et al., 1984a), especially since both these activities were detected in a field sample of corn in the U.S.

Registry No. Moniliformin, 52591-22-7; fusarin C, 79748-81-5.

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Received for review January 10, 1986. Accepted June 9, 1986.

Functional Properties of Rapeseed Protein Products with Varying Phytic Acid Contents

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Rapeseed meal and three rapeseed protein isolates containing different levels of phytic acid (0.9–4.6%) were compared with soybean meal and a commercial soybean protein isolate in terms of functional properties. Rapeseed products exhibit lower nitrogen solubility, higher water absorption, lower moisture adsorption, and, in some cases, better oil absorption than the corresponding soybean products. In general, rapeseed products show similar or higher emulsifying activity and emulsion stability compared with soybean products. The low-phytate products have better emulsifying properties than their high-phytate counterparts. Rapeseed products are characterized by overall favorable foaming capacity and foam stability compared with soybean products. The foaming properties are concentration dependent and are influenced by NaCl and sucrose. The level of phytic acid barely affects the foaming properties of rapeseed products.

Several groups have developed processes for the production of rapeseed protein concentrates and isolates; the different approaches have been summarized in some reviews (Rutkowski, 1975; Olson and Anjou, 1979; Sosulski, 1983; Mieth et al., 1983).

A procedure was reported from this laboratory for preparing two rapeseed protein isolates of acceptable light colors in high yield, employing a countercurrent alkaline extraction of the meal protein and its subsequent two-step precipitation from the extract at pH 6.0 and 3.6 (El Nockrashy et al., 1977). In a later study, it was observed that conditions favoring a high yield of protein isolates also result in enrichment of phytic acid in the isolates (Blaicher et al., 1983). A procedure involving acidic extraction of phytates from rapeseed meal at pH 4.0 prior to countercurrent extraction of the protein at pH 11.0 and subsequent isoelectric precipitation of protein at pH 4.7 could eliminate most of the phytic acid from the isolate although the protein yield was thereby considerably reduced (Blaicher et al., 1983).

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The functional properties of rapeseed protein products have not been studied extensively (Sosulski, 1983). It is well-known that the processing steps employed as well as the associated nonprotein components can significantly influence the functional properties of protein products. In the present study, therefore, the functional properties of low- and high-phytate rapeseed isolates prepared by countercurrent extraction–isoelectric precipitation procedure (El Nockrashy et al., 1977; Blaicher et al., 1983) have been determined and compared with those of a commercial soybean isolate. A major objective of this study was to find if the phytic acid contents of the products had an influence on their functional properties.

EXPERIMENTAL SECTION

Materials. Rapeseed, *Brassica napus*, cv. Erglu, was defatted into rapeseed meal from which two rapeseed protein isolates, RPI-I and RPI-II, were prepared according to El Nockrashy et al. (1977) by countercurrent extraction of the meal protein followed by consecutive precipitations at pH 6.0 and 3.6, respectively. In addition, a low-phytate rapeseed protein isolate (RPI-III) was prepared from rapeseed meal by extraction of phytate at pH 4.0 prior to countercurrent extraction of the protein at pH 11.0 and its precipitation at pH 4.7 (Blaicher et al., 1983). Edible grade soybean, *Glycine max*, was ground, defatted by ex-

0021-8561/86/1434-0775$01.50/0

traction with *n*-hexane in a Soxhlet apparatus, desolventized at room temperature, and sieved to pass a 0.20-mm screen. This soybean meal was used as a standard for comparison with rapeseed meal. The soybean protein isolate employed for comparison was a commercial product (Purina Protein 710) that was kindly provided by Interfood Deutschland GmbH, D-6380 Bad Homburg, Federal Republic of Germany.

Chemical Analyses. Moisture content of the samples was determined by drying in an air oven at 130 °C for 1 h, and nitrogen estimations were carried out according to a semimicro Kjeldahl procedure (AOAC, 1975). Phytic acid was determined by the procedure adopted by Blaicher et al. (1983).

Functional Properties. Nitrogen solubility was determined as follows. The sample was dispersed in distilled water at a meal to solvent ratio of 1:20 (w/v) by a magnetic stirrer and the dispersion adjusted to pH 7.0 by addition of 0.2 N NaOH under stirring. Following further stirring for 30 min, the pH was checked and readjusted if necessary. The dispersion was centrifuged at 1000*g* for 10 min, and nitrogen in the aliquots taken from the supernatant was estimated. Nitrogen solubilized was expressed as the percent of the nitrogen content of the sample.

