CAROTENOIDS OF CORN AND SORGHUM

V. Distribution of Xanthophylls and Carotenes in Hand-Dissected and Dry-Milled Fractions of Yellow Dent Corn[1]

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ABSTRACT

Three lots of whole yellow corn were hand-dissected into bran, germ, floury endosperm, and horny endosperm. Two of the corns were varieties representative of those grown in the central Corn Belt; the third was a mixture used for commercial dry-milling. Components from each lot were analyzed for xanthophylls and carotenes. Fractions from commercial dry-milling of the mixture were analyzed for comparative purposes. Average carotenoid contents of hand-dissected fractions, in p.p.m., were: whole corn, 19.2; bran, 1.7; germ, 4.6; floury endosperm, 9.4; and horny endosperm, 27.6. Distribution of carotenoids in the kernel, based on relative weights of the four major fractions in percent were: bran, 1; germ, 3; floury endosperm, 16; and horny endosperm, 80. Carotenoid contents of commercial dry-milled fractions, in p.p.m., were: whole corn mixture, 20.8; bran, 12.2; germ, 9.5; floury endosperm, 17.1; and horny endosperm, 28.8. Xanthophylls comprised the greater portion of carotenoids in all fractions.

Although white corn is preferred for some food products, the majority of corn processed by dry-millers is yellow. The color of yellow corn results primarily from two general classes of carotenoid pigments – xanthophylls and carotenes. Xanthophylls impart color to egg yolks and to the skin and shanks of broilers and fryers. Carotenes are vitamin A precursors and a source of color in butterfat of milk and body fat of cattle.

Steenbock and Coward (8) (using hand-dissected fractions of whole yellow corn) stated that vitamin A activity is concentrated in the endosperm rather than in the germ. Also, Meyer and Hetler (7) indicated that the concentration is greatest in the outer part of the endosperm. The amounts of individual carotenoids in whole corn have been reported (2,3). However, quantitative information concerning location and concentration of xanthophylls in yellow corn is lacking. In the present work, the distribution of carotenoids is compared in hand-dissected and commercial dry-milled fractions of yellow corn.

Materials and Methods

Materials. Pioneer S × 20 and Pioneer 329[3] hybrid yellow corns

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[3]Mention of trade products or firm names does not imply that they are endorsed or recommended by the Department of Agriculture over similar products or other firms not mentioned.

were used for hand-dissection studies. The varieties are representative of those grown in the central Corn Belt. The corn was grown under field conditions and harvested by a picker-sheller. The kernels were slightly immature, which is typical of much of the corn harvested today. Moisture was reduced without any artificial drying.

The whole corn was soaked in water before hand-dissection with a scalpel into bran (pericarp), germ, and endosperm. The tip-cap was included with the pericarp. The floury endosperm was separated from the horny endosperm with dental drills. The thin horny endosperm layer at the top of the kernel was first removed with a No. 40 bur. Most of the exposed floury endosperm section could be removed with pliers; any remaining required removal with a No. 38 bur.

Various fractions were taken from the process stream in a typical commercial dry-milling operation. The corn used for preparing those fractions probably contained several varieties.

Analytical Method. Xanthophylls and carotenes were determined by a previously described method (1). All values are reported on a moisture-free basis.

Results and Discussion

Hand-Dissected Fractions. Results of separating the three corn samples into bran, germ, floury endosperm, and horny endosperm (Table I) are similar to previously published values (4,6). The slightly

TABLE I

DISTRIBUTION OF CAROTENOIDS IN HAND-DISSECTED YELLOW DENT CORN FRACTIONS

FRACTION	VARIETY [a]	DRY WEIGHT	CAROTENES	XANTHOPHYLLS	TOTAL CAROTENOIDS	TOTAL CAROTENOIDS
		%	*p.p.m.*	*p.p.m.*	*p.p.m.*	%
Whole corn	A	100.0	1.8	19.0	20.8	100
	B	100.0	2.0	13.9	15.9	100
	C	100.0	1.7	19.1	20.8	100
Bran	A	7.4	0.3	1.1	1.4	1
	B	7.6	0.3	1.8	2.1	1
	C	8.3	0.2	1.4	1.6	1
Germ	A	10.1	0.5	3.5	4.0	2
	B	10.0	1.0	3.5	4.5	4
	C	10.3	1.3	4.1	5.4	3
Floury endosperm	A	33.0	1.1	12.8	13.9	23
	B	36.1	0.3	3.0	3.3	9
	C	27.5	1.1	10.0	11.1	15
Horny endosperm	A	49.5	2.3	27.3	29.6	74
	B	46.3	3.2	20.8	24.0	86
	C	53.9	3.7	25.5	29.2	81

[a] A, Pioneer S × 20. B, Pioneer 329. C, corn mixture used for preparation of commercial dry-milled fractions.

higher bran values reported in this work probably result from fragments of the endosperm adhering to the pericarp. Horny endosperm accounted for approximately 50% of the total kernel, compared to 30% for the floury endosperm.

