CORN CAROTENOIDS: EFFECTS OF TEMPERATURE AND MOISTURE ON LOSSES DURING STORAGE[1]

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ABSTRACT

Shelled dent corn from the seed of a single cross of high carotene parentage was stored in the dark for 3 years at 3 and 11% moisture and at 7° and 25°C. Losses of total carotenoid pigments, most rapid during the early part of the storage period, were approximately a logarithmic function of time. Temperature exerted a greater influence than moisture content.

The carotene fraction was the least stable pigment fraction. Half of the initial carotene was lost at 7°C.; three-quarters was lost at 25°C. Losses of zeinoxanthin and the carotendiols (lutein and zeaxanthin) were about equal and all occurred at slower rates than that of carotene. Today's yellow hybrids, which tend to be comparatively low in pigments initially, may fall to very low levels after long storage periods.

While it is often recognized that yellow corn loses some of its carotenoid pigment during storage, knowledge is lacking on the rate of loss and the factors which influence this rate. Morrison (1) has cited an Iowa mimeographed report of evidence that stored shelled corn lost a fourth of its provitamin A activity in the first year, and half of its activity in 4 years. However, the experimental data were not made available.

In the present work, yellow corn was stored under four different conditions and analyzed for its different carotenoids at intervals during a 3-year period.

Materials and Methods

Fourteen pounds of shelled dent corn from the seed of a single cross of high-carotene parentage Kys × 16992-17 were used in this experiment. The newly harvested corn was dried to 11.0% moisture at 100°F. in an air-circulating oven, and 7 lb. were removed for the storage experiments. The remaining 7 lb. continued to dry in the oven for several days, after which the moisture content was found to be 3.0% by the AOAC oven method. Each of the two portions was then divided into fourteen subportions of about ½ lb. which were placed in screw-capped amber glass jars. These were placed in dark storage rooms at 7° and 25°C., as indicated in the table below.

One jar from each treatment was taken for carotenoid analysis immediately. Other jars were taken after 4, 8, 12, 24, and 36 months'

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Treatment	*No. of Jars*	*Moisture Content*	*Storage Temperature*
		%	°C.
11–25	7	11	25
11–7	7	11	7
3–25	7	3	25
3–7	7	3	7

storage. Initial results were averages of triplicate analyses. Subsequent data represent averages of duplicate analyses. Analyses were performed by rehydration-extraction and chromatography in a simplified version of a method which has been described (3). The carotene fraction was read at 478 mμ to give an estimate of beta-carotene with the exclusion of the zeacarotenes and zeta-carotene. The xanthophyll esters were not removed from the cryptoxanthin fraction.

Results and Discussion

Losses of pigment were most rapid during the early part of the storage period. Total carotenoid pigment values obtained as the sum of the individual fractions indicate that the losses were approximately a logarithmic function of time. Equations for lines fitted to the data, when X is storage time and Y is total pigment, are shown below, along with correlation coefficients.

$$11\%,\ 7°:\quad \log Y = 1.7000 - 0.002401\ X. \qquad (r = -0.68)$$
$$11\%,\ 25°:\quad \log Y = 1.6751 - 0.01127\ X. \qquad (r = -0.90)$$
$$3\%,\ 7°:\quad \log Y = 1.5961 - 0.002786\ X. \qquad (r = -0.67)$$
$$3\%,\ 25°:\quad \log Y = 1.5735 - 0.00973\ X. \qquad (r = -0.96)$$

Storage temperatures exerted a much greater influence than moisture content on the rate of loss of total pigment (Table I). Unfortunately, the drying operation in reducing the moisture from 11 to 3% effected a loss of about 25% of the total pigment. However, log values of total pigments in the "dry" corn subsequently paralleled those in the normal (11%) corn.

The individual pigments disappeared at different rates (Table I). The carotene (hydrocarbon) fraction showed the lowest stability of all of the fractions. At both moisture levels the corn stored at 25° lost about three-quarters of the initial carotenes during the 3-year period. At 7° the losses were only half as great. The xanthophylls (carotendiols), lutein and zeaxanthin, disappeared less rapidly than the carotenes and at a rate similar to the carotenols, zeinoxanthin and cryptoxanthin. The values for the latter are, however, not a fully reliable index of cryptoxanthin stability because of the presence of

TABLE I

CHANGES IN THE DIFFERENT CAROTENOID FRACTIONS
(All values are averages of two analyses, expressed as γ per g. of corn)

MOISTURE	STORAGE TEMP.	PERIOD OF STORAGE	CAROTENES	ZEINOXANTHIN	CRYPTOXANTHIN AND ESTERS	LUTEIN	ZEAXANTHIN	POLYOXYPIGMENTS	SUM OF PIGMENTS
%	°C.	*mos.*							
11	25	0	4.8	3.4	5.5	19.8	16.9	3.4	53.8
		4	3.6	2.1	5.1	17.5	16.5	2.0	46.8
		8	2.5	2.2	3.3	16.0	10.4	2.8	37.2
		12	1.8	1.9	2.4	10.8	6.7	1.6	25.2
		24	1.7	1.8	3.2	11.3	7.7	1.9	27.6
		36	1.0	1.3	2.8	7.6	5.2	1.8	19.5
11	7	0	4.8	3.4	5.5	19.8	16.9	3.4	53.8
		4	3.1	2.2	5.0	20.5	12.5	2.6	45.9
		8	3.5	2.4	4.5	23.2	15.1	2.7	51.4
		12	3.4	2.9	4.0	14.6	14.2	2.3	41.4
		24	3.4	2.4	6.1	19.3	12.4	2.5	46.1
		36	2.6	2.5	5.6	15.8	12.6	2.3	41.1
3	25	0	3.9	2.3	5.0	15.7	9.9	2.8	39.6
		4	3.3	1.8	5.0	14.4	10.1	2.3	36.9
		8	2.6	1.7	3.4	12.0	7.8	2.0	29.5
		12	2.7	2.1	3.1	8.4	6.3	1.7	24.2
		24	1.4	1.4	3.1	8.6	5.8	2.0	22.3
		36	1.1	1.3	2.5	6.5	4.4	1.6	17.2
3	7	0	3.9	2.3	5.0	15.7	9.9	2.8	39.6
		4	3.1	1.4	5.0	13.2	10.7	2.5	35.9
		8	3.5	2.1	4.0	17.9	12.4	2.2	42.1
		12	3.5	2.5	4.0	11.5	8.8	2.5	32.8
		24	3.0	2.3	5.5	15.0	10.2	2.0	38.0
		36	2.2	2.1	4.5	10.3	8.6	2.0	29.5

about 25% of carotenol esters in this fraction (3) from this single cross.

It is probable that some of the deviation of points from linear in the log relationship is due to analytical error. Unfortunately, the analyses were performed by different analysts, working independently, in each of the three years, with the result that standard error of the estimate values were greater than were observed (3) when different analysts worked individually but concurrently on common samples. Although these analytical variations are somewhat disconcerting they are still relatively small in relation to the over-all changes in pigment content during the period of study.

The results of this study indicate that carotene losses from corn in storage may be more rapid than is generally realized. The losses at 7°C. storage temperature were more rapid than the rate Morrison (1) has indicated for ordinary storage. However, 7°C. is probably well below the mean yearly temperature for most of the corn in storage.

When one considers also the tendency to select low-carotene inbreds for breeding stock (2) and the long storage periods to which the product is sometimes subjected as a surplus commodity, one concludes that yellow corn often may fall far short of the provitamin content usually attributed to it in the formulation of feeds for our farm animals.

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