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WET MILLING VS. AIR CLASSIFICATION OF FIELD PEAS TO ISOLATE PROTEIN, STARCH AND FIBER

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The efficiencies of protein and starch recoveries by pin milling and air classification of field peas exceeded those obtained by wet processing which exhibited 30% losses of dry matter in the effluent. Pin milling reduced amylograph viscosity whereas refined starch exhibited high viscosity during the heating and cooling cycle. Wet processed proteinates showed high water hydration and oil absorption capacities whereas the air classified protein fraction was superior in whipping and foam stability.

INRODUCTION

Soybean flours, protein concentrates and protein isolates have been used widely as nutritional supplements and functional ingredients in foods. In addition to high protein and lysine contents, soybean products exhibit strong functional properties, especially water solubility, water and fat binding and emulsification. On the other hand, grain legumes are consumed primarily as whole or split seeds and only limited quantities are processed into flours or more refined products. Starchy legume flours appear to have weaker functional properties than defatted soybean flour [4], due in part to their lower protein contents. Youngs [7] developed a process for separation of the protein and starch fractions in field peas (*Pisum sativum*) by fine grinding and air classification. The functional properties of the protein fraction was greatly enhanced over the flour [5] but antinutritive factors were concentrated into the fine fraction with the protein [2].

Field peas have also been processed into refined starch and protein isolates by procedures derived from the traditional corn starch and soybean protein industries [6]. Small plants for the commercial production of air classified and wet processed products from field peas have been established in Western Canada.

The objectives of the present study were to compare the processes of protein and starch concentration by dry air classification and wet alkali extraction of protein and starch from field peas. The yields, composition and functionality of the crude and refined products were determined in pilot plant studies and on the commercial products.

EXPERIMENTAL PROCEDURES

About 20 kg of Trapper field peas were dehulled on a resinoid disc abrasive dehuller, followed by air aspiration to remove 10% of hulls. The dehulled cotyledons were coarse-ground in a hammer mill and subdivided for dry and wet processing.

Dry process. A portion of the ground peas were pin milled to about 325-mesh on an Alpine Pin Mill, model 250 CW (Alpine American Corp., Natick, MA) (Fig. 1). The pin-milled flour was fractionated into light and dense particles on an Alpine Air Classifier Type 132 MPa at a cut point of 15 microns (800-mesh) diameter between the two fractions, followed by a reclassification of the dense fraction. The two protein fractions were combined.

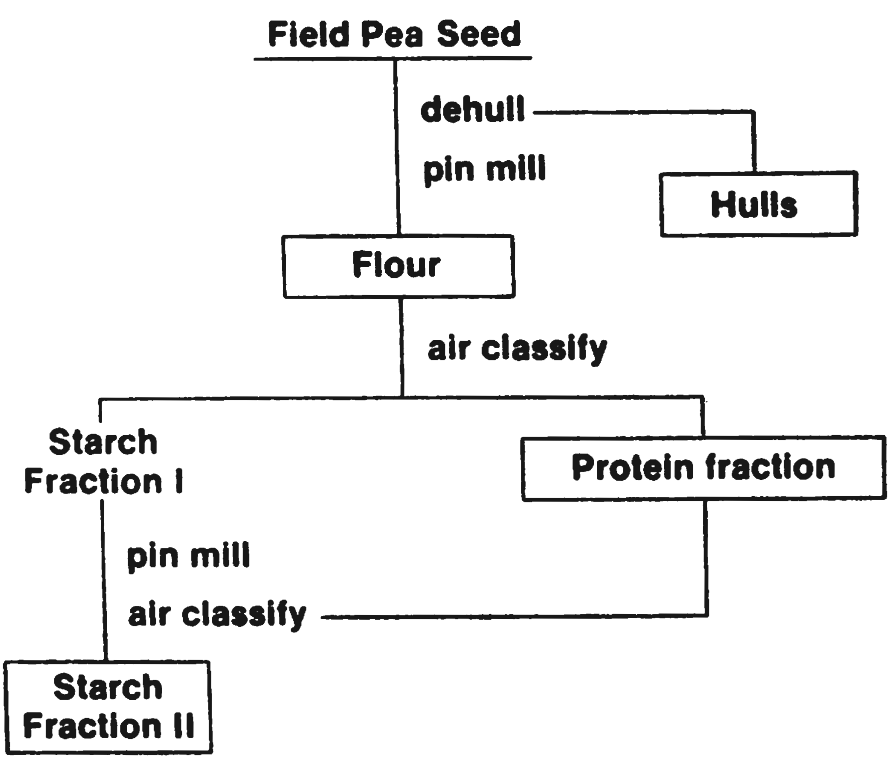

Fig. 1. Flow diagram for pin milling and air classification of field pea into protein and starch fractions.

