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Functional Properties of Poppy Seed Meal

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Water and fat absorption capacity, emulsification capacity, and foam capacity and stability of defatted poppy seed meal have been determined and compared with those of soybean meal. Poppy seed meal had lower water absorption capacity but higher fat absorption capacity than soybean meal. The emulsification capacity was almost the same as that of soybean meal in the range pH 4.0–7.0. The foam capacity and stability values were inferior to those of soybean meal at all the pH values. Incorporation of NaCl up to 0.1 M improved emulsification capacity of poppy seed meal and foam capacity up to 0.2 M.

Poppy seeds are obtained from the fruits of *Papaver somniferum* L., which is cultivated as the chief source of commerical opium, with the seeds as a byproduct. The seed contains around 23% protein and 50% oil. The seeds are used in breads and confectionary and sweet preparations. From this laboratory, we have reported the solubility, gel filtration, gel electrophoresis, and ultracentrifugal behavior and amino acid composition of the total proteins of poppy seed (Srinivas and Narasinga Rao, 1981). However, there is no information available in the literature on the functional properties of poppy seed proteins meal. In this investigation, we report the water and fat absorption capacity, emulsification capacity, foam capacity, and foam stability of defatted poppy seed meal and compare them with those of defatted soybean meal.

MATERIALS AND METHODS

Poppy seed of the variety Dhawla chotta and soy bean of the variety Bragg were purchased from the Government Opium Factory, Neemuch, Madhya Pradesh, India, and the local market, respectively.

Preparation of Defatted Meals. Defatted poppy seed meal was prepared by the method reported earlier (Srinivas and Narasinga Rao, 1981). Poppy seed was cleaned to remove the impurities and then flaked. The flakes were solvent extracted six times with hexane and air-dried to remove the solvent. The defatted meal was ground to a fine powder and passed through a 80-mesh sieve (BSS). Defatted soybean meal was prepared as follows. Soybean was dried at 45 °C for 6–7 h, decuticled, and split in a sheller to remove the outer husk. Water (10%) was added to the split dhal, mixed thoroughly, and kept overnight for equilibration followed by flaking and drying at 45 °C. The dried flakes were defatted by repeated extraction with hexane.

The protein (N × 6.25) content of the poppy seed and soybean meal was 50.0% and 49.4%, respectively.

Water Absorption Capacity (WAC). The WAC was determined according to the procedure of Sosulski (1962). The values are expressed as the amount of water retained by 100 g of meal.

Fat Absorption Capacity (FAC). This was measured by the method of Sosulski et al. (1976) using groundnut oil. FAC is expressed as the amount of oil bound by 100 g of meal.

Emulsification Capacity (EC). This was determined according to the procedure of Beuchat et al. (1975) using 2 g of meal. Refined groundnut oil was used for the measurements. EC was determined as a function of pH and NaCl concentration at room temperture (~28 °C). EC is expressed as milliliters of oil emulsified by grams of meal.

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Table I. Water and Fat Absorption Capacity of Poppy Seed and Soybean Meal[a]

material	water abs, g/100 g of meal	fat abs, g/100 g of meal
poppy seed meal	124	250
soybean meal	149	138

[a] The values are average of duplicate determinations.

Foam Capacity (FC) and Foam Stability (FS). These were determined by the method of Lawhon et al. (1972). Meal (3 g) was taken in 100 mL of distilled water and the slurry was adjusted to the desired pH value (2.0–10.0). This was quantitatively transferred into Braun mixer and whipped for 5 min at 1600 rpm. The slurry was poured into a 250-mL measuring cylinder, and the total volume and the liquid volume were noted after 30 s. The difference in the volume is the foam and is expressed as percent foam capacity. The foam stability was determined by measuring the volume of foam at 5, 30, 60, and 120 min after pouring the slurry into the measuring cylinder and is expressed as percent volume increase.

The effect of salt was studied (at pH 6.4) by using NaCl solution of different molarities.