Water absorption was determined by dispersing 0.5 g of the sample in 3 mL of distilled water in a centrifuge tube by a Vortex mixer. Other steps were similar to those outlined by Sosulski (1962). Five determinations were carried out on each sample.

Moisture adsorption was estimated by measuring the percent weight gain after exposing the sample for 48 h to a relative humidity of 84% that was built up with saturated KCl solution in a desiccator at 25 °C (Hagenmaier, 1972). Estimations were performed in duplicate.

Oil absorption was estimated by the method of Lin et al. (1974) using corn oil (Mazola, Maizena Markenartikel GmbH, D-7100 Heilbronn, Federal Republic of Germany). However, oil retained by the sample was measured as weight gain by the sample due to oil absorption (Dench et al., 1981). Five estimations were carried out on each sample.

Bulk density was determined by the method of Wang and Kinsella (1976), and means of four determinations were reported.

Emulsifying activity and emulsion stability of the samples were studied by the method of Yasumatsu et al. (1972), but emulsions were prepared with sample dispersions at pH 7.0 at an ultimate sample concentration of 2.5% (w/v) in the emulsions. The sample, 1.25 g, was dispersed in 20 mL of distilled water with a magnetic stirrer. The dispersion was adjusted to pH 7.0 with 0.2 N NaOH and the volume made up to 25 mL with distilled water. Corn oil (Mazola), 25 mL, was added and the mixture homogenized for 3 min at the highest speed (Ultra-Turrax homogenizer, Janke & Kunkel, D-7813 Staufen, i.Br., Federal Republic of Germany). The emulsion so obtained was divided between two 30-mL centrifuge tubes and centrifuged at 1300*g* for 5 min. The height of the emulsion layer, expressed as percent of the total height of fluid in the tube, was reported as emulsifying activity. Emulsion stability was determined in a similar manner, but heating (80 °C/30 min in a water bath) and cooling (running tap water, 15 min) of the emulsion preceded centrifugation. Emulsions were prepared in duplicate.

Least gelation concentration was determined by the method of Coffmann and Garcia (1977), employing the modification described by Sathe et al. (1982).

Table I. Protein and Phytic Acid Contents of Rapeseed and Soybean Products[a]

sample	protein (N × 6.25), %	phytic acid, %	pH of suspensn (10% w/v) in water
rapeseed meal	41.0	4.3	5.9
RPI-I	92.9	4.6	6.3
RIP-II	98.2	1.3	3.7
RPI-III	94.4	0.9	4.7
soybean meal	52.8	1.4	6.8
soybean isolate	92.0	0.7	7.0

[a] Expressed on a dry-weight basis.

Emulsifying capacity was determined in 10 mL of a 1% (w/v) aqueous dispersion of the sample at pH 7.0 by titrating with corn oil (Mazola) colored with Oil-Red-O (Marshall et al., 1975) to the breakpoint of the emulsion. Emulsifying capacity was expressed as the amount of oil emulsified by 100 mg of sample. Subsequently, a volume of oil equivalent to 80% of the emulsifying capacity was added to 10 mL of the sample dispersion and blended for 10 s (Thompson et al., 1982) on a Virtis 23 blender (The Virtis Co., Gardiner, NY), Model 6-105-AF. The emulsion was transferred to a 50-mL graduated cylinder and emulsion stability recorded in terms of the percent aqueous phase separated over a period of 0–6 days. Means of two or more estimations were recorded for both emulsifying capacity and emulsion stability.

Foaming capacity and foam stability were evaluated as follows. The sample, 4.0 g, was whipped with 40 mL of distilled water for 5 min at high speed in a Virtis 23 blender. The total volume as well as the volume of liquid draining out of the foam were read at definite intervals of time in the precalibrated Virtis flasks. Foaming capacity was measured in terms of volume increase on whipping expressed as percent of original volume of the liquid. Foam stability was expressed as percent liquid drainage in relation to initial liquid volume as a function of standing time. Since foam volume did not change proportionally with drainage, it was also recorded at intervals. Foaming capacity and foam stability were also determined at neutral pH. Adjustment of pH was carried out as in the determinations of emulsifying activity and emulsion stability. Effects of concentration on foaming were evaluated by whipping 2, 4, 6, 8, and 10% (w/v) slurries. Foaming experiments were also carried out in 0.5 M NaCl solution and in aqueous dispersions at a sample to sucrose ratio of 1:1 (w/w). All foaming experiments were conducted in duplicate.