Wet process. The remainder of the pea meal was slurried in 0.02% NaOH for 1 hr and filtered through a vibrating screen to remove fiber before fine grinding on a Morehouse 200 wet mill (Morehouse Industries, Fullerton, CA) operated at 3600 rpm (Fig. 2). The slurry was adjusted to pH 10.2 and centrifuged on a Fletcher basket centrifuge at 3400 rpm (1800 × g) to separate the starch and protein. The protein extract was adjusted to pH 4.5 with 1 N HCl and the whey separated from the curd by centrifugation in the basket centrifuge (1100 × g). The fiber, starch and protein curds were washed twice, with the proteinate being adjusted to pH 7 before freeze drying.

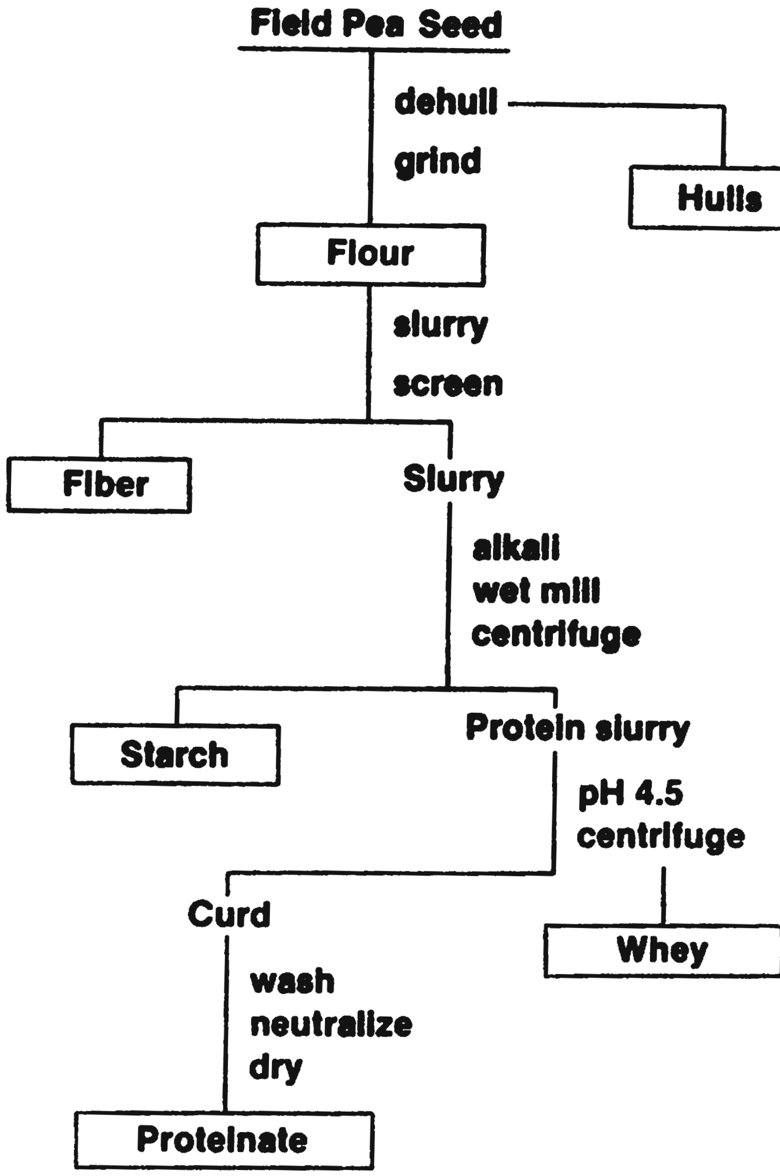

Fig. 2. Flow diagram for preparation of purified fiber, starch and proteinate from field pea by wet processing techniques

Commercial products. Field pea flour and protein concentrate were obtained from ProStar Mills (1982) Ltd., Saskatoon, Saskatchewan, and the protein isolate was provided by Woodstone Foods, Portage La Prairie, Manitoba. Soybean flour and protein isolate and whipping protein were obtained from A. E. Staley Manufacturing Co., Tecatur, IL.

