Air Classification of Rapeseed Meal

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ABSTRACT

Air classification of defatted, pulverized rapeseed meal was studied. A protein shift into the fines of between 11.5 and 17.2% was observed. Correlations of the shift of glucosinolates and phytic acid with that of protein ($r = 0.99$ and 0.97, respectively) were significant ($P < 0.1\%$ and $P < 1\%$, respectively). Concentrations of protein, glucosinolates, and phytic acid decreased at the lowest cut size (<3.5 μm). The preponderance of nitriles formed by the reaction of myrosinase on the glucosinolates was similar in all fractions.

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Air classification of meals has proven to be an effective technique for producing starch-rich and protein-rich fractions from a number of cereals and legumes (Vose 1978). The separation is possible as starch granules are considerably larger than protein bodies. Only a few studies have been carried out on air classification of oilseed meals. The low starch content gives little scope for protein shifting during air classification (Elkowicz and Sosulski 1982).

Defatted rapeseed meal is high in protein, ranging from 33.0 to 47.9% (Ohlson 1972). A high level of fiber and the presence of glucosinolates limit its value as food or feed. Seth and Clandinin (1973) separated pulverized rapeseed meal by air classification into low-hull and high-hull fractions. The fine fraction contained 25% more metabolizable energy than the original meal. No cut size for the separation was given. Tape et al (1970) air classified rapeseed meal after aqueous extraction using a cut size of 200 mesh (75 μm) and achieved a protein concentration of 55% in the fines fraction, compared with 46% in the unclassified meal. The objective of this study was to investigate the extent of protein shifting and the distribution of antinutritional and toxic constituents during air classification of rapeseed flour.

MATERIALS AND METHODS

Three rapeseed cultivars from two different species were used: *Brassica napus* (cv. Norli and Jet Neuf) and *Brassica campestris* cv. toria (Nepal). Seed was wet milled in a ball-mill using hexane as the solvent. The solvent was changed after 2 hr, and milling then continued for another hour. The meal was vacuum filtered on a Buchner funnel, and the solvent was removed in a vacuum desiccator.

Air classification was carried out using an Alpine 100MZR laboratory zig-zag air classifier (Alpine Corp., Augsburg, Federal Republic of Germany). Separation cut size was varied by adjusting the speed of the classifier wheel and the air flow rate. Cut size was obtained empirically from a calibration curve (Lauer 1979). Each meal sample was air classified repeatedly with a progressively increasing cut size. The weight of the fines was calculated by difference (initial weight of meal less weight of coarse fraction), and the protein shift was determined by the method of Gracza (1959).

Crude protein was determined using the method of Tingvall (1979). The method of Wetter and Youngs (1976) was used to estimate the glucosinolate content of meals. The endogenous enzyme was destroyed by the addition of boiling buffer, and myrosinase extracted from white mustard meal by the method of Appelqvist et al (1967) was added. The method was modified by the addition of 2 m*M* of L-ascorbic acid to the digest. The total isothiocyanate content of the meal was expressed as 3-butenylisothiocyanate equivalents. Nitriles and epithionitriles formed during glucosinolate autolysis were extracted and separated as described by Daxenbichler et al (1970). Phytate was determined by the method of Latta and Eskin (1980). Neutral detergent fiber was estimated using the procedure described by AACC method 32-20 (1983). Ash analysis was carried out using AOAC method 14.006 (1980).

RESULTS AND DISCUSSION

Milling

Wet-milling in hexane was a very effective procedure for size reduction as 70 to 75% of the particles in all three meals were smaller than 15 μm.

Particle size is important in air classification and should be sufficiently small so that cell components can be separated. The finest particle sizes reported have been achieved using impact pulverizer mills, such as pin or stud mills. Wheat milled using a studmill (Anonymous 1979) yields a flour with 25–30% of the particles measuring less than 16 μm in diameter. Davin (1983) reported particle size distribution of defatted rapeseed meals, which were prepared using different mills. The best results are achieved on an impact mill (Farmer mill design, Law Corp. Senlis, France) at 3,000 rpm whereby 50% of the particles are between 250 and 630 μm.

Protein Fractionation

Protein content of the fines fractions generally increased with increasing classifier speed and decreasing cut size (Table I). The

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TABLE I
Component Analysis of Rapeseed Meals and Their Air-Classified Fractions