In all functional tests, the recorded observations on any given sample had a coefficient of variation of <2%.

RESULTS AND DISCUSSION

Composition of Protein Products. The protein and phytic acid contents of rapeseed and soybean products are shown in Table I. Rapeseed meal contains considerably less protein than soybean meal. The values for the two meals are comparable with those reported by Sosulski and Bakal (1969) for rapeseed meal and dehulled soybean meal on an oil-free dry basis. In the present study, the soybean meal used was practically free of hulls because these could be efficiently eliminated by sieving. Rapeseed isolates have similar protein contents, which, in turn, are comparable with that of soybean isolate.

The rapeseed isolate, RPI-I, obtained by precipitation at pH 6.0 from the alkaline extract, has the highest phytic acid content (Table I), indicating that most of the phytic acid forms insoluble complexes with proteins during this precipitation. Though somewhat lower in phytic acid than RPI-I, rapeseed meal has the highest phytic acid to protein

Table II. Nitrogen Solubility, Water Absorption, Moisture Adsorption, Oil Absorption, and Bulk Density of Rapeseed and Soybean Products

sample	N sol (pH 7.0), %	water abs, g/g	moisture ads, g/g	oil abs, g/g	bulk density, g/mL
rapeseed meal	40.7	2.18	8.49	1.39	0.234
RPI-I	5.0	2.34	7.57	1.96	0.296
RPI-II	17.6	2.10	7.23	1.92	0.273
RPI-III	50.2	1.96	8.13	0.95	0.671
soybean meal	76.8	1.75	10.72	1.51	0.381
soybean isolate	56.0	1.49	12.41	1.56	0.434

ratio. The RPI-III and the soybean isolate exhibit the lowest phytic acid contents.

Nitrogen Solubility, Water Absorption, Moisture Adsorption, Oil Absorption, and Bulk Density. The data presented in Table II show that, among the rapeseed products, RPI-I has the lowest nitrogen solubility. Only 5% of the sample nitrogen from RPI-I was soluble at pH 7.0, which lies near its isoelectric region. The RPI-II, prepared by precipitation at pH 3.6, exhibits considerably higher nitrogen solubility at neutral pH than RPI-I but markedly lower than RPI-III. The value for nitrogen solubility of RPI-III at pH 7.0 is higher than those reported by Sosulski et al. (1976) for a rapeseed protein isolate at pH 6.0 (12.7%) and at pH 8.0 (36.9%). For the preparation of RPI-III, the meal was subjected to a preextraction at pH 4.0 that ensures maximum dissolution of phytic acid and minimum dissolution of meal nitrogen. This step, apparently, does not exert an adverse influence on the solubility of the final product. The nitrogen solubility of RPI-III at pH 7.0 approaches that of soybean isolate. Rapeseed and soybean meals have widely differing nitrogen solubilities at neutral pH. The values obtained in the present study are consistent with those reported in the literature (Sosulski and Bakal, 1969; McWatters and Holmes, 1979).

Apart from the nature of the proteins in different products, the phytic acid content also appears to influence their nitrogen solubility. In general, nitrogen solubility at pH 7.0 increases with decreasing levels of phytic acid in the product. The differences in nitrogen solubility between rapeseed meal and RPI-I, despite their similar phytic acid contents, may be due to native state of proteins in rapeseed meal as well as differences in the nature of phytate–protein complexes in the meal compared with the isolate.

All the rapeseed products investigated have similar values of water absorption (on an average 2.0 g/g) (Table II). Sosulski et al. (1976) reported values of water absorption of around 3.0 g/g for rapeseed meal and a rapeseed protein isolate. Varietal differences as well as differences in the mode of preparation of the products may be responsible for these deviations. Despite its markedly lower protein content, rapeseed meal shows a water absorption similar to those of rapeseed isolates. This suggests that the nonprotein components of rapeseed, especially the carbohydrates and crude fibers, exhibit similar water-binding capacity as the proteins.