Chemical analyses. The samples were analyzed by standard AACC [1] procedures for moisture (air-oven method), crude protein (Method 46-13), crude fat (Method 30-25), crude fiber (Method 32-10), total ash (600C, 3 hr), starch (Method 76-20) and total sugars (Method 80-60). Color characteristics of the dried products were measured with the Hunter Color Difference Meter. AACC [1] procedures were used to determine water hydration capacity (Method 88-04) and nitrogen solubility index (NSI) (Method 46-23). The pH solubilities curves for the proteins were determined using the 2-hr extraction periods over the pH range 2-11 by adjustment with 1.0 NHCl or NaOH. Pasting characteristics of 12.0% (w/v, db) slurries of the flours and starch were determined on a Brabender Visco/Amylograph (Method 22-10). Oil absorption capacity, oil emulsification, whippability and foam stability were measured by the procedures of Lin et al. [3]. The chemical values reported in the tables are means of duplicate determinations, dry basis.

RESULTS AND DISCUSSION

Processing efficiences. The crude protein and starch contents were 22.2 and 55.0%, respectively, in the defulled seed flour (Table 1). The cut point of 15 microns on the Alpine air classifier gave a fine: coarse split of 31.8:61.7 with invisible losses being 6.5% of the flour (Fig. 3). Based on the protein content of 52.7% in air classified (AC) protein fraction, the recovery of protein in the fine fraction was 75.5%. The recovery of starch in AC starch fraction was much higher at 93.3% due to its starch content of 83.2%. Much of the crude fat, fiber, ash and simple sugars shifted into the fine fraction, diluting the protein concentrations. There was also residual starch in AC protein fraction and residual protein in AC starch fraction.

Table 1. Composition of proximate constituents and carbohydrates in field pea flours and dry and wet processed products, and soy controls, % dry basis

Processed product	Crude protein[a]	Crude fat	Crude fiber	Ash	Starch	Simple sugars
	Pilot plant study					
Dehulled seed flour	22.2	1.3	1.3	2.8	55.0	7.0
AC protein fraction[b]	52.7	2.9	2.9	5.7	8.3	12.7
AC starch fraction	6.4	0.6	0.5	1.3	83.2	3.5
WP proteinate[c]	87.7	3.0	0.2	5.8	0.0	0.0
WP starch	0.4	0.1	0.8	0.2	94.0	0.0
WP fiber	0.8	1.2	47.3[d]	1.7	0.0	0.0
	Commercial products					
Field pea flour	27.4	1.0	1.9	2.7	55.7	—
AC protein fraction	51.7	3.7	2.8	5.5	7.1	—
WP proteinate	88.0	1.7	1.3	4.4	2.7	—
Soy flour	52.8	0.9	4.2	5.8	2.4	—
Soy proteinate	90.2	0.4	0.6	4.0	1.8	—

[a] N × 6.25
[b] AC = air classified product
[c] WP = wet processed product
[d] Acid detergent fiber

The protein content of wet processed (WP) proteinate was 87.7% (Table 1) and the proteinate yield of 18.2% (Fig. 3) resulted in a protein recovery of 72.7%. Lipid and ash were the main non-protein constituents of WP proteinate. The refined WP starch, at 94% starch content and a yield of 48.4%, gave a recovery of 79.2%, well below that of the AC process. Losses of starch and protein in the whey

