CAROTENOIDS OF CORN AND SORGHUM

II. Carotenoid Loss in Yellow-Endosperm Sorghum Grain during Weathering[1]

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ABSTRACT

When exposed to weathering after pollination, sorghum retained only 50% of the carotenoids present in protected seed heads. Carotenes and xanthophylls decreased continuously, with no preferential loss of individual carotenoids. The presence of red pigments in the pericarp did not inhibit loss of carotenoids. The adverse effect of weathering on yellow-endosperm sorghum grain is a major problem in the program for breeding high-carotenoid sorghums.

Carotenoid pigments include two general classes — the carotenes and the xanthophylls. The carotenes are important in feed grains as vitamin A precursors and as a source of yellow color in milk and body fat of cattle. Xanthophylls impart desirable yellow color to egg yolks and to the skin of broilers and fryers. At present, corn is the only grain providing significant amounts of xanthophylls and carotenes in mixed feeds.

Although ordinary sorghum varieties lack these pigments, plant breeders have recently developed true yellow-endosperm varieties containing one-fourth to one-half the normal pigment content of yellow corn (2). A major problem in the breeding program is the rapid loss of the pigments from sorghum grain in the field (3). This report presents a detailed study of the carotenoid pigments in protected and exposed yellow-endosperm grain and a trial introduction of a colored pericarp as a possible means of inhibiting loss of carotenoids.

Materials and Methods

Materials. Yellow-endosperm sorghum grains were grown in 1959 at the Nebraska Agricultural Experiment Station in Lincoln. Four strains were used to determine the rate of loss of carotenoids during weathering. Data on two of the strains, selected as representative, are

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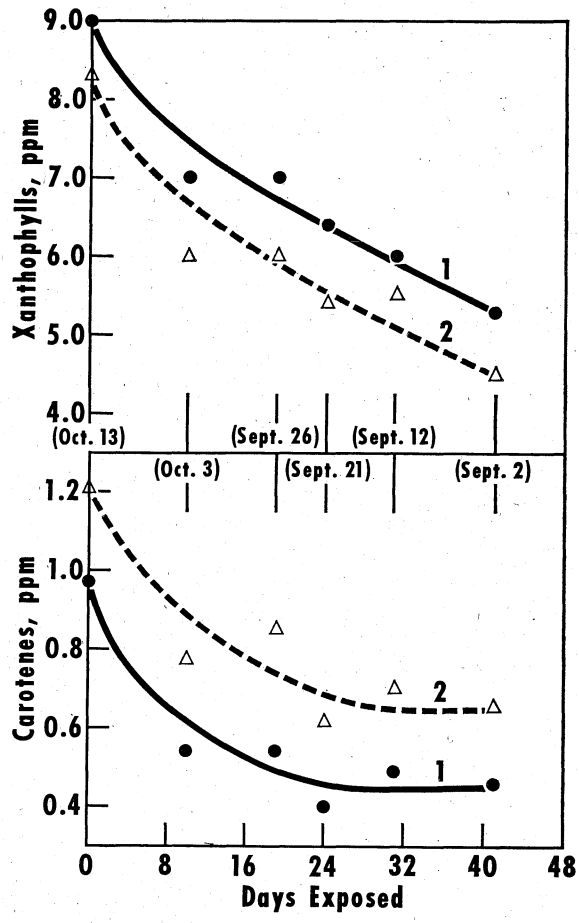

Fig. 1. Loss of carotenes and xanthophylls in representative strains of yellow-endosperm sorghum grain during weathering.

given in Fig. 1. The 50%-bloom stage of strain 2 was estimated as August 2 and of the other three strains as August 7. On September 2, kraft paper bags, 50-lb. wet strength, were put over 25 or more heads of comparable maturity in each plot. On this same date five heads of similar maturity were tagged but not protected. Five bags were removed in each plot on the following dates: September 12, 21, and 26 and October 3 and 13. These dates correspond to the exposure time shown in Fig. 1. The harvest date was October 13.