RESULTS AND DISCUSSION

Water Absorption Capacity (WAC). The WAC of poppy seed meal was 124% of its weight compared to 149% for soybean meal (Table I). The reported WAC of soybean meal ranges from 130 to 240% (Lin et al., 1974; Sosulski and Fleming, 1977). The lower WAC of poppy seed meal may suggest that poppy seed meal is less hydrophilic in nature than soybean meal. The polar amino acid residues of proteins have affinity for water molecules. The polar amino acid content of poppy seed proteins was 64.6 g/100 g (Srinivas and Narasinga Rao, 1981) and that of soybean proteins 62.9 g/100 g protein (FAO, 1972). Thus, there was no marked difference in the polar amino acid content of poppy seed and soybean proteins. The conformation of poppy seed (Srinivas and Narasinga Rao, 1985) and soybean proteins (Sureshchandra et al., 1984) is also nearly the same; both have about 30% β-sheet structure and 70% aperiodic structures. Perhaps, the polar amino acid residues do not play a critical role in determining WAC. More likely, differences in the nature of carbohydrates are responsible for the differences in WAC.

Fat Absorption Capacity (FAC). The FAC of poppy seed meal was 250% compared to 138% for soybean meal (Table I). The higher FAC of poppy seed meal indicates that it is more lipophilic than soybean meal. The nonpolar amino acid content of poppy seed proteins is 39.9/100 g (Srinivas and Narasinga Rao, 1981) and that of soybean

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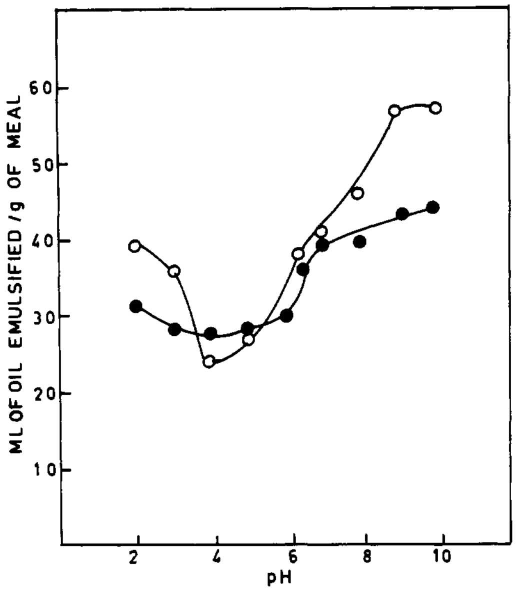

Figure 1. Effect of pH on the emulsification capacity: ●, poppy seed meal; ○, soybean meal.

41.0/100 g of protein (FAO, 1972). On this basis, FAC of poppy seed meal should be nearly the same as that of soybean meal. The reason for higher FAC of poppy seed meal is not clear. Probably other constituents apart from the proteins present in the meal (carbohydrate) might have contributed to FAC.

Emulsification Capacity (EC). Figure 1 shows the effect of pH on the EC of poppy seed and soybean meal. The EC vs. pH profile of poppy seed meal showed a broad minimum in the range of pH 3.0–6.0, compared to a sharp minimum at pH 4.0 with soybean meal. The values at minima were 27 and 24 mL of oil emulsified per gram of poppy seed and soybean meal respectively. The EC value of poppy seed meal was lower between pH 2 and 3 and pH 8 and 10 compared to soybean meal. However, at pH 7.0, the EC values for both the meals were almost the same. The nitrogen solubility of defatted poppy seed meal in water showed minimum solubility at pH 6.5 and pH 1–3. The solubility profile in 1 M NaCl solution was different from that in water. There was only one solubility minimum around pH 2.0, and at pH 6.6 the solubility was maximum (Srinivas and Narasinga Rao, 1981). Soybean meal is known to have minimum solubility at pH 4–4.5. Thus, the EC vs. pH profile resembled the nitrogen vs. pH profile for both the meals. Significant correlation between EC of various proteins such as bovine serum albumin, β-lactoglobulin, ovalbumin, lysozyme, and K-casein with surface hydrophobicity and solubility has been reported (Nakai, 1983).

