NOTE

Comparison of Coarse and Fine Corn Fiber for Corn Fiber Gum Yields and Sugar Profiles

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Cereal Chem. 77(5):560–561

Wet-milled corn fiber typically consists of hemicellulose (40%), cellulose (12%), protein (10%), and other substances such as lignin and ash (10%) and a unique oil (3%) that is very different in composition compared with commercial corn (germ) oil (Moreau et al 1996). Recent research on corn fiber (Doner and Hicks 1997, Doner et al 1998) has shown that a novel alkaline hydrogen peroxide extraction process can generate a valuable corn fiber gum (CFG) from the hemicellulose B fraction. Sugar composition of corn fiber gum is mainly D-xylose (48–54%), L-arabinose (33–35%), and small amounts of galactose, glucuronic acid, and glucose (Whistler and BeMiller 1956). Corn fiber gum has several useful properties and can be used in adhesives, thickeners, and stabilizers (Wolf et al 1953), and as film formers and emulsifiers (Whistler 1993) in various food or industrial applications.

Most corn fiber is prepared by the corn wet-milling industry, where it is commonly known as white fiber. White fiber is a mixture of corn coarse fiber (also known as pericarp or bran) and the corn fine fiber (or the inner cellular fiber). Most of the research on corn fiber gum (CFG), including yields and sugar composition profiles of the polysaccharide, has been done using white fiber as the starting material. There is lack of information on the corn fiber gum yields and the sugar profiles for individual coarse and fine fiber fractions. This information is important because a process has been developed recently in which coarse fiber (pericarp) can be recovered in a corn dry-grind ethanol process and then can be used as a feedstock for corn fiber gum extraction (Singh et al 1999). The present conventional corn wet-milling process can be easily modified to recover the coarse fiber separately from the fine fiber. This would allow one to take advantage of any unique differences that may occur in the gums from the two fiber fractions for unique applications. In fact, several decades ago, the corn wet-milling process was used to recover fine fiber separately from pericarp fiber (Kerr 1950).

In this study, comparison was made for three commercial corn hybrids between the coarse and fine fiber fractions (obtained under controlled laboratory conditions) for corn fiber gum yields and the sugar composition profiles for the polysaccharides.

MATERIALS AND METHODS

Three yellow dent corn hybrids (36K27, 33R87, and 3394) grown during the 1998 crop season at the Agricultural Engineering Farm, University of Illinois at Urbana-Champaign, were field-dried to 14–16% moisture content and combine-harvested. All three hybrids were hand-cleaned to remove broken corn and foreign material, packaged in plastic bags, and stored at 4°C until wet-milling. The whole kernel moisture content of the samples was measured using the 103°C convection oven method (AACC 2000). Wet-milling was done in duplicate using the 100-g laboratory corn wet-milling procedure as outlined by Eckhoff et al (1996), and both fine and coarse fiber fractions were recovered separately. The collected fiber samples were dried for moisture content determination using the two-stage, convection oven procedure (AACC 2000).

Dried fiber samples, 4–5 g were used for corn fiber gum (CFG) extraction after preliminary destarching with α-amylase (Doner et al 1998). CFG extraction from the fiber samples was done as outlined by Doner et al (1998), using the protocol wherein NaOH was added to the level of 2 meq of alkali/g of fiber. The amount of starch in the fiber samples was determined by a commercial analytical lab (Silliker Laboratories Group, Cedar Rapids, IA) (Table I).

The neutral sugar composition of corn fiber gum (CFG) samples was determined by HPLC after acid hydrolysis (Saulnier et al 1995) using 1*N* H_2SO_4 at 100°C for 1.5 hr. Samples were neutralized by adding $BaCO_3$ and shaking for ≈0.5 hr. Samples were filtered through a Buchner funnel (to remove $BaSO_4$), rinsed with water, and then gravity filtered into a vial. Water was evaporated under a N_2 stream and 0.5 mL of water was added. The samples were filtered through a 0.2-μm membrane filter (Anotop 10 plus, Whatman). Samples were analyzed (BioRad Aminex HPX-87P column, 300 × 7.8 mm) with de-ashing guard cartridges. Column temperature was controlled at 60°C using a column heater (BioRad). Degassed deionized water was used as the eluent at a flow rate of 0.6 mL/min. Samples (10 μL) were injected using an autoinjector (Alcott). A refractive index detector (HP1047A, Hewlett Packard) was used to measure eluted sugars. Data was collected and analyzed (Chrom-Perfect LE data software). Glucuronic acid levels were determined by the *m*-phenylphenol method (Blumenkrantz and Asboe-Hansen 1973).

Analysis of variance (ANOVA) and Duncan's multiple range test were used (SAS Institute, Cary, NC) for CFG yield and sugar composition data. The level selected to show statistical significance was 5% ($P < 0.05$).

RESULTS AND DISCUSSION

The fiber yields were dependent on the hybrids and had values of 5.5–8.2% for coarse fiber and 6.6–7.0% for fine fiber (Table I). Across the hybrids, there was no significant difference between the coarse and fine fiber yields. No significant differences were observed between the three commercial corn hybrids for the average fiber yields (across the coarse and fine fiber fractions).

