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Low-Fiber Canola. Part 1. Chemical and Nutritive Composition of the Meal

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ABSTRACT: The objective of the current study was to evaluate the chemical and nutritive composition of meals derived from a newly developed yellow-seeded *Brassica napus* canola and the canola-quality *Brassica juncea*. In comparison with its conventional black-seeded counterpart, meal derived from yellow-seeded *B. napus* canola contained more protein (49.8 vs 43.8% DM), more sucrose (10.2 vs 8.8% DM), and less total dietary fiber (24.1 vs 30.1% DM). *B. juncea* canola showed intermediate levels of protein, sucrose, and dietary fiber (47.4, 9.2, and 25.8%, respectively). The reduction in fiber content of yellow-seeded *B. napus* canola was a consequence of a bigger seed size, a lower contribution of the hull fraction to the total seed mass, and a lower content of lignin with associated polyphenols of the hull fraction. The meal derived from yellow-seeded *B. napus* canola would appear to have quality characteristics superior to those from black-seeded *B. napus* or yellow-seeded *B. juncea*.

KEYWORDS: *low-fiber canola, chemical composition, Brassica napus, Brassica juncea, dietary fiber*

■ INTRODUCTION

Canola meal is a commonly used ingredient in animal diets. It is generally agreed that canola meal could be more competitive in the marketplace if it had more protein, more energy, and less dietary fiber.[1] Various approaches have been taken to reduce the fiber content, increase the protein content, and improve the nutritive value of canola meal. These include breeding for low-fiber, yellow-seeded canola, seed dehulling, or the use of feed enzymes to enhance nutrient utilization by growing monogastric animals.[2]

Earlier studies with *Brassica rapa* (*campestris*) canola have demonstrated that the black and yellow seeds differed significantly in oil, protein, and fiber contents, with yellow seeds containing more oil and protein and less fiber.[3,4] In the past 20 years, plant breeders have incorporated the yellow seed coat characteristic into the agronomically important *Brassica napus* canola. Earlier research from this laboratory has demonstrated a high negative relationship ($r = -0.88$) between protein and dietary fiber content in meals derived from black- and yellow-seeded *B. napus* canola.[5] In comparison with the earlier yellow-seeded lines, meal derived from the *B. napus* line YN97-262 developed in the late 1990s contained more protein (46.2 vs 45.2% DM), more sucrose (9.0 vs 7.8%), and less dietary fiber (26.6 vs 30.8%) than its black-seeded counterpart.[6] In addition, a higher ($P < 0.05$) body weight gain (398 vs 342 g/bird/14 days) and improved feed conversion ratio (1.53 vs 1.60 g feed/g gain) were observed in broiler chickens fed a diet containing meal from yellow-seeded *B. napus*, indicating its superior quality characteristics to that of the black-seeded *B. napus*. Recently, further improvements to the quality of yellow-seeded *B. napus* canola (increased yield, increased oil, true yellow color) have been made at the Saskatoon Research Centre, Agriculture and Agri-Food Canada, Saskatoon, Canada, by Dr. G. Rakow and his group with the new line YN01-429 having improved agronomic characteristics (i.e., increased yield), stabilized yellow seed color,[7] and improved quality characteristics.[8] From a recent publication in this journal[9] and the presentations at the 2011 Rapeseed Congress in Prague,[10] it became evident that plant selection programs directed toward the development of yellow-seeded *B. napus* canola have been underway in other countries, including Germany and Poland.

Canola-quality (i.e., low-glucosinolate, low-erucic acid) forms of *Brassica juncea* mustard, known for its pure yellow seed coat color, have also been developed at Agriculture and Agri-Food Canada, Saskatoon Research Centre.[11] Under western Canadian conditions, *B. juncea* suffers less from heat and drought stress, exhibits better disease resistance, and matures earlier than *B. napus* canola. Such characteristics are the basis for high yields of oil and low chlorophyll content in the seed.

The objective of this study was to evaluate the chemical and nutritive composition of newly developed yellow-seeded *B. napus* canola and the canola-quality *B. juncea*. The meal derived from the conventional black-seeded *B. napus* canola served as a control.