The effect of NaCl concentration on the EC of poppy seed meal and soybean meal is shown in Figure 2. The measurements were made in water having the appropriate concentrations of the salt. The pH of the suspension was 6.4. In both cases, EC increased with increase in salt concentration up to a certain level and then decreased. The maximum value was observed at 0.1 and 0.4 M NaCl concentration with poppy seed and soybean meal, respectively. The beneficial effect of low concentrations of NaCl has been reported by several workers (Carpenter and Saffle, 1965; Nath and Narasinga Rao, 1981; Rahma, 1979; Narayana and Narasinga Rao, 1982; Ramanatham et al., 1978) and possibly is due to the salting in effect of NaCl. Ions cause changes in electrostatic and hydrophobic forces in proteins that in turn affect their EC (Damodaran and Kinsella, 1982).

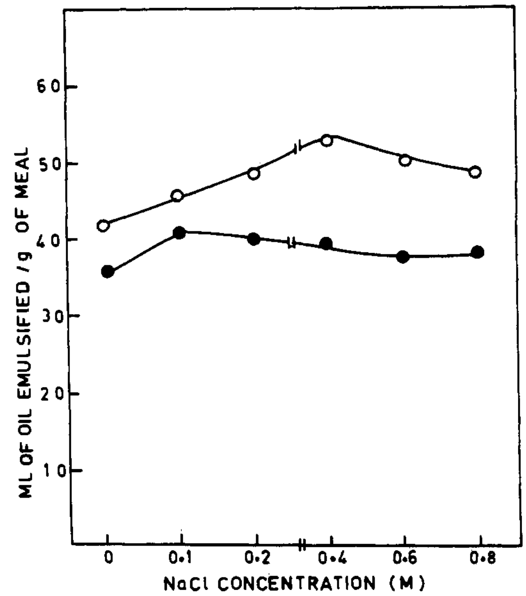

Figure 2. Effect of NaCl concentration on the emulsification capacity: ●, poppy seed meal; ○, soybean meal.

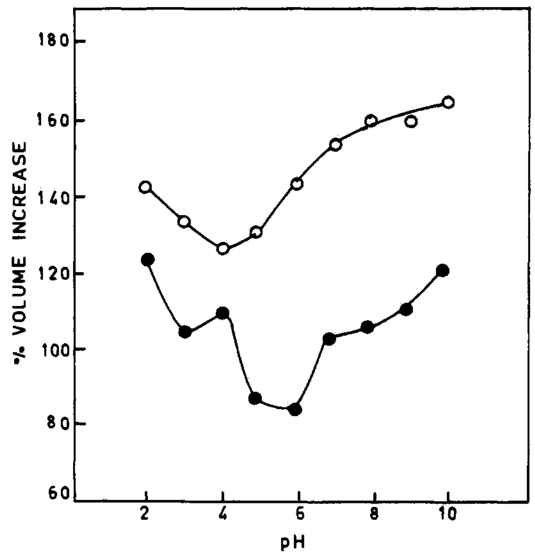

Figure 3. Effect of pH on the foam capacity: ●, poppy seed meal; ○, soybean meal.

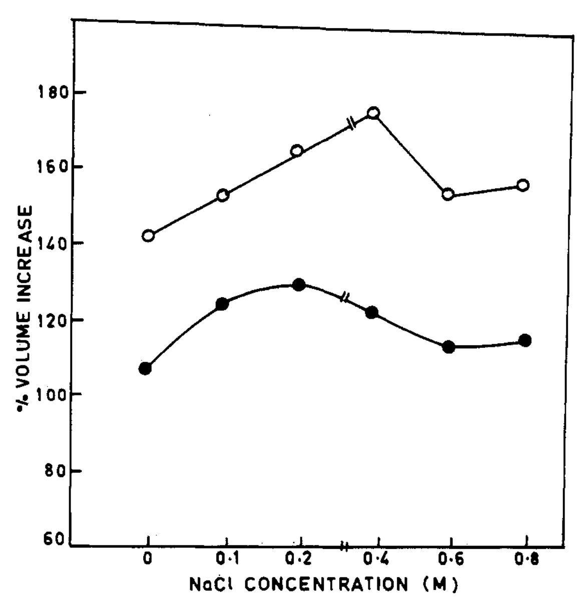

Figure 4. Effect of NaCl concentration on the foam capacity: ●, poppy seed meal; ○, soybean meal.