The soybean products absorb less water compared with the rapeseed products. The soybean isolate has the lowest water absorption among all the products tested. Commercial soybean isolates vary widely in their water absorption capacities. Another soybean isolate (Purina Protein 500 E) showed a water absorption of 6.0 g/g of sample. It is known that a determination of water absorption of protein products by the centrifuge method does not allow a true assessment of the water-binding capacity of products that contain a high proportion of water-soluble protein (Quinn and Paton, 1979; Thompson et al., 1982). Therefore, the data on water absorption reported are supplemented by values of moisture adsorption (Table II). These results illustrate a distinct difference in the water-binding pattern between rapeseed and soybean products. Soybean isolate, having the least water absorption, exhibits the greatest moisture adsorption. Soybean meal also has considerably higher moisture adsorption than the rapeseed products. The soybean products contain substantially higher proportions of water-soluble protein than the rapeseed products as indicated by the data on nitrogen solubility at pH 7.0 (Table II). The lowest water absorption by the soybean products despite the highest moisture adsorption is apparently due to the loss of soluble protein in the supernatant during the determination of water absorption by the centrifuge method. The different rapeseed products, however, do not differ significantly in their moisture adsorption. The data on moisture adsorption show that soybean proteins inherently possess a higher water-binding capacity than rapeseed proteins. This may be ascribed to possible differences in the proportion of hydrophilic groups as well as to differences in the conformational features of the two groups of proteins.

Table III. Gelation and Emulsification Characteristics of Rapeseed and Soybean Products

sample	least gelation concn, %	emuls act. (pH 7.0), %	emulsn stability (pH 7.0), %
rapeseed meal	10	61	89
rapeseed meal[a]	*b*	78	95
RPI-I	8	68	80
RPI-II	12	61	61
RPI-III	>16	87	91
soybean meal	12	65	67
soybean isolate	16	66	65

[a] Emulsion containing 6% (w/v) rapeseed meal. [b] Not determined.

Rapeseed products differ considerably in their oil absorption (Table II). While RPI-I and RPI-II have similar values of oil absorption, RPI-III shows a markedly lower value. Oil absorption of rapeseed meal is intermediate between that of RPI-III and those of RPI-I and RPI-II. Rapeseed meal also shows a somewhat lower oil absorption than soybean meal. The rapeseed isolates, RPI-I and RPI-II, exhibit higher oil absorption than the soybean isolate, but for RPI-III the oil absorption is very low. The values of oil absorption for rapeseed products given in Table II are markedly lower than those reported by Sosulski et al. (1976) and Thompson et al. (1982). These authors, however, estimated oil absorption by reading the volume of free oil following centrifugation either by direct means or after decanting. This procedure, to our experience, often leads to an overestimation of the amount of oil actually retained by the sample. Nonpolar side chains of protein molecules are considered to be the primary sites of lipid–protein interaction. However, oil absorption estimated by the centrifuge method would obviously be influenced by the capacity of the sample to physically trap oil in its bulk volume. In support of this assumption, there are reports that show a high negative correlation between oil absorption and bulk density for sesame, soybean, and alfalfa leaf proteins (Wang and Kinsella, 1976; Dench et al., 1981). The values of oil absorption and bulk density in Table II appear to be broadly consistent with the above observations.

Gelation and Emulsion Properties. The data given in Table III show that RPI-I has the minimum value of

Table IV. Emulsifying Capacity and Emulsion Stability of Rapeseed and Soybean Products

sample	emul capacity (pH 7.0), mL oil/100 mg sample	% aq phase separated at room temp (21 °C) after time (day)					
		0	0.25	1.0	2.0	3.0	6.0
rapeseed meal	21.7	0	68	70	72	75	85
RPI-I	25.0	0	68	75	75	75	75
RPI-II	30.3	0	0	0	0	0	0
RPI-III	26.2	0	0	0	0	0	0
soybean meal	26.5	0	10	15	20	20	23
soybean isolate	43.5	0	0	0	0	0	0