■ MATERIALS AND METHODS

Plant Material. Seed samples of yellow-seeded *B. napus* line YN01-429, black-seeded *B. napus* line N89-53, and canola type yellow-seeded *B. juncea* (var. Xceed) (Figure 1) were obtained from Agriculture and Agri-Food Canada Research Center, Saskatoon, SK, Canada, and were crushed at the POS Pilot Plant in Saskatoon, SK, Canada, using the conventional prepress solvent extraction process.

Analytical Procedures. In preparation for chemical analyses, samples were ground to pass through a 1 mm sieve. The meals were subjected to crude protein (N × 6.25) analysis using a nitrogen analyzer, model NS-2000 (Leco Corp., St. Joseph, MI, USA). Standard AOAC (2005) procedures were used for dry matter (930.15), fat (2003.06), total phosphorus (965.17), and ash (942.05) determi-

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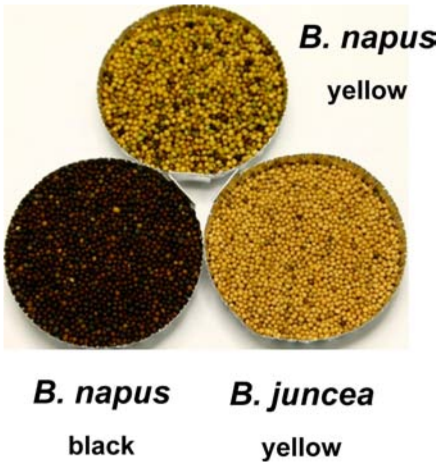

Figure 1. Samples of black- and yellow-seeded canola used in the study.

nation.[12] Phytate phosphorus was determined using the procedure described by Haug and Lantzsch.[13] Samples for amino acid (AA) analysis were prepared according to the AOAC procedures 994.12, alternatives 3 and 1 (sulfur AA), and 988.15 (tryptophan) and then determined using an amino acid analyzer (S4300, Sykam GmbH, Eresing, Germany). Starch was analyzed using the Megazyme Total Starch Kit (Megazyme International Ireland Ltd., Co. Wicklow, Ireland). Carbohydrates (glucose, fructose, sucrose, raffinose, and stachyose) and glucosinolates were determined by gas−liquid chromatography as described by Slominski et al.[14] and Slominski and Campbell,[15] respectively.

Dietary fiber was determined by a combination of neutral detergent fiber (NDF) and detergent-soluble nonstarch polysaccharide (NSP) measurements and was calculated as the sum of NDF and detergent-soluble NSP.[14] Neutral detergent fiber was determined using an Ankom fiber analyzer (Ankom Technology, Macedon, NY, USA) and AOAC procedure 2002.04.[12] Total NSP, cellulose, and noncellulosic NSP were determined by gas−liquid chromatography (component neutral sugars) using an SP-2340 column and a Varian CP3380 gas chromatograph (Varian Inc., Palo Alto, CA, USA) and colorimetry (uronic acids) using a Biochrom Ultrospec 50 (Biochrom Ltd., Cambridge, UK) and the procedure described by Englyst and Cummings[16,17] with some modifications.[18] The content of NSP was measured in both the meals and the NDF residues. Neutral detergent-soluble NSP was calculated as total sample NSP minus NSP present in the NDF residue, and total dietary fiber was determined by summation of NDF and NDF-soluble NSP. The contents of crude protein (N × 6.25) and ash in NDF residue were also measured. The value for lignin and associated polyphenols was calculated by difference [NDF − (NSP + protein + ash)].[14] Water-soluble NSP was determined using the procedure described earlier.[19]

Seed Fractionation and Chemical Analysis of Hulls and Embryos. The seed subsamples of the respective black- and yellow-seeded *B. napus* and *B. juncea* canola from the crushing operation at the POS Pilot Plant in Saskatoon (see Plant Material) were also subjected to fractionation to determine the weights and composition of the hull and embryo fractions. Seed size was determined in triplicate by weighing 100 seeds from each sample and was expressed in grams per 1000 seeds. Fractionation of the seeds was conducted by manual separation. Briefly, 3.5 g of seeds from each sample was gently crushed by spatula, and hulls and embryos were carefully separated and weighed. Both hull and embryo fractions were then subjected to analyses of fat, sucrose, oligosaccharides, NDF, and NSP using the procedures described above. NDF was measured in duplicate for hulls and in quadruplicate for embryos. Due to the small sample size, NDF residues from replicates were pooled and then subjected to crude protein analysis.