Table II. Foam Capacity and Foam Stability of Poppy Seed and Soybean Meal[a]

	pH	% volume increase 30 s	5 min	30 min	60 min	120 min
poppy seed meal	2.0	124	82	60	52	40
	3.0	104	58	48	44	34
	4.0	110	64	52	48	40
	5.0	88	44	34	34	34
	6.0	84	46	30	20	10
	6.5	104	52	10	b	b
	8.0	106	58	40	26	24
	9.0	112	64	44	22	16
	10.0	122	64	46	18	10
soybean meal	2.0	142	102	82	70	66
	3.0	134	94	80	68	64
	4.0	126	76	58	54	48
	5.0	132	100	62	58	56
	6.0	144	104	82	78	70
	7.0	154	116	92	84	78
	8.0	160	106	90	86	78
	9.0	160	108	88	80	56
	10.0	166	118	96	90	62

[a] The values are averages of two independent measurements. [b] Foam collapses.

Table III. Effect of NaCl Concentration on Foam Capacity and Stability of Poppy Seed and Soybean Meal[a]

	NaCl concn, M	% volume increase 30 s	5 min	30 min	60 min	120 min
poppy seed meal	0	106	70	40	b	b
	0.1	124	84	70	24	b
	0.2	128	86	70	14	b
	0.4	120	72	54	46	b
	0.6	112	62	53	44	12
	0.8	114	62	52	41	32
soybean meal	0	142	103	94	78	75
	0.1	152	118	102	94	86
	0.2	164	126	104	98	90
	0.4	168	122	98	91	85
	0.6	152	108	88	84	76
	0.8	154	106	84	80	74

[a] The values are averages of two independent determinations. [b] Foam collapses.

Foam Capacity and Foam Stability. Figure 3 shows the FC vs. pH profile of poppy seed and soybean meal. At extreme acid and alkaline pH, EC was high, and its value was minimum at pH 6.0 for poppy seed meal and pH 4.0 for soybean. The FC value of poppy seed meal was inferior to that of soybean at all the pH values studied.

The effect of NaCl on the FC of both the meals in the range of 0–0.8 M NaCl concentration is shown in Figure 4. In these measurements, the pH of the meal suspension was 6.4. In contrast to soybean meal, which showed increase in FC values upto 0.4 M NaCl concentration, poppy seed meal showed higher FC values up to 0.2 M NaCl concentration only. Salts probably affect foaming by enhancing solubility at lower concentration. At high concentrations salting out may occur and thus reduce foaming (Kinsella, 1976).

FS of the meals was determined by measuring FC over a period of time. FS was also studied as a function of NaCl concentration. The pH of the slurry in this experiment was 6.4. The results are given in Tables II and III.

The FC of poppy seed meal decreased to a value of 70% from an initial value of 106% at the end of 5 min. The foam collapsed at 60 min. However, NaCl concentration in the range of 0.6 and 0.8 M afforded little protection to the foam. The FS of poppy seed meal in water and NaCl solution was lower than that of soybean meal. For poppy seed meal, the FS increased with NaCl concentration up to 0.2 M. Above this concentration, FS decreased. The FC and FS of poppy seed meal was inferior to that of soybean meal at all the pH values and different NaCl concentration (Tables II and III). Perhaps, this could be attributed to the properties of poppy seed proteins. The foaming property is also influenced by various factors such as protein sources, method of preparation, composition, solubility, pH, concentration, temperature, duration of heating, and presence of salts, sugars, etc. (Kinsella, 1976).

Registry No. H_2O, 7732-18-5; NaCl, 7647-14-5.

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