Table V. Foaming Capacity and Foam Stability of Rapeseed and Soybean Products

sample	vol inc, %	foam vol (%) after time (min)				drainage (%) after time (min)					
		0	5	60	120	5	10	30	60	90	120
rapeseed meal	209	100	83	71	70	50	59	72	76	76	76
RPI-I	233	100	82	74	73	61	69	79	85	86	86
RPI-II	214	100	84	78	74	51	56	64	66	69	69
RPI-III	208	100	78	62	56	64	75	86	89	91	91
soybean meal	173	100	76	66	64	65	68	78	85	86	89
soybean isolate	204	100	83	73	70	51	61	76	78	78	79

least gelation concentration. Heated and cooled dispersions of RPI-III show no firmness up to a concentration of 16%. The rapeseed isolates, RPI-I and RPI-II, show lower values of least gelation concentration than the soybean isolate, and the corresponding value for rapeseed meal is lower than that of soybean meal. However, least gelation concentration, in our opinion, does not characterize the true gelling property of rapeseed products. In fact, at higher concentrations, heated and cooled dispersions of rapeseed products form highly viscous, often immobile pastes but fail to exhibit the typical gelation characteristics of soybean products. Similar observations have been made with various rapeseed products by Sosulski et al. (1976) and Thompson et al. (1982).

The emulsifying properties are known to be significantly influenced by pH. Therefore, these properties were determined at pH 7.0 for all the products for a reliable comparison. Both emulsifying activity and emulsion stability of rapeseed products compare favorably with those of the corresponding soybean products (Table III). The proportions of soluble protein in the products seem to influence their emulsion characteristics significantly. Thus, RPI-III, having a high nitrogen solubility and a low phytic acid content (Tables I and II), shows better emulsion characteristics than the other rapeseed products (Table III). Moreover, at equivalent sample concentrations, the emulsifying activity of rapeseed meal compares well with those of RPI-I and RPI-II, but at equivalent protein concentration, i.e. 2.5 times sample concentration and correspondingly higher proportion of soluble protein, rapeseed meal shows considerably higher emulsifying activity. Previous reports have also shown that emulsifying activity of protein products from various sources are related to their soluble protein contents (Yasumatsu et al., 1972; Volkert and Kelin, 1979).

In general, rapeseed products show considerably higher values of emulsion stability than emulsifying activity. This tendency is either absent or insignificant with soybean products. Since the sample concentration chosen is high enough to completely emulsify all the added oil, variations in the values of emulsifying activity and emulsion stability are primarily due to water loss during centrifugation. It appears that in different samples the hydrophilic side chains of the protein molecules oriented toward the aqueous phase can bind and retain varying amounts of water, thus giving rise to variations in emulsifying activity. It is possible that heating leads to dissociation of some proteins and that the subunits have more water-binding sites than the oligomeric protein, with the net result of an incresed emulsion stability compared with emulsifying activity. The low-phytate rapeseed isolate (RPI-III), having the highest emulsifying activity among all the products tested, also exhibits the highest emulsion stability.

Emulsifying capacity values determined by a titration method show a somewhat different pattern compared with those of emulsifying activity and emulsion stability (Table IV). Among the rapeseed products, RPI-II has the highest emulsifying capacity. The other two rapeseed isolates exhibit similar emulsifying capacities. Rapeseed meal has a lower emulsifying capacity than soybean meal whereas all the rapeseed isolates are poorer emulsifiers than soybean isolate. The emulsifying capacities of the rapeseed isolates presented in Table IV are slightly lower than those reported by Kadagoda et al. (1973). Emulsions prepared with soybean isolate as well as RPI-II and RPI-III did not show separation of water up to 6 days (Table IV). The RPI-I has a poor emulsion stability, with 75% of the water phase of its emulsion being separated within 24 h. In comparison with soybean meal, rapeseed meal exhibits distinctly poor emulsion stability. The results given in Table IV also show that the low-phytate products, RPI-II and RPI-III, have emulsion properties superior to the high-phytate products, RPI-I and the rapeseed meal.

The two sets of data on emulsion properties presented in Tables III and IV indicate that emulsions prepared with protein products behave differently when emulsification is carried out with a large excess of sample in the aqueous phase than when emulsion is prepared with just enough sample in the dispersion to emulsify all added oil. A decrease in emulsifying capacity with increased protein concentration has been observed by Lin et al. (1974) with sunflower seed and soybean and by Sathe et al. (1982) with lupin seed products.

Foaming Properties. The data on foaming capacity and foam stability of rapeseed and soybean products, determined at neutral pH, are given in Table V. Rapeseed products show better foaming capacity than the corresponding soybean products. Sosulski et al. (1976) also reported increased whippability of rapeseed flour, concentrates and an isolate as compared with soybean products. The data given in Table V show that the highest volume increase is exhibited by RPI-I but, in terms of percent drainage, RPI-II has the greatest foam stability.

