THE CARBOHYDRATE CONTENT OF YELLOW-SEEDED CANOLA

B.A. Slominski and L.D. Campbell
Department of Animal Science, University of Manitoba
Winnipeg, Manitoba, R3T 2N2

INTRODUCTION

Canola meal contains a relatively high amount of fiber due to the high content (30%) of hull in the meal (Bell, 1984). Hulls from yellow-seeded rapeseed have been reported to be lower in fiber than those from brown-seeded types (Stringam et al., 1974) and plant selection programs have been directed toward increased yellow seed content to decrease the fiber content and thereby increase the nutritive value of the meal. Studies were conducted to characterize the carbohydrate components in yellow-seeded canola and through comparison with brown-seeded canola to assess the potential for improvement in nutritive quality by increasing the content of yellow seeds.

MATERIALS AND METHODS

Canola samples representing fourteen partly yellow- or fully yellow-seeded lines/varieties and four brown-seeded varieties of canola were provided by Dr. P. McVetty of the Department of Plant Science, University of Manitoba, Winnipeg, Canada; Dr. B. Uppstrom of Svalof AB, Svalov, Sweden and Dr. K. Downey of Agriculture Canada Research Station, Saskatoon, Canada. In preparation for analysis, the samples were crushed and extracted with n-hexane for 2 hrs in a Soxhlet apparatus. Following drying, the samples were ground to pass a 1-mm sieve and reextracted with hexane for 4 hrs.

Low molecular weight carbohydrates (sucrose, raffinose, stachyose) were extracted with 80% ethanol, derivatised with piridine/MSTFA/TMCS (100:50:10 v/v) and determined by gas-liquid chromatography using a column packed with 3% OV-7 on chromosorb W (HP). For starch analysis samples were hydrolysed enzymatically [α-amylase (EC 3.2.1.1; Termamyl 120L, Novo Industri A/S) and amyloglucosidase (EC 3.2.1.3; Boehringer)] and the released glucose was determined by the hexokinase - glucose-6-phosphate dehydrogenase method (Boehringer). Non-starch polysaccharides (NSP) were determined by gas-liquid chromatography (component neutral sugars) and by colorimetry (uronic acids) using the procedure described by Englyst and Cummings (1984) with minor modifications (Slominski and Campbell, 1990). In addition, polysaccharides were divided into water-soluble and water-insoluble fractions. Extraction with Tris-HCl buffer (pH 7) for 4 hr. at 40°C followed by component sugar analyses were done to obtain water-soluble NSP and water-insoluble NSP were calculated as total NSP minus water-soluble NSP. The method of Goering and Van Soest (1970) was used to determine neutral detergent fiber (NDF). The contents of NSP, protein (Kjeldahl nitrogen) and ash in NDF residues of canola samples were measured to determine the content of lignin plus polyphenols in canola. The values for lignin plus polyphenols were calculated by difference [NDF - (NSP + protein + ash)]. Neutral-detergent-soluble polysaccharides (NDSP) were calculated as total sample NSP minus NSP present in the NDF residue and total dietary fibre was determined by summation of NDF and NDSP values. Kjeldahl nitrogen and ash were assayed by standard AOAC procedures.

In addition to the oligosaccharide analyses described above an attempt was made to assess the presence of any fructosyl or galactosyl derivatives of sucrose with a degree of polymerization greater than that for stachyose (DP>4). The fully yellow-seeded variety, Parkland, was used for this analysis. Two grams of meal were extracted overnight with 80% ethanol and centrifuged. The residue was evaporated to dryness in vacuo and redissolved in 80% ethanol for application to a 30 x 2.5 cm Sephadex LH-20 column. Four ml fractions were collected and analysed for sucrose, raffinose and stachyose. Subsequently, Sephadex LH-20 fractions of elution volumes 45-62 and 63-86 ml were combined as Fraction A and Fraction B, respectively. Ethanol was removed from each of the fractions and the residues were hydrolyzed in 0.1 M HCl for 1 hr. at 100°C (Henry and Saini, 1989). The monosaccharide composition was determined by gas-liquid chromatography of component sugars as alditol acetates (Englyst and Cummings, 1984).

RESULTS AND DISCUSSION

The content of major carbohydrates and NSP component sugar analysis for yellow- and brown-seeded canola are shown in Table 1. Yellow-seeded canola contained more sucrose than brown-seeded canola while both types of canola had similar values for oligosaccharides and starch. The concentrations of sucrose and oligosaccharides in brown-seeded canola determined in this study are almost identical with those reported by Theander et al. (1976) and Finlayson (1977). A lower value (<1%) was reported for starch content in brown-seeded rapeseed (Finlayson, 1977). As indicated in Fig. 1 the sucrose content of yellow-seeded samples was positively correlated with the percentage of yellow seeds in the samples and was higher by 3-4 percentage points in some fully yellow-seeded lines/varieties as compared to brown-seeded varieties.

