the 24-month storage. Results obtained with the stored spray dried peanut preparation agree with the report of Nash et al. (1971) that the solubility of both 7S and 11S fractions of soybean protein decreased with prolonged storage of soybean meal.

Drum dried protein preparations exhibited less emulsifying capacity than the spray dried or freeze dried preparations (Table 4). Spray dried and freeze dried soybean protein had a higher capacity to emulsify protein-fat aqueous mixtures than similarily treated peanut protein. Freeze dried peanut protein preparations stored for 18 months showed less emulsifying capacity than similar preparations freshly made or extracted from steamed peanuts. Steaming did not influence emulsifying capacity of peanut proteins. This is in contrast to the reported improvement of emulsification capacity by heating peanuts (McWatters and Cherry, 1975). The apparent

Table 4. Emulsifying capacity[1] (ml oil/100 mg protein) of peanut and soybean proteins as influenced by processing and storage treatments.

Treatment	Emulsifying capacity	Emulsion pH
Peanut		
SD	25.1	7.0
FD	22.4	6.9
DD	12.5	7.2
Soybean		
SD	36.4	7.1
FD	41.4	6.9
DD	8.3	7.2
SD Peanut		
Fresh	25.1	7.0
24 mo. storage	25.2	7.2
36 mo. storage	21.9	7.0
FD Peanut		
Fresh	22.4	6.9
Steamed	22.8	7.0
18 mo. storage	11.9	6.7

[1]Results are expressed as the average of two replications.

Table 5. Foam capacity (V_0/100 mg protein)[1] and foam stability (V_f/V_o x 100) for peanut and soybean proteins as influenced by drying method.

Method	Foam capacity	Foam stability
	Peanut	
SD	26.3±1.0	26.8±1.8
FD	21.3±4.6	97.8±1.9
DD	21.7±11.6	19.1±7.1
	Soybean	
SD	34.4±6.9	90.0±9.5
FD	31.4±1.4	77.3±8.9
DD	38.9±9.3	18.4±8.0

V_o = initial volume

V_f = final volume after 15 minute intervals

[1]Foam capacity and foam stability values are presented as means ± standard deviation.

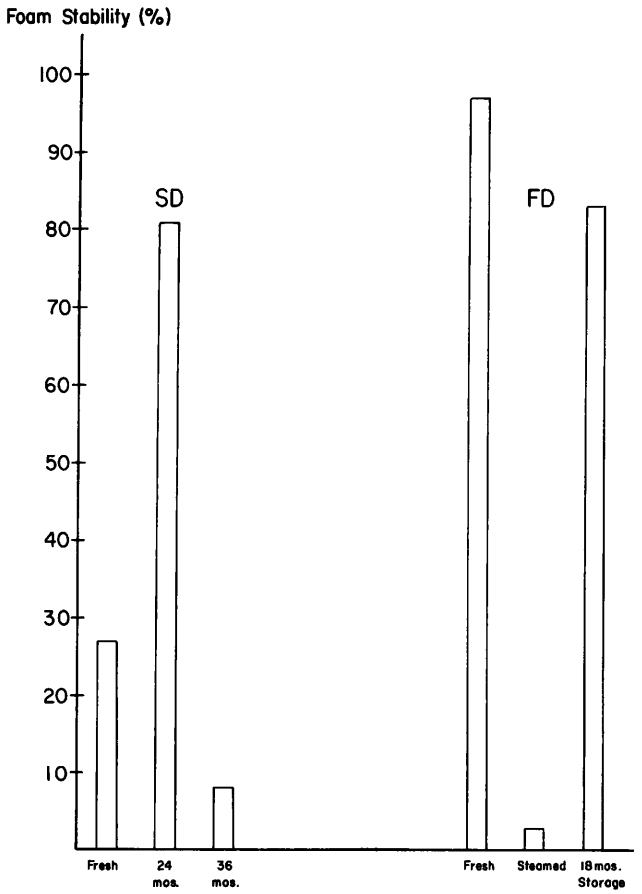

Fig. 3. Foam stability (%) of SD and FD peanut protein preparations as influenced by storage at 24°C and moist heat treatment (107°C for 20 min.).

variance in results is probably due to a difference in degree of heat treatment. More severe heat treatment was used by McWatters and Cherry (1975) (100° for 45-90 min). These authors observed no increases in emulsifying capacity by heating peanuts at 100°C for 15 and 30 min. No differences were found in the emulsifying of freshly prepared spray dried peanut protein preparations and those stored for 24 mo; a slight decrease occurred after 36 mo.

The capacity of soybean protein preparations to foam was higher than that of peanut protein preparations (Table 5). No significant differences were observed in the foaming capacity of both protein preparations due to the method of drying. Foams produced by the drum dried peanut and soybean protein preparations were less stable than those prepared by the spray or freeze drying. Freeze dried peanut preparation showed a better foam stability than the soybean preparation while the reverse was true for the spray dried preparations. Spray dried and freeze dried peanut protein preparations stored for 24 and 18 months, respectively, showed about 80% foam stability (Fig. 3). Extending the storage period to 36 months for the spray dried protein resulted in much decreased foam stability. Similarly, steaming peanuts prior to protein extraction led to a considerable loss in foam stability. Wu et al. (1976) found that washing of hexane-extracted sunflower meal with methanol increased its foam stability. Such a treatment may be needed to improve foam stability of peanut and soybean proteins.

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