Rapeseed Cultivar	Fraction Particle Size (μm)	Fraction Yield (%)	Protein (N × 6.25) (%)[a]	Glucosinolate[a] (mg/g)[b]	Protein Shift (%)	Glucosinolate Shift (%)	Phytate (%)[a]	Ash (%)[a]	Neutral Detergent Fiber (%)
Toria	meal	...	32.8	7.1	...	...	3.9	9.3	28.1
	<3.5	34.0	38.9	8.3	6.32	5.75	4.5	8.2	15.1
	3.5–7.5	32.1	44.5	10.8	11.45	16.73	6.5	11.0	13.8
	7.5–15	6.9	30.1	6.1	−0.57	−0.97	3.2	10.6	21.4
	15–30	13.8	17.8	2.2	−6.31	−9.52	0.6	8.3	59.5
	>30	13.2	7.9	0.6	−10.02	−12.08	0.0	7.4	67.8
Norli	meal	...	36.0	11.2	...	...	4.1	7.4	25.2
	<3.5	26.0	42.2	13.2	4.48	4.64	4.3	7.1	25.2
	3.5–7.5	28.0	46.1	14.9	7.86	9.25	5.6	7.9	14.6
	7.5–15	21.0	37.8	12.7	1.05	2.81	4.8	7.4	16.0
	15–30	10.0	27.1	6.2	−2.47	−4.46	1.1	8.1	40.9
	>30	15.0	13.4	1.8	−9.42	−12.59	0.0	6.7	65.8
Jet Neuf	meal	...	35.5	10.6	...	...	4.5	7.9	25.3
	<3.5	10.3	40.5	11.9	1.45	1.26	4.0	7.6	15.5
	3.5–7.5	43.1	41.8	13.2	7.65	10.57	6.4	8.2	15.7
	7.5–15	21.0	39.6	13.1	2.42	4.95	4/2	9.1	14.8
	15–30	14.8	24.6	5.4	−4.54	−7.26	1.7	6.9	42.5
	>30	10.8	15.0	1.3	−6.24	−9.48	0.0	6.2	69.7

[a] Fat-free, dry-weight basis.
[b] 3-Butenyl-isothiocyanate equivalents.

TABLE II
Breakdown (%) of Progoitrin and Gluconapin During Enzymatic Autolyses to 1-Cyano-2-hydroxy-3-butene (N) and to the Corresponding Epithionitrile (ETN)

Rapeseed Cultivar	Cut Size (μm)											
	Meal		<3.5		3.5–7.5		7.5–15		15–30		>30	
	N	ETN	N	ETN	N	ETN	N	ETN	N	ETN	N	ETN
Toria	0	53.6	0	61.0	0	54.0	0	57.1	0	48.9	0	57.0
Norli	4.4	1.0	4.1	1.1	4.0	1.0	3.8	0.9	2.2	0.6	2.2	0
Jet Neuf	5.1	0.7	ND[a]	ND	4.9	0.6	5.1	0.7	4.5	0.7	4.7	0.6

[a] Not determined.

highest protein content was found in the fine fraction 3.5 to 7.5 μm in diameter with a decrease occurring in the fines less than 3.5 μm. It is generally assumed that decreasing the cut size will result in an increase in the protein content of the fractions. At extremely small cut sizes as in this study, it is possible that hemicellulose particles and other cell wall components are being concentrated. Cell wall materials have been reported to fractionate into the fines (Reichert 1982, Elkowicz and Sosulski 1982). The total protein shift into the fine (<15 μm) fractions was 18.3, 13.4, and 11.5% for Toria, Norli, and Jet Neuf, respectively. These figures compare with 42% for fababeans and 17% for cowpeas obtained with similar equipment at a cut size of 12–15 μm (Cloutt et al 1987).

In rapeseed the hull constitutes 16–18% of the total weight of the seed; defatting the seed increases this to approximately 30%. Purified hulls from different rapeseed cultivars contain approximately 7% of the seeds' nitrogen (Finlayson 1974). Thus, exclusion of hull components would account for the shifting of protein into the fines. Vose (1976) reported that crude fiber content of coarse fractions from air-classified pea meal was reduced from 8 to 1% if the peas were dehulled before air classification.

Glucosinolate Fractionation

Glucosinolate content in the fines was found to increase as the cut size decreased (Table I). For all three samples, a high correlation coefficient was found between protein and glucosinolate content in the various fines fractions ($r > 0.99$, $P < 0.1$). Shifting of glucosinolates into the fines was generally greater than the shifting observed for protein. The coarse fraction was found to have a very low glucosinolate content (Table I).

Glucosinolates are hydrolyzed enzymatically upon cell maceration in the presence of water. The pattern of breakdown products is determined by the environment (pH, temperature) and factors present in the seed, such as ferric ion (Tookey et al 1970). An epithio-specifier protein acts as a cofactor directing the breakdown toward epithionitriles (Tookey 1973). The proportion of nitriles formed from the original glucosinolate showed little variation among the fines fractions (Table II). Hence, the epithio-specifier protein did not shift.

Phytic Acid Fractionation

Rapeseed meals contain high levels of phytic acid. Latta and Eskin (1980) and Uppstrom (1980) reported between 4 and 5%, whereas Jones (1979), using the iron precipitation method, reported levels exceeding 7% in rapeseed protein concentrates. Phytic acid was not found in the coarse fraction at a cut size greater than 30 μm (Table I). The correlation between protein and phytic acid concentration in the fines fraction was significant ($r = 0.98$, $P < 1\%$).

Ash and Fiber Fractionation

Ash content was lowest in the coarsest fraction (Table I) of each sample. The highest concentration was found in the 3.5–15 μm fraction.

Values for neutral detergent fiber were similar in the fractions less than 3.5, 3.5–7.5, and 7.5–15 μm in diameter. Differences in neutral detergent fiber did not account for reduced protein shifting into the finest fraction (<3.5 μm) observed for each sample.

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