Distribution of carotenoids in the hand-dissected fractions was similar in the three yellow corn samples (Table I). Xanthophylls accounted for the greater portion of total carotenoids in all fractions.

Very small amounts (1.4 to 2.1 p.p.m., approximately 1% of the total) of carotenoids were located in the bran, regardless of the range of pericarp colors from pale yellow to red. Absence of a good correlation between pericarp color and carotenoid level again indicates that some varieties of corn may contain yellow or red pigments that have no carotenoid characteristics (1).

Carotenoid content of the germ ranged from 4.0 to 5.4 p.p.m. and accounted for only 2 to 4% of the total.

Carotenoids in the floury endosperm showed considerable variation in both amounts (3.3 to 13.9 p.p.m.) and percentage of the total (9 to 23). The floury endosperm in Pioneer 329 appeared very white compared to pale yellow in the other two samples. The color difference is reflected in the lower carotenoid level (3.3 p.p.m.) of the floury endosperm of Pioneer 329 compared to the other samples.

The major portion (74 to 86%) of the total carotenoids is located in the horny endosperm. Carotenoid level of this fraction ranged from 24.0 to 29.6 p.p.m. Therefore the total endosperm (floury plus horny) accounted for 95 to 97% of the total carotenoids. These observations agree with the qualitative results reported by others (7,8).

The association of 95% of the total carotenoids with the endosperm indicates that previous methods (5) used for predicting levels of carotenes and xanthophylls in breeding samples will continue to give satisfactory results. These methods are based on the mean of a weight of two-thirds for the female gametes and one-third for the male gametes.

Commercial Dry-Milled Fractions. Distribution of carotenoids in the corn mixture used for commercial dry-milling was similar to that in the other two corns. The major portion (81%) of the total carotenoids was located in the horny endosperm (Table I), with lesser amounts distributed in the floury endosperm, germ, and bran. The results should be typical, since the corn probably contained a number of varieties.

Distribution of carotenoids in the commercial dry-milled fractions (Table II) reflects the general pattern found in the hand-dissected fractions. Carotenoid level (28.8 p.p.m.) of the horny endosperm of

TABLE II

DISTRIBUTION OF CAROTENOIDS IN COMMERCIAL DRY-MILLED FRACTIONS OF YELLOW CORN

FRACTION	CAROTENES	XANTHOPHYLLS	TOTAL
	p.p.m.	*p.p.m.*	*p.p.m.*
Whole corn	1.7	19.1	20.8
Bran	0.8	11.4	12.2
Germ	1.8	7.7	9.5
Floury endosperm (corn break flour)	1.5	15.6	17.1
Horny endosperm (corn grits)	2.9	25.9	28.8

the commercial fraction is in excellent agreement with that (29.2) (Table III) of the hand-dissected sample. Carotenoid contents of the floury endosperm, germ, and bran indicate that these individual fractions each contain fragments from other parts of the corn kernel.

TABLE III

COMPARISON OF TOTAL CAROTENOIDS IN HAND-DISSECTED AND COMMERCIAL DRY-MILLED FRACTIONS OF YELLOW CORN

FRACTION	TOTAL CAROTENOIDS	
	Hand-Dissected	Commercial
	p.p.m.	*p.p.m.*
Whole corn	20.8	20.8
Bran	1.6	12.2
Germ	5.4	9.5
Floury endosperm	11.1	17.1
Horny endosperm	29.2	28.8

The method used in this work separates the carotenoids into two major fractions – xanthophylls and carotenes. Information on the kinds of carotenoids included in each fraction is given in the procedure (1). Variation in the ratio of xanthophylls to carotenes in the hand-dissected and dry-milled fractions suggests that certain individual carotenoids may be concentrated in parts of the kernel. In the germ, lower ratios of xanthophylls to carotenes support the theory that carotenes should logically be found in the oil-bearing fraction.

Further work is planned in determining the individual carotenoids in the various anatomical fractions.

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