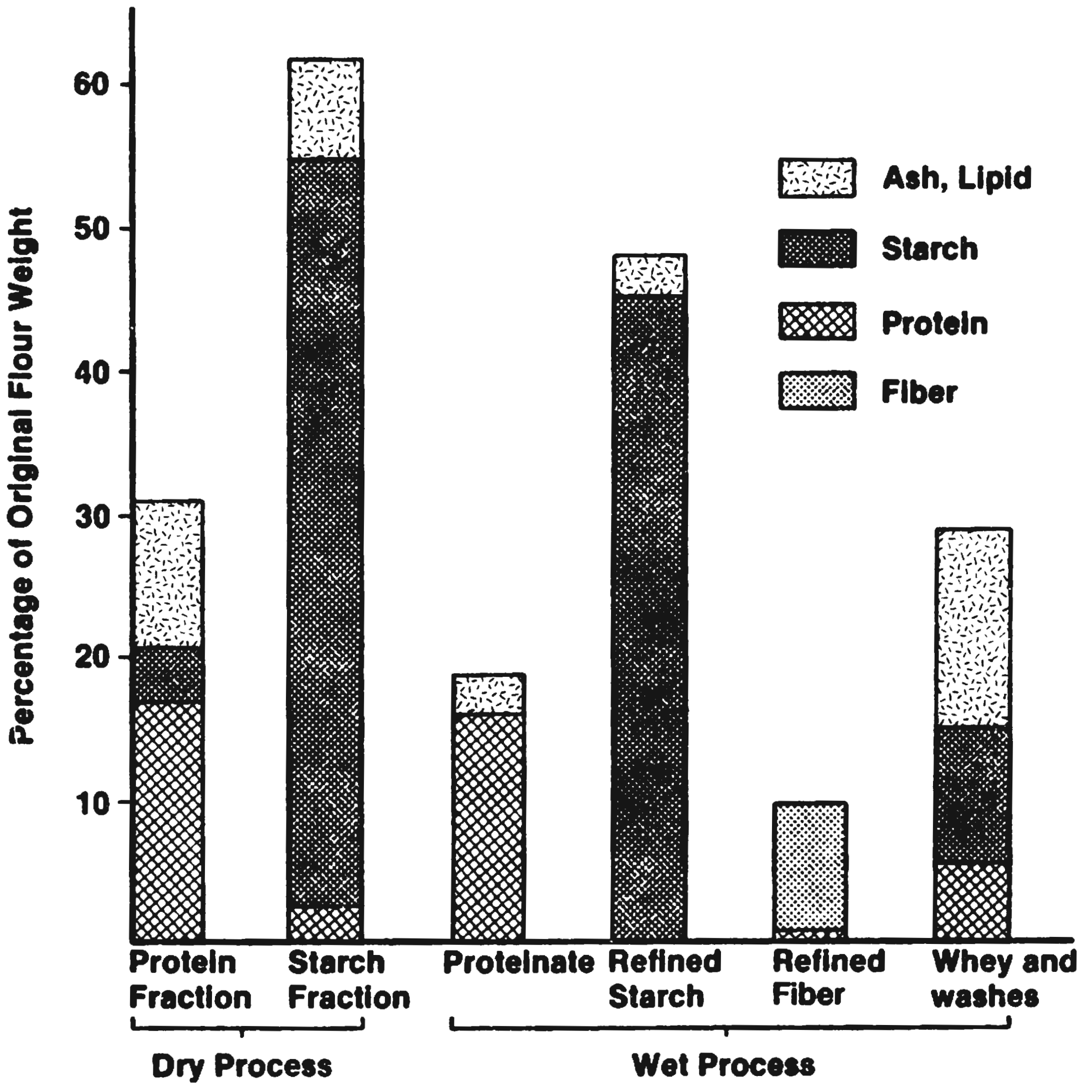

Fig. 3. Yield of products from dry and wet processing of field pea flours, and their concentrations of protein, starch and fiber

and washes were substantial, and fully 30% of the flour dry matter would have to be recovered from these effluents. However, there was a recovery of refined fiber that accounted for 8% of the total products.

Except for the higher protein content of the field pea flour, the composition of commercial field pea products were similar to the values obtained in the pilot plant study. The compositions of soy flour and proteinate were comparable to those of the AC protein fractions and WP proteinates, respectively.

Product colours. The field pea and soy flours were creamy-yellow in colour and pin milling improved the lightness of the AC protein and starch fractions (Table 2). The WP proteinates were light brown in appearance whereas the WP starch was essentially white and WP fiber retained a light shade of yellow.

Starch properties. The field pea flour gave an amylogram which was typical of legume flours in their intermediate peak and cold viscosity values relative to cereal flours [4] (Table 3). Despite the high concentration of starch into the AC starch fraction, the amylograph viscosities were substantially lower than those of the flour. However, WP starch exhibited a much stronger amylogram than would be expected from its starch content.