Table VI. Effect of Salt (NaCl) and Sugar (Sucrose) on Foaming Capacity and Foam Stability of Rapeseed Products

sample[a]		vol inc, %	foam vol (%) after time (min) 0	5	60	120	drainage (%) after time (min) 5	10	30	60	90	120
rapeseed meal	A[a]	208	100	83	74	72	51	61	71	76	78	78
	B	209	100	80	72	70	59	66	75	79	80	83
	C	215	100	83	73	72	54	63	75	79	80	80
RPI-I	A	234	100	81	75	73	53	65	74	78	80	80
	B	221	100	93	74	72	20	51	68	75	78	80
	C	243	100	85	75	73	51	58	68	69	69	76
RPI-II	A	244	100	84	80	79	51	58	61	63	63	63
	B	259	100	97	83	82	19	38	50	55	56	58
	C	243	100	88	81	80	41	50	56	60	61	61
RPI-III	A	63	46	25	17	14	98	98	98	98	98	98
	B	200	100	95	73	70	13	44	61	68	70	73

[a] Key: A = without additive at unadjusted pH values of 5.9, 6.3, 3.7, and 4.7 for rapeseed meal, RPI-I, RPI-II and RPI-III, respectively; B = with 0.5 M NaCl; C = with sucrose at sample to sucrose ratio of 1:1 (w/w).

Table VII. Effect of Sample Concentration on Foaming Properties of Rapeseed Products

sample concn, %	rapeseed meal vol inc, %	rapeseed meal drainage after 60 min, %	RPI-I vol inc, %	RPI-I drainage after 60 min, %	RPI-II vol inc, %	RPI-II drainage after 60 min, %
2	223	86	130	85	125	83
4	208	76	234	78	244	63
6	194	70	238	68	235	51
8	191	63	233	59	231	50
10	194	60	206	49	234	35

Foams from RPI-I and RPI-III are marginally less stable than those from soybean isolate. On the other hand, the foam obtained with rapeseed meal has a distinctly higher stability than that obtained with soybean meal. A comparison with the data presented in Table II, however, does not show any close relationship between nitrogen solubility and foaming properties. Structural and conformational features of proteins as a whole rather than solubility alone appear to be the primary determinants for foaming properties.

Table VI shows the values of foaming capacity and foam stability of rapeseed products as influenced by NaCl and sucrose. A comparison with the data in Table V indicates that foaming capacity as well as foam stability of rapeseed meal and RPI-I at unadjusted pH values does not differ significantly from those at pH 7.0. This is probably because even without adjustment their pH lies close to 7.0 and consequently there is not much difference in ionic environment. In the case of RPI-II, an increase in foaming capacity and foam stability at its unadjusted pH over pH 7.0 is evident. In contrast, RPI-III forms a very poor and unstable foam at its unadjusted pH, apparently because of its minimum solubility at that pH.

Sodium chloride exerts variable influence on individual products (Table VI). Thus, NaCl does not affect the foaming capacity of rapeseed meal but causes a decrease in foam stability. With RPI-I, addition of NaCl results in a loss of foaming capacity and an increase in foam stability. Sodium chloride increases foaming capacity as well as foam stability of RPI-II and RPI-III, the influence being very pronounced on the latter. Literature reports on influence of salts on protein foams are conflicting. Increased foaming capacity of proteins often observed at lower concentrations of NaCl has been attributed to increased protein solubility (Sosulski, 1977). Normally, salts destabilize protein foams primarily because they reduce the electrostatic forces between polypeptide chains by increasing the ionic strength of the medium (Kinsella, 1981). The native proteins in rapeseed meals seem to behave accordingly in the presence of NaCl. It is likely that the rapeseed protein isolates contain high proportions of salt-soluble globulin and improvement in solubility caused by NaCl overcomes the destabilizing influence of increased ionic strength. Addition of sugar leads to a slight increase in foaming capacity of rapeseed meal and RPI-I. In the case of rapeseed meal, the foam stability remains practically unchanged. However, with RPI-I and RPI-II a marginal increase in foam stability is observed. According to Kinsella (1981) polyhydroxy compounds such as sucrose tend to enhance foam stability, apparently by increasing the viscosity of lamellar water and thereby retarding drainage.