Statistical Analysis. All studies were set up as completely randomized designs, and data were tested by the GLM procedure of the SAS program.[20] Means were separated by Tukey's honestly significant difference. All statements of significance are based on $P \leq 0.05$.

RESULTS AND DISCUSSION

Chemical Composition of Canola Meals. Canola meal samples were produced by a pilot plant specifically for the purpose of this research, and no byproducts of oil refining (i.e., gums, soapstocks) were added back into the meal. Thus, the fat content of all samples (Table 1) averaged 1.7% DM and was

Table 1. Chemical Composition of Meals Derived from Black- or Yellow-Seeded *B. napus* Canola and Canola-Quality *B. juncea* (% DM)[a]

component	*B. napus*, black	*B. napus*, yellow	*B. juncea*, yellow	SEM
crude protein	43.8 c	49.8 a	47.4 b	0.20
fat	1.8 a	1.6 b	1.7 b	0.02
carbohydrates				
monosaccharides[b]	0.2 b	0.3 a	0.3 a	0.01
sucrose	8.8 c	10.2 a	9.2 b	0.07
oligosaccharides	3.1 b	2.5 c	3.6 a	0.07
raffinose	0.6 a	0.5 b	0.6 a	0.01
stachyose	2.6 b	2.0 c	3.0 a	0.07
starch	0.4 ab	0.4 a	0.3 b	0.02
dietary fiber	30.1 a	24.1 c	25.8 b	0.24
ash	7.3 a	7.0 b	7.2 a	0.01
phosphorus (P)	1.30 a	1.24 b	1.23 b	0.01
phytate P	0.78	0.80	0.78	0.006
nonphytate P	0.52 a	0.44 b	0.45 b	0.004
glucosinolates[c] (μmol/g)	27.1 a	17.1 b	17.2 b	0.39

[a] n = 4 for protein; 3 for ash, phytate, and total P; and 2 for carbohydrates, dietary fiber, and fat. Means within a row with no common letters (a−c) differ significantly ($P < 0.05$). [b] Includes glucose and fructose. [c] Includes gluconapin, glucobrassicanapin, progoitrin, gluconapoleiferin, gluconasturtin, glucobrassicin, and 4-hydroxyglucobrassicin.

lower than that of the conventional canola meal (i.e., 3.8%, as-fed basis).[21] When compared with its yellow-seeded predecessor lines YN90-1016 and YN97-262, canola meal derived from the newly developed line YN01-429, used in the current study, contained more protein (50 vs 46% DM, on average) and less dietary fiber (24 vs 27%),[5,6] suggesting its more favorable quality characteristics. In addition, and in comparison with its black-seeded counterpart, meal derived from yellow-seeded *B. napus* contained more ($P < 0.05$) protein, more glucose and fructose, more sucrose, similar amounts of starch, and less ($P < 0.05$) dietary fiber, oligosaccharides, and glucosinolates. Therefore, and from the monogastric animal nutrition point of view, a higher metabolizable energy value is expected from the yellow-seeded *B. napus* meal due to its higher available carbohydrate content (i.e., sucrose) and lower fiber and glucosinolate contents.

When the meals derived from yellow-seeded *B. napus* and *B. juncea* canola were compared, higher ($P < 0.05$) amounts of oligosaccharides and dietary fiber and lower ($P < 0.05$) amounts of protein and sucrose were found in *B. juncea* meal. Among the three types of meal evaluated in the current study, yellow-seeded *B. napus* appeared to have superior quality characteristics (i.e., highest protein and sucrose and lowest dietary fiber contents) compared with that of black-seeded *B. napus* with intermediate quality characteristics observed for *B. juncea*. Both yellow-seeded types, however, contained less total phosphorus (P), resulting from the decrease in nonphytate P.