Table 2. Hunterlab colour values (L = lightness; a = +red.. −green; b = +yellow, −blue) of field pea products and soy controls

Processed product	L	a	b
	pilot plant study		
Dehulled seed flour	87.9	−0.3	19.1
AC protein fraction	92.7	−1.0	13.3
AC starch fraction	93.8	−1.2	11.6
WP proteinate	81.3	0.3	24.2
WP starch	96.8	−0.7	2.4
WP fiber	91.4	−1.1	8.4
	commercial products		
Field pea flour	90.5	−1.4	15.2
AC protein fraction	88.2	−1.0	17.3
WP proteinate	80.3	−0.9	16.3
Soy flour	86.0	−2.3	17.1
Soy proteinate	84.5	−1.8	16.4

Table 3. Visco/Amylograph properties of field pea flour and starch products

Processed products	Starch content %	Peak viscosity B.U.[a]	Cold paste viscosity B.U.
Dehulled seed flour	55.0	400	840
AC starch fraction	83.2	260	600
WP starch	94.0	610	1250

[a]B.U. = Brabender units

Nitrogen solubility. The pH of legume flours has a marked influence on nitrogen solubility, but the range of values among the present protein products of pH 6.5-7.0 (Table 4) was insufficient to have a marked effect on functional properties [4, 5].

The field pea fluors showed high nitrogen solubility but pin milling reduced the index by 20-40% (Table 4). The WP protein produced in the pilot plant was highly soluble at pH 6.8 but the commercial WP proteinate and soy proteintate exhibited low solubilities. The nitrogen solubilities of the commercial products were determined over the pH range of 2-11 (Fig. 4). This data illustrated that AC protein fraction was only slightly less soluble than field pea flour from pH 2-6 but the values levelled off at 70-80% solubility between pH 6-11. On the other hand, the commercial WP proteinate was lower in solubility between pH 3-10. The low solubility profiles for soy flour and proteinate may have reflected heat treatments to inactivate trypsin inhibitors.

Functional properties. The AC protein fractions showed significant improvements in water hydration and oil absorption capacities over the field pea flours,

Table 4. Functional properties of field pea flours, dry and wet processed products and soy controls, % dry basis

Processed product	Natural pH unites	Nitrogen solubility index, %	Water hydration capacity g/g sample	Oil absorption capacity %	Oil emulsification capacity %
	pilot plant study				
Dehulled seed flour	6.7	82.4	0.9	73	64
AC protein fraction	6.5	47.2	1.2	93	76
AC starch fraction	6.8	—	1.0	59	14
WP proteinate	6.8	83.6	2.6	249	78
WP starch	8.4	—	1.2	68	7
WP fiber	8.4	—	20.1	—	—
	commercial products				
Field pea flour	6.6	80.3	0.8	41	69
AC protein fraction	6.6	65.1	1.1	59	74
WP proteinate	6.6	38.1	2.5	98	73
Soy flour	6.6	20.6	1.7	56	74
Soy proteinate	7.0	30.6	2.6	103	90