The foaming properties of rapeseed products are dependent on concentration (Table VII). In the case of rapeseed meal, foaming capacity decreases with increasing sample concentration in aqueous dispersions from 2 to 6%. For RPI-I and RPI-II, a pronounced increase in foaming capacity occurs on increasing sample concentration in the dispersion from 2 to 40%. Further increase in sample concentration decreases foaming capacity of RPI-II marginally. In the case of RPI-I, the foaming capacity increases slightly up to a sample concentration of 6% and then decreases gradually. With RPI-I and RPI-II, it seems that, at a sample concentration of 2%, the proportion of the soluble protein in the dispersion is not high enough to cover the entire air–water interface available for subsequent interaction and stabilization of the air droplets, thus resulting in poor foaming capacity. It was observed during whipping that, at lower concentrations of sample in the dispersions, relatively large air bubbles are formed. The decrease in foaming capacity beyond a particular sample concentration depending on the product is primarily due to formation of finer bubbles and stronger foams. This is also evidenced from the steadily decreasing drainage with increasing concentration of samples.

The results presented in Tables V–VII indicate that, in general, the phytic acid level in the products does not have any noticeable influence on foaming properties. The high-phytate products and the low-phytate ones perform equally well as foaming agents. An exception is the relatively poor foaming capacity and foam stability of RPI-III compared with the other two rapeseed isolates that may

be due to acid treatment prior to protein extraction (Blaicher et al., 1983).

CONCLUSIONS

Rapeseed products having low or high phytic acid content exhibit overall favorable functional properties compared with soybean products. This indicates that, irrespective of the phytic acid content of the final product, countercurrent extraction followed by isoelectric precipitation yields protein products with good functional properties. Phytic acid, in the range present in rapeseed products investigated, apparently has little influence on the functional properties with the exception of emulsifying capacity and emulsion stability (Table IV), which are generally better for products containing low levels of phytic acid. Removal of phytic acid by acid extraction prior to protein extraction was aimed at preparing a nutritionally favorable product (Blaicher et al., 1983). This treatment obviously does not influence most of the functional properties of the protein isolate adversely. However, some loss in foaming capacity and foam stability occurs. The overall good foaming properties of rapeseed products compared with soybean products indicate a good potential for their application in whipped food products.

Registry No. NaCl, 7647-14-5; phytic acid, 83-86-3; sucrose, 57-50-1.

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Received for review December 26, 1985. Accepted May 14, 1986.

Rapid Determination of Cell Wall Monosaccharides in Flaccidgrass[1]

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A two-stage trifluoroacetic acid (TFA) hydrolysis (2 N TFA followed by 0.25 N TFA each for 1 h at 121 °C) gave repeatable recoveries of fiber monomers and allowed detailed analyses of structural carbohydrates in a subtropical grass. The second hydrolysis was essential to cleave glycosyl trifluoroacetates, formed in the primary hydrolysis, to the free carbohydrate monomers and TFA. At optimal hydrolysis conditions cell wall preparations of *Pennisetum flaccidum* Griseb. (flaccidgrass), with neutral detergent fiber concentrations of 67.3%, yielded xylose, glucose, arabinose, and galactose monomers in the ratio of 24:11.5:5:1, respectively. Optimum monomer recovery occurred between 1- and 2-h hydrolyses in primary treatments with 2 N TFA. Under those conditions individual monomers differed in their survival, with some isomerization detected requiring correction for precise determination. This was accomplished by using an internal standard (sorbitol) added to samples either pre- or posthydrolysis.

Chemical solubilization of cell wall polysaccharides generally yields a heterogeneous mixture of components that gives little information about the in situ carbohydrate polymers. Hemicellulose hydrolysis in acid or base is often incomplete while cellulose, prepared by the removal of other polysaccharide constituents, invariably contains small amounts of glycosyl residues other than glucose. These may be chain terminator monomers (Darvill et al., 1980) or other hemicellulosic sugars bound tightly to the β 1-4 glucan chains (Mühlethaler, 1967). The quantitative recovery of sugars in acid hydrolysates of cell wall preparations is, therefore, difficult. Traditional methods of hydrolysis of cell wall polysaccharides to their component monomers involve hot, dilute mineral acid treatment. Monosaccharide dehydration and the differential ease of glycosidic bond hydrolysis prevent quantitative recovery of monomers in acid hydrolysates. Bailey (1973) found

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[1]Paper No. 10149 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7601, in cooperation with the USDA, ARS. In partial fulfillment of the requirements of the MS degree. North Carolina State University, Raleigh, NC.

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0021-8561/86/1434-0780$01.50/0