From the dietary fiber data presented in Table 2, it is evident that the reduction in fiber content is a direct consequence of reduced lignin with associated polyphenols content and some reduction in protein and minerals associated with the fiber fraction. As illustrated in Table 2, meals derived from yellow-seeded *B. napus* and *B. juncea* canola were associated with lower ($P < 0.05$) dietary fiber in comparison with the meal derived from black-seeded canola, which is in agreement with earlier studies.[5,6,14,22] The lowest fiber content was found in yellow-seeded *B. napus* and, in comparison with its black-seeded counterpart, was reduced by 6 percentage points. Such a reduction was reflected in decreased ($P < 0.05$) levels of each fiber component, with the most pronounced decrease (i.e., by 3.4 percentage points) observed for the fraction of lignin with associated polyphenols. In this context, earlier research by Theander et al.[22] indicated that the lignin levels were similar in hulls of black- and yellow-seeded *B. rapa* canola, whereas the polyphenol content (condensed type) was higher in black hulls. Therefore, they concluded that polyphenols rather than lignin would dominate in black-seeded canola. As reviewed by Schofield et al.,[23] cyanidin, pelargonidin, and leucocyanidin have been identified as basic units of condensed tannins of rapeseed/canola hulls. Naczk et al.[24] reported that the total amount of tannins in canola hulls ranges from 1.9 to 6.2 g per 100 g of oil-free hulls, with insoluble polymeric tannins dominating. In addition to giving the meal a dark color, tannins may form complexes with protein and proteolytic enzymes in the gastrointestinal tract, thereby negatively affecting endogenous AA losses and protein utilization by animals.

Table 2. Dietary Fiber Components of Meals Derived from Black- or Yellow-Seeded *B. napus* Canola and Canola-Quality *B. juncea* (% DM)[a]

component	*B. napus*, black	*B. napus*, yellow	*B. juncea*, yellow	SEM
nonstarch polysaccharides	20.2 a	18.7 b	20.0 a	0.24
lignin and polyphenols	7.1 a	3.7 c	3.9 b	0.01
glycoprotein	2.1 a	1.5 c	1.7 b	0.01
minerals	0.7 a	0.3 b	0.3 b	0.02
total fiber	30.1 a	24.1 c	25.8 b	0.24

[a] $n = 2$. Means within a row with no common letters (a−c) differ significantly ($P < 0.05$).

Selection for yellow seed coat color, a visual marker of lower polyphenol content, has been a priority in plant breeding in an attempt to reduce the fiber content of the meal.[25] Yellowness of seeds, which is thought to be associated with a reduction of proanthocyanidin content, represents a major agronomic trait for *Brassica* crop improvement and is linked to increased seed oil and decreased dietary fiber content.[26] Elimination of proanthocyanidins through plant breeding resulted in translucent hulls with the yellowness of the seed resulting from the yellow color of the oil present in the embryo.

Although water-soluble polyphenols (tannins) could, in part, be responsible for some antinutritional effects, the fact that the canola tannins are for the most part located within the cells of the hull fraction, it is reasonable to assume that their antinutritive effect is minimal. However, the reduction in the polyphenol content of yellow-seeded canola may contribute to the quantitative changes within the seed resulting in improved nutritive value of the meal due to increased protein, sucrose, and energy contents at the expense of fiber components.

Nonstarch polysaccharides in canola meal include pectic polysaccharides, cellulose, and a variety of noncellulosic polysaccharides including xylans, xyloglucans, arabinans, arabinogalactans, and galactomannans.[18] In contrast with the results of our previous research, and relative to its black-seeded counterpart, a slight decrease ($P < 0.05$) in the content of NSP was observed in the meal derived from yellow-seeded *B. napus* (Table 3). In comparison with the two *B. napus* meals, *B. juncea* had a slightly different NSP component sugar profile with a higher content of uronic acids, indicating a relatively high concentration of pectic polysaccharides (i.e., rhamnogalacturonans with attached side-chain subunits).[27] When characterized according to solubility in water, all meal samples contained a relatively low content (i.e., 1.8−2.8% DM) of water-soluble NSP, with yellow *B. napus* having the highest value.