Table 1. Carbohydrate content of defatted meals derived from yellow- and brown-seeded lines/varieties of canola (% dry matter)

	Type of sample	
Component	Yellow-seeded (n=14)	Brown-seeded (n=4)
Sucrose	9.8 ± 0.6[1]	7.7 ± 0.8
Oligosaccharides[2]	2.4 ± 0.4	2.5 ± 0.4
Starch	2.6 ± 0.2	2.5 ± 0.3
Soluble NSP[3]	2.0 ± 0.3	1.5 ± 0.1
Insoluble NSP[3]	19.4 ± 0.4	16.4 ± 1.2
NSP component sugars (%)[4]		
Rhamnose	1.0 ± 0.1	1.1 ± 0.1
Fucose	1.2 ± 0.2	1.2 ± 0.1
Arabinose	25.7 ± 1.8	25.2 ± 0.9
Xylose	9.1 ± 0.3	9.0 ± 0.7
Mannose	2.1 ± 0.1	2.2 ± 0.1
Galactose	8.6 ± 0.3	9.3 ± 0.5
Glucose	28.5 ± 1.2	27.8 ± 2.8
Uronic acids	23.8 ± 2.3	24.2 ± 2.9

[1]Mean ± SD.

[2]Includes raffinose and stachyose.

[3]NSP = non starch polysaccharides; solubility was determined by extraction in Tris-HCl buffer (pH 7; 40°C) for 4 hr.

[4]Component sugar analyses were similar for soluble and insoluble NSP.

The total amount of NSP tended to be higher for yellow-seeded canola (Table 1) which is in agreement with previous results from this laboratory (Slominski and Campbell, 1990). The higher level of NSP in the yellow-seeded samples was reflected in a proportional increase in component sugar content rather than in qualitative changes in the sugar profile. In this regard the data presented in the current study do not confirm our earlier suggestion of a higher xylan content in yellow-seeded as compared to brown-seeded canola (Slominski and Campbell, 1990). When characterised according to solubility in water (40°C, pH 7) both yellow- and brown-seeded canola samples were shown to contain a low content of water-soluble NSP.

Neutral detergent fibre values for yellow-seeded canola were lower than those for brown-seeded canola (Table 2). This is in agreement with reports of a lower fibre value for yellow-seeded rapeseed (Stringam et al., 1975; Bell and Shires, 1982) which was attributed to thin seed coats in yellow-seeded canola (Stringam et al., 1975). However, as pointed out by Theander and Aman (1979), NDF values underestimate cell wall residue due to losses of soluble polysaccharides in the NDF solution. A higher degree

of loss of NDSP was evident for yellow-seeded canola as compared with brown-seeded canola in the current study (Table 2). Considering this factor total dietary fibre for yellow-seeded canola averaged 27.3% which was only slightly lower than that for brown-seeded canola (30.1%). In this regard total dietary fiber gives a true reflection of the relatively high content of NSP in yellow-seeded canola.

Table 2. Fiber content of defatted meals derived from yellow-seeded or brown-seeded lines/varieties of canola (% dry matter)

Type of sample	NDF[1]	NDSP[2]	Total dietary fiber
Yellow-seeded (n=14)	18.8 ± 1.6[3]	8.4 ± 0.8	27.3 ± 1.6
Brown-seeded (n=4)	25.7 ± 1.0	4.4 ± 0.3	30.1 ± 0.9

[1]Neutral detergent fiber.

[2]Neutral detergent soluble polysaccharides.

[3]Mean ± SD.

The total dietary fiber values for yellow-seeded samples were lower than those for brown-seeded samples due to the much lower content of lignin and associated polyphenols in the later group (Table 3). The lignin plus polyphenol content of the meal was shown to be directly related to yellow-seed content (Fig. 2). This relationship is probably due to changes in polyphenol content as Theander et al. (1977) reported that the lignin contents of yellow- and brown-seeded rapeseed were similar and that polyphenols rather than lignin were predominant in brown-seeded canola.

Table 3. Composition of neutral detergent fiber in defatted meals derived from yellow-seeded or brown-seeded lines/varieties of canola (% dry matter)

Type of sample	NSP[1]	Protein	Ash	Lignin plus polyphenols
Yellow-seeded (n=14)	13.3 ± 0.6[2]	2.2 ± 0.3	0.4 ± 0.1	3.2 ± 1.0
Brown-seeded (n=4)	13.3 ± 0.5	3.5 ± 0.1	1.0 ± 0.1	8.0 ± 1.1

[1]Non-starch polysaccharides.