Grain samples used for studies on individual carotenoids and the inhibition of pigment loss were similarly prepared. However, the re-

sults compare carotenoids present only at zero exposure time and maximum exposure (approximately 40 days).

Analytical Method. Carotenes and xanthophylls were determined by a previously described method (1).

Results and Discussion

Loss of Carotenoids during Weathering. Exposure of four strains of yellow-endosperm sorghum grain to weathering produced a continuous loss of both carotenes and xanthophylls (Fig. 1). Grain exposed for the maximum period (41 days) retained only 47–58% of the carotenes and 54–66% of the xanthophylls present at zero exposure time. A trend to higher ratios of xanthophylls to carotenes for the exposed samples is indicated, but the significance is questionable because of the low level of carotenes and the presence of xanthophyll esters in the carotene fraction (1,2). The highest contents of carotenes (1.2 p.p.m.) and of xanthophylls (9 p.p.m.) in the samples under the most favorable conditions (zero exposure) were low compared with those of Nebraska 701 yellow corn (carotenes – 2.4 p.p.m., xanthophylls – 28 p.p.m.) grown under the same conditions.

Individual carotenoids in protected and exposed grain were separated by column chromatography and identified by absorption spectra and relative positions on the column (2). Two xanthophylls – lutein and zeaxanthin – accounted for 60–75% of the total carotenoids (Table I) in both the protected and exposed samples. Individual carotenoids were not preferentially lost during exposure of the maturing grain.

TABLE I

INDIVIDUAL CAROTENOIDS IN PROTECTED AND EXPOSED YELLOW-ENDOSPERM SORGHUM GRAINS

CAROTENOID	SAMPLE 3				SAMPLE 4			
	Protected		Exposed [a]		Protected		Exposed [a]	
	%	*ppm*	%	*ppm*	%	*ppm*	%	*ppm*
Band I	18	1.3	11	0.3	22	1.8	20	0.8
Zeaxanthin	47	3.4	52	1.7	34	2.8	43	1.6
Lutein	20	1.4	22	0.8	28	2.2	25	1.0
Band II	5	0.4	3	0.2	6	0.4	3	0.1
beta-Carotene	10	0.6	12	0.3	10	0.8	9	0.3
Total	100	7.1	100	3.3	100	8.0	100	3.8

[a] Exposure to weathering was approximately 40 days.

Effect of Colored Pericarps. Sorghum grain samples with a red pericarp seemed visually to contain more yellow pigment in the endosperm than did those with a white pericarp. Since this observation

suggested that red color in the pericarp might inhibit photochemically induced loss of carotenoids, breeding was conducted to obtain the three types of pericarp and endosperm combination shown in Table II.

TABLE II

EFFECT OF PERICARP COLOR ON LOSS OF CAROTENOIDS FROM SORGHUM GRAIN DURING WEATHERING

SAMPLE	SEED CHARACTERISTICS		TREATMENT	CAROTENES	XANTHOPHYLLS
	Pericarp	Endosperm		*ppm*	*ppm*
5	Good yellow	Good yellow	Protected	0.6	5
			Exposed	0.3	3
6	Good yellow	Good yellow	Protected	0.7	6
			Exposed	0.3	3
7	White	Fair yellow	Protected	0.5	3
			Exposed	0.2	2
8	White	Fair yellow	Protected	0.4	3
			Exposed	0.2	2
9	Red	Good yellow	Protected	0.4	3
			Exposed	0.2	2
10	Red	Good yellow	Protected	0.4	3
			Exposed	0.2	2

Exposure of the heads to weathering reduced carotenoid content approximately 50% in all three types. The presence of colored pericarps did not inhibit loss of carotenoids from the endosperm. Samples containing a red pericarp and good yellow endosperm (samples 9 and 10) were no higher in carotenoid content than those containing a white pericarp and fair yellow endosperm (samples 7 and 8). The degree of visual yellow pigmentation should not be used as the sole basis for estimating carotenoid content, since sorghum contains yellow pigments that have no carotenoid characteristics (2).

Literature Cited

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