Table 3. Nonstarch Polysaccharides (NSP) of Meals Derived from Black- or Yellow-Seeded *B. napus* Canola and Canola-Quality *B. juncea* (% DM)[a]

component	*B. napus*, black	*B. napus*, yellow	*B. juncea*, yellow	SEM
NSP	20.2 a	18.7 b	20.0 a	0.24
cellulose	5.7 a	4.9 b	5.7 a	0.08
noncellulosic NSP	14.5	13.8	14.3	0.12
water-soluble NSP	1.8 b	2.8 a	2.2 b	0.19
water-insoluble NSP	18.4 a	15.9 b	17.8 a	0.19
NSP component sugars (% of total)				
rhamnose	1.2	1.0	1.2	0.02
fucose	1.0	0.8	0.8	0.02
arabinose	22.9	24.8	24.1	0.37
xylose	9.1	10.3	7.5	0.13
mannose	2.6 a	2.1 b	1.5 c	0.03
galactose	7.9	8.8	7.7	0.12
glucose	29.6 a	27.2 b	27.6 b	0.26
uronic acids	26.6 b	26.5 b	30.4 a	0.28

[a] $n = 2$. Means within a row with no common letters (a−c) differ significantly ($P < 0.05$).

The profile of indispensable (essential) amino acids (AA) (Table 4) indicated that in comparison with black-seeded *B. napus*, yellow-seeded *B. napus* contained more total AA per 16 g N ($P < 0.05$), resulting from higher levels of arginine, phenylalanine, asparagine, and glutamic acid (nonessential AA data not shown). However, lysine and methionine contents of yellow-seeded *B. napus* were lower than those of its black-seeded counterpart ($P < 0.05$), which from the animal nutrition point of view is considered to be an undesirable characteristic. There was no difference in the contents of indispensable and total AA between the two meals from yellow-seeded canola except that lysine content was lower ($P < 0.05$) in *B. juncea* than in *B. napus*.

The glucosinolate content of canola meals is shown in Table 5. In comparison with black-seeded *B. napus*, the meals from yellow-seeded *B. napus* and *B. juncea* canola contained less glucosinolates (27.1 vs 17.1 and 17.2 μmol/g DM, respectively). Similar differences in glucosinolate content between black- and yellow-seeded canola were observed earlier

Table 4. Indispensable and Total Amino Acids of Meals Derived from Black- or Yellow-Seeded *B. napus* Canola and Canola-Quality *B. juncea* (g/16 g N)[a]

amino acid	*B. napus*, black	*B. napus*, yellow	*B. juncea*, yellow	SEM
arginine	5.7 b	6.3 a	6.4 a	0.09
methionine	2.1 a	1.9 b	2.0 b	0.03
methionine + cystine	4.5 a	4.2 b	4.1 b	0.03
lysine	6.1 a	5.7 b	5.3 c	0.05
leucine	6.9 b	7.2 ab	7.3 a	0.09
isoleucine	3.9 b	4.1 ab	4.3 a	0.07
phenylalanine	4.0 b	4.2 a	4.1 ab	0.04
threonine	4.3	4.3	4.3	0.01
tryptophan	0.9	0.8	0.9	0.03
valine	4.5	4.8	4.7	0.08
total amino acids	92.4 b	95.0 a	94.3 ab	0.38

[a]n = 2. Means within a row with no common letters (a−c) differ significantly ($P < 0.05$).

Table 5. Glucosinolate Content of Meals Derived from Black- or Yellow-Seeded *B. napus* Canola and Canola-Quality *B. juncea* (μmol/g DM)[a]

component	*B. napus*, black	*B. napus*, yellow	*B. juncea*, yellow	SEM
sinigrin (2-propenyl)	0.1 b	0.1 b	0.2 a	0.01
gluconapin (3-butenyl)	5.8 b	4.1 c	11.7 a	0.13
glucobrassicanapin (4-pentenyl)	1.5 a	1.1 b	0.7 c	0.04
progoitrin (2-hydroxy-3-butenyl)	11.6 a	4.1 b	1.6 c	0.10
gluconapoleiferin (2-hydroxy-4-pentenyl)	0.2	0.2	0.1	0.00
gluconasturtin (2-phenylethyl)	0.7 a	0.5 b	0.4 c	0.01
glucobrassicin (3-indolylmethyl)	0.1	0.1	0.1	0.01
4-hydroxyglucobrassicin (4-hydroxy-3-indolylmethyl)	7.1 a	7.0 a	2.6 b	0.21
total	27.1 a	17.1 b	17.2 b	0.39