[2]Mean ± SD.

Chromatographic separation of ethanol soluble carbohydrates in yellow-seeded canola on a Sephadex LH-20 column is shown in Fig. 3. Further analysis of the various fractions as shown in Table 4 indicated that only trace amounts of component sugars were found in Fraction A (void volume) and Fraction B (elution volumes for oligosaccharides of DP>4). It can be suggested from these data that galactooligosaccharides or fructosans of intermediate molecular weight make an insignificant contribution to the overall profile of canola carbohydrates.

Table 4. Component sugar content of ethanol soluble carbohydrates in Sephadex LH-20 fractions of yellow-seeded canola (mg g^{-1} DM of original material)

	Component sugar[1]				
Fraction	Ara	Man Fru[2]	Gal	Glu Fru[2]	Total
A	0.43	0.02	0.04	0.03	0.52 ± 0.05
B	0.16	0.04	0.16	0.14	0.50 ± 0.03

[1]Ara, arabinose; Man, mannose; Fru, fructose; Gal, galactose; Glu, glucose.

[2]Peaks with retention times identical to those of mannose and glucose were noted for alditol acetate derivatives of fructose

CONCLUSION

Selection for yellow seed coat color in canola breeding programs has resulted in the development of lines/varieties which can be characterized by high contents of sucrose (10%) and NSP (21%) and a low content of lignin and polyphenols (3%). In addition, while yellow-seeded canola was shown to contain low molecular-weight oligosaccharides, insignificant quantities of carbohydrates of intermediate molecular weight were detected. Although the responses may vary among species of animals these characteristics of the carbohydrate profile in yellow-seeded canola are an indication of improved nutritional quality.

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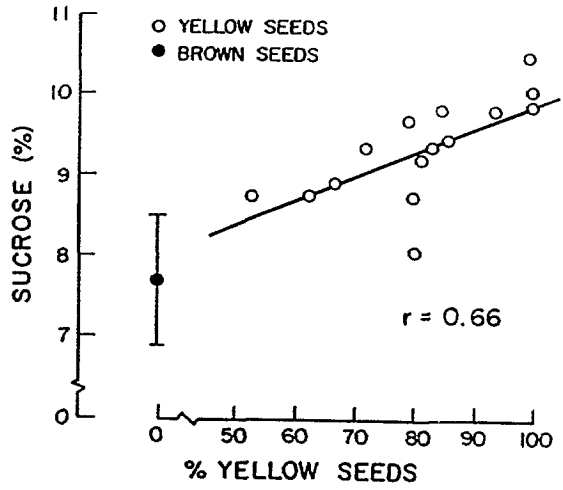

Fig. 1. Relationship between the sucrose content of selected lines/varieties of canola and % yellow seedcoat content.

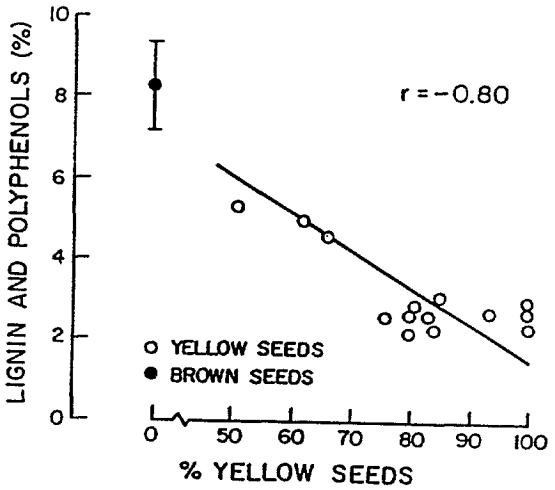

Fig. 2. Relationship between the content of lignin and polyphenols in selected lines/ varieties of canola and % yellow seedcoat content.

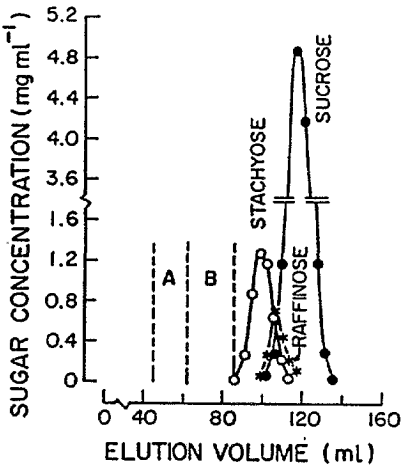

Fig. 3. Sephadex LH-20 chromatography of 80% ethanol soluble carbohydrates from yellow-seeded canola cv. Parkland.