A trend similar to that observed in the fiber yield for the three hybrids was observed in the corn fiber gum yields. Depending on the hybrid, corn fiber gum yields values were 18.6–22.5% for coarse fiber and 18.5–19.1% for fine fiber fractions. There was no significant difference for corn fiber gum yields between coarse fiber and fine fiber. These results suggest that the fiber fraction of these three corn hybrids consisted of ≈50% each of coarse fiber and fine fiber, and both fractions would yield the same amount of corn fiber

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Publication no. C-2000-0809-01R.

TABLE I
Fiber Yields, Corn Fiber Gum (CFG) Yields, CFG Sugar Composition[a] and Starch Content in Coarse (CF) and Fine Fiber (FF) for Three Corn Hybirds

Sample	Fiber Yield (%)	CFG Yield (%)	CFG Sugar Composition (%)					Starch in Fiber (%)
			Xylose	Arabinose	Galactose	Glucuronic Acid	Glucose	
36K27 (CF)	8.21	20.25	54.45	34.45	6.60	4.50	2.05	15.40
36K27 (FF)	6.98	18.50	47.80	40.15	5.80	6.25	2.80	50.90
33R87 (CF)	5.55	18.61	55.35	34.85	5.15	4.65	2.55	15.60
33R87 (FF)	7.95	18.51	48.65	40.40	5.45	5.50	3.85	52.50
3394 (CF)	6.95	22.50	56.05	34.80	5.85	3.30	1.90	16.20
3394 (FF)	6.64	19.07	48.55	40.70	5.40	5.35	1.75	46.00
Hybird avg.								
36K27	7.59a[b]	19.37a	51.12a	37.30a	6.20a	5.37a	2.42ab	
33R87	6.75a	18.56a	52.00a	37.62a	5.30a	5.07a	3.20a	
3394	6.79a	20.78a	52.30a	37.75a	5.62a	4.32a	1.82b	
Fiber type avg.								
CF	6.90a	20.45a	55.28a	34.70b	5.87a	4.15b	2.17a	
FF	7.19a	18.69a	48.33b	40.42a	5.55a	5.70a	2.80a	

[a] All yields and sugar compositions are averages of two values.
[b] Values followed by the same letter within a treatment are not significantly different ($P < 0.05$).

gum. CFG yields observed in this study were relatively low compared with the yields reported in the literature (Wolf et al 1953, Rutenberg and Herbst 1957, Watson and Williams 1959, Doner and Hicks 1997, Doner et al 1998). Recovery of CFG largely depends on the conditions (alkali concentration, type of alkali used, pH, temperature, and time used for extraction) used for its isolation. However, the CFG yields in this study were comparable to yields obtained in our previous study on the "Quick Fiber" samples (Singh et al 1999). It is likely that the relatively low yields observed in this study are because of very low-scale (4–5 g of fiber) processing. However, based on our previous experience, we expect the gum that was extracted would represent the composition of the coarse and fine fiber in starting material.

A significant difference was observed in the average sugar composition between the coarse fiber and fine fractions for the amount of xylose, arabinose, and glucuronic acid (Table I). No significant differences were observed for average galactose, the remaining sugar in the corn fiber gum polysaccharide. Xylose and arabinose content of coarse fiber, depending on the hybrids, had values of 54.4–56.0% and 34.4–34.8%, respectively. In the fine fiber fractions, depending on the hybrid, the xylose and arabinose content values were 47.8–48.6% and 40.1–40.7%, respectively. The average (across the three corn hybrids) xylose content of the fine fiber fraction was ≈6.9% lower, and the average arabinose content was ≈5.7% higher than that of the coarse fiber fraction. These results suggest that in the fine fiber, the β-D-xylan backbone is much more heavily branched with arabinose units, with arabinose-xylose ratios averaging 0.836. On the average, this ratio in coarse fiber is just 0.627. These differences should result in differences in properties between corn fiber gums from fine and coarse fiber. The average glucuronic acid (across the three corn hybrids) was 1.5% higher in the fine fiber fraction compared with that in the coarse fiber fraction. No significant difference was observed in the average xylose, arabinose, galactose, and glucuronic acid content between the three commercial corn hybrids (across the fiber fractions).

The glucose levels listed in Table I indicate the level of alkali-soluble starch in the corn fiber gum preparations was 1.75–3.85%, which shows that the preliminary enzymatic (α-amylase) destarching step was quite effective. About one half of the fine fiber fractions in the three hybrids consisted of starch (Table I), so well over 90% was removed by the enzymatic saccharification of these samples. There were significant differences between hybrids in residual glucose levels. The average glucose content of 33R87 was ≈1.4% higher compared with 3394. No significant difference in average glucose content was observed between 36K27 and 33R87 or 36K27 and 3394. As described above for CFG yields, variation in glucose levels may be due to lack of reproducibility in low-scale processing.

These results suggest that there are no significant differences in the corn fiber gum yields from coarse and fine fiber fractions. However, there are significant differences in the sugar composition of the corn fiber gums from coarse and fine fiber. Further testing is required to determine whether the properties (adhesiveness, emulsification, film formation, etc.) of corn fiber gum from fine and coarse fiber are different. Differences would be expected based on the greatly elevated arabinose-xylose ratios in the fine fiber as compared with coarse fiber. In addition, further study is required to rationalize this higher degree of CFG polymer branching in fine fiber.

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[Received September 23, 1999. Accepted March 2, 2000.]