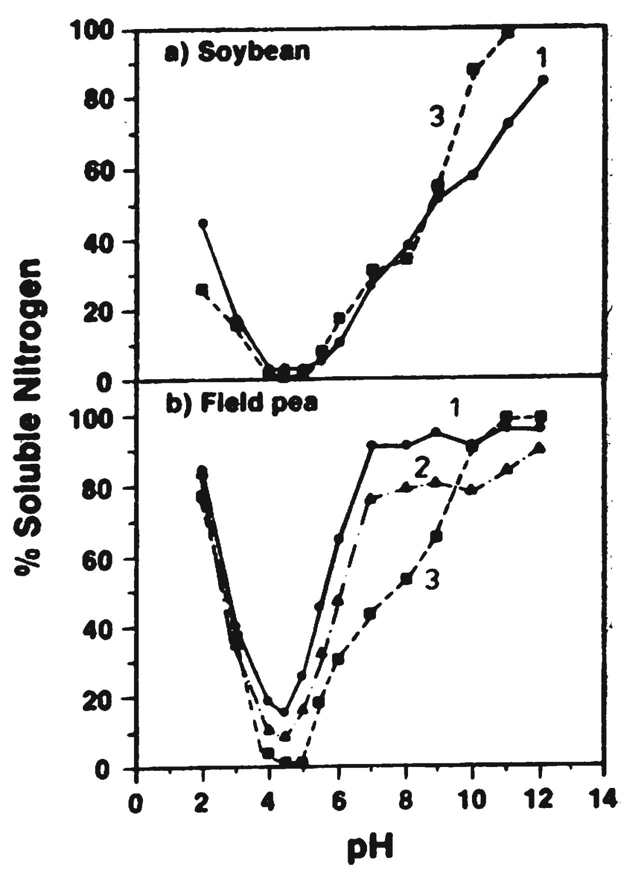

Fig. 4. Nitrogen solubility curves for flours (1), protein concentrate (2), and protein isolates (3) from (a) soybean and (b) field pea

being lower than soy flour in water hydration but greater in oil absorption (Table 4). However, the WP proteinates and soy proteinate showed very high values for these functional properties, much greater than would be predicted from the differences in protein content. The higher protein samples showed higher values for oil emulsification as well but the differences were not large.

AC protein fraction showed strong whipping properties although soy flour exhibited the best stability (Table 5). WP proteinate had better foaming properties than soy proteinate but the hydrolyzed soy protein demonstrated the degree of foaming and foaming texture required by the food industry.

Table 5. Whippability and foam stability of commercial field pea and soy protein products, dry basis

Commercial product	Volume of foam after whipping, ml					Foam texture
	initial	10 min	30 min	60 min	120 min	
Field pea flour	300	250	210	180	100	coarse
AC protein fraction	565	465	430	280	210	coarse
WP proteinate	315	260	230	210	175	medium
Soy flour	370	310	285	260	225	coarse
Soy proteinate	120	110	105	95	80	medium
Whipping protein[a]	1150	1070	945	725	30	fine

[a]Whipping protein from hydrolyzed soy protein

CONCLUSIONS

The efficiencies of protein (75.5%) and starch (93.3%) recoveries by air classification of pin milled field pea exceeded those of wet processing into proteinate (72.7%), starch (79.2%) and fiber (8% yield). A high proportion of the 30% losses of dry matter in the effluents was protein and starch. Wet processing darkened the proteinate but the refined starch exhibited strong Visco/Amylograph properties compared to the AC starch fraction. Pin milling depressed nitrogen solubility whereas wet processing could provide a high or low solubility, depending on the method od drying. The WP proteinates showed very high water hydration and oil absorption capacities whereas the whipping properties of AC protein fraction exceeded those of other field pea and soy products.

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PORÓWNANIE MIELENIA NA MOKRO I SEGREGACJI POWIETRZNEJ DO IZOLACJI BIAŁKA, SKROBI I BŁONNIKA Z GROCHU

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Streszczenie

Nasiona grochu (*Pisum sativum*) zostały poddane procesom mielenia "ping milling" oraz powietrznej segregacji na frakcje białka i skrobi lub alternatywnie białko, skrobia i błonnik były uzyskane przez ekstrakcję wodną w środowisku alkalicznym. Wydajność odzysku frakcji białkowej (75,5%) oraz skrobi (93,3%) przewyższała analogiczne wydajności odzysku w czasie procesu segregacji na mokro (odpowiednio 72,7% i 79,2%).

Jakkolwiek w procesie segregacji na mokro odzyskiwano 8% wyodrębnionego błonnika o wysokiej zdolności absorpcji wody (20,1 g/g próbki) straty suchej masy w tym procesie wynosiły 30%.

Segregacja na sucho redukowała lepkość amylograficzną frakcji skrobiowej, podczas gdy wydzielona skrobia zwiększała lepkość. Wydzielone na mokro białczany wykazały wysokie zdolności absorpcji wody oraz oleju, podczas gdy frakcja białkowa uzyskiwana na sucho wykazywała lepsze zdolności pienienia i stabilność piany.

Przemysłowo wytworzone produkty białkowe z grochu były porównywalne z wytwarzanymi w instalacji pilotowej z wyjątkiem niższych rozpuszczalności azotu; nie były one gorsze od analogicznych produktów sojowych w większości właściwości funkcjonalnych.