[a]n = 3. Means within a row with no common letters (a−c) differ significantly ($P < 0.05$).

in this laboratory for the samples from 2003 and 2004 crop years (i.e., 27.4 vs 20.8 μmol/g DM; on average).[8] Although growing conditions could have some effect, the reduced level of glucosinolates in the current sample of yellow-seeded *B. napus* canola compared to the samples from 2003 ande 2004 crop years (by 4 μmol/g) reflects a continued decrease in glucosinolate content due to selection pressure by canola breeders.[28] The glucosinolate profile of canola-quality *B. juncea* mustard is different from that of *B. napus*, with the aliphatic 3-butenyl glucosinolate (gluconapin) predominating. Despite the fact that the level is relatively low, it is not clear what potential repercussions this has for the nutritive value of the meal. In general, early adverse effects observed when high levels of aliphatic glucosinolates were fed to monogastric animals were due to the pungency of isothiocyanates, the breakdown products of aliphatic glucosinolates, as opposed to the antithyroid activity and bitterness of goitrin, the breakdown product of progoitrin, the predominant glucosinolate of *B. napus* species.

Seed Fractionation Study. To elucidate the differences in chemical composition of the meals, a seed fractionation study was conducted. This study was undertaken to determine if the difference in fiber content between black- and yellow-seeded canola is solely due to lignin with associated polyphenols content or if there are other components that contribute to the difference in fiber concentration.

Limited quantities of the hull and embryo fractions were produced for fractionation study becausse manual dehulling was very difficult due to the small seed size and tight adherence of the hulls to the embryos. As illustrated in Table 6, yellow-seeded *B. napus* had the biggest seed size and *B. juncea* the smallest ($P < 0.01$). The contribution of the hull fraction to the total seed mass was highest for black-seeded *B. napus* and lowest for its yellow-seeded counterpart, whereas *B. juncea* had an intermediate value (15.9, 11.0, and 13.7 g/100 g of seed, respectively), which when calculated on a fat-free basis accounted for 24.6, 15.7, and 19.5 g/100 g of meal, respectively. The fat content of the hull fractions did not differ among the samples and averaged 2.2 g/100 g of seed. The highest level of fat was in embryos of black-seeded *B. napus* and the lowest in *B. juncea*. Due to a shortage of the hull and embryo fractions, singular analysis of sucrose and oligosaccharides was conducted, and thus no statistical evaluation of data was possible. The embryos of black-seeded *B. napus* were relatively low in sucrose when compared with those of yellow-seeded *B. napus* and *B. juncea* canola. No differences in oligosaccharide contents were observed among the hull and embryo fractions.

Fiber analysis revealed that hulls contributed 51, 35, and 43% of dietary fiber to the total seed fiber content of black- and yellow-seeded *B. napus* and *B. juncea*, respectively (Table 7). Considering the hull fraction weights shown in Table 6 and the total fiber contents presented in Table 7, fiber components accounted for 57−60% of the hull fraction in black-seeded *B. napus* and *B. juncea* and were higher than that of yellow-seeded *B. napus* (46%). The fiber composition of hulls also differed, with *B. juncea* containing the highest level of NSP (42%), whereas black-seeded *B. napus* contained the highest amounts of lignin with associated polyphenols and minerals (21%). In the embryo fraction, the highest level of fiber was in *B. juncea*

Table 6. Seed, Embryo, and Hull Weights and Their Composition in Black- or Yellow-Seeded *B. napus* Canola and Canola-Quality *B. juncea* (Full-Fat, As-Is Basis)[a]

						carbohydrates (g/100 g seed)			
		fraction wt (g/100 g seed)		fat (g/100 g seed)		sucrose		oligosaccharides	
canola type	1000 seed wt (g)	embryo	hull	embryo	hull	embryo	hull	embryo	hull
B. napus, black	2.94 b	84.1 c	15.9 a	43.3 a	2.6	4.1	0.5	1.24	0.06
B. napus, yellow	3.85 a	89.0 a	11.0 c	41.5 b	2.2	5.2	0.2	1.23	0.07
B. juncea, yellow	2.49 c	86.3 b	13.7 b	37.3 c	1.9	5.2	0.4	1.96	0.02
SEM	0.08	0.40	0.40	0.20	0.20	–[b]	–	–	–

[a]n = 4 for seed weight; 2 for fraction weight and fat; and 1 for sucrose and oligosaccharides. Means within a column with no common letters (a−c) differ significantly ($P < 0.05$). [b]Not available.

Table 7. Fiber Components of the Embryo and Hull Fractions of Black- or Yellow-Seeded *B. napus* Canola and Canola-Quality *B. juncea* (g/100 g Seed; Full-Fat, As-Is Basis)[a]

	nonstarch polysaccharides		lignin and polyphenols		glycoprotein		total fiber	
canola type	embryo	hull	embryo	hull	embryo	hull	embryo	hull
B. napus, black	5.2 b	5.0 b	1.7	3.4 a	1.9	0.7	8.8 c	9.1 a
B. napus, yellow	6.0 a	3.3 c	1.5	1.2 c	2.0	0.5	9.5 b	5.0 c
B. juncea, yellow	6.1 a	5.7 a	1.7	2.0 b	2.9	0.5	10.7 a	8.2 b
SEM	0.10	0.02	0.30	0.02	–[b]	–	0.10	0.02

[a]n = 2 for NSP, total fiber, lignin, and ash analysis; and 1 for glycoprotein. Means within a column with no common letters (a−c) differ significantly ($P < 0.05$). [b]Not available.

(12%) due to its high content of NSP (7%) and lower content of fat (see Table 6). When expressed on a fat-free basis (data not shown), no significant difference was observed in fiber composition among embryos, but when compared with black-seeded *B. napus* and yellow-seeded *B. juncea*, the total fiber content of yellow-seeded *B. napus* was lowest (20 vs 21.5 and 21.7 g/100 g, respectively). On the 100 g whole-seed basis, fiber contents of hulls had the same trend as that observed for the meals (see Table 2). Black-seeded *B. napus* hulls contributed the highest amount of fiber rich in lignin with associated polyphenols and minerals to the total seed fiber content. Yellow-seeded *B. napus* contained the lowest levels of total fiber and its components in the hull fraction. As a result of larger embryos and high NSP contents, the two yellow-seeded types contributed more embryo fiber to the seed weight when compared with black-seeded *B. napus*. In this context, earlier research on *B. rapa* canola revealed that black hulls were thicker and contained more fiber than yellow hulls, whereas no difference was found in the embryo fractions.[3] When fed to pigs, the digestibility of protein and the energy of yellow hulls was much higher than that of black hulls (20 vs 0% and 30 vs 2%, respectively).[4]

Results of the seed fractionation study indicate that the reduction in fiber content observed in meal derived from yellow-seeded *B. napus* canola is a consequence of a bigger seed size, a lower contribution of the hull fraction to the total seed mass, and a lower fiber content (i.e., lignin with associated polyphenols, NSP, and minerals) of the hull fraction. Thus, an improved nutritive value of meal derived from yellow-seeded *B. napus* canola is expected.

In conclusion, the new yellow-seeded *B. napus* canola appears to have superior quality characteristics compared with that of its black-seeded counterpart as manifested by its higher protein and sucrose (energy) contents and lower dietary fiber content. Canola-quality *B. juncea* canola has reduced concentrations of protein, sucrose, and dietary fiber and a potentially lower nutritive value compared with that of yellow-seeded *B. napus*.

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Notes

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ABBREVIATIONS USED

AA, amino acids; DM, dry matter; NDF, neutral detergent fiber; NSP, nonstarch polysaccharides

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