Vitamin A Value of Sweet Corn

Carotenoid composition in four cultivars and six lots of commercially processed sweet corn was studied. Seven carotenes and two monohydroxy carotenoids were separated. The major pigments were zeinoxanthin and β-zeacarotene. Since zeinoxanthin is biologically inactive and β-zeacarotene has lower provitamin A activity as compared to that of β-carotene, the actual vitamin A value of sweet corn is much lower than the prevalent literature values that include several non provitamin A carotenoids.

Since 1919 when the difference in carotene contents between yellow corn and white corn was known (Steenbock, 1919), the composition of individual carotenoids in field corn grain has been studied extensively because they are an important source of yellow pigment in animal feed. Corn grain breeding programs have been directed to the increase in yellow pigment for animal feed. Kuhn and Grundmann (1934) were among the first to attempt to characterize the individual carotenoids of corn grain. They isolated zeaxanthin, cryptoxanthin, and β-carotene. Fraps and Kemmerer (1941) identified α-carotene and a neocryptoxanthin. White et al. (1942) isolated lutein and neozeaxanthin, and Callison et al. (1953) separated several neo-β-carotene in yellow corn meal. Since then Quackenbush and co-workers at Purdue University isolated various carotenoids from corn grain and its products (Petzold et al., 1959; Petzold and Quackenbush, 1960; Quackenbush et al., 1961).

Emphasis on sweet corn quality, however, has been placed upon texture and flavor; therefore, there is not much information on its carotenoid composition and particularly on the individual components with provitamin A activity. During the 1940s several papers on total carotene content of canned sweet corn were published (Pressley et al., 1944; Guerrant et al., 1945; Hinman et al., 1947). Tichenor et al. (1965) separated for the first time β-carotene and monohydroxy carotenoids from frozen sweet corn. More recently Farrow et al. (1973) reported vitamin A content of canned sweet corn based on AOAC (1970) methods which determine total carotene and total monohydroxy pigments. Total carotene and total monohydroxy pigment analyses which have been used widely and have been adopted as official analytical methods do not exclude the non provitamin A carotenoids, and consequently calculated vitamin A values are not accurate (Gebhardt et al., 1977; Lee and Robinson, 1980). Since vitamin A values of sweet corn in today's nutrient tables are based on these conventional analytical methods and on reports published more than 20 years ago, it is of great interest to quantitate accurate vitamin A values on recently introduced cultivars of sweet corn.

The objective of this study was to separate individual carotenoids and to determine the actual amount of provitamin A carotenoids in processed sweet corn.

EXPERIMENTAL SECTION

Materials. Four cultivars of sweet corn grown under normal conditions during the 1979 season at the Vegetable Research Field of the New York State Agricultural Experiment Station were processed in no. 303 cans in a pilot plant simulating commercial processing practices. Commercial canned and frozen corn samples from six different companies were obtained at the local markets.

Analysis. From randomly selected cans, a 1.2-kg sample was used for each analysis. Procedures of sample preparation, extraction, and separation of carotenes followed the methods of Purcell (1958) and Sweeney and Marsh (1970). The monohydroxy carotenoid fraction was rechromatographed on a column of MgO–Hyflo Super Cel, and its major components, zeinoxanthin and β-cryptoxanthin, were eluted gradually by increasing concentrations of acetone in hexane (Quackenbush et al., 1970). For confirmation of the identity of β-cryptoxanthin, authentic crystalline β-cryptoxanthin obtained from orange was run together with the samples. Maximum absorbance (λ_{max}) and absorption coefficient ($E^{1\%}_{1cm}$) values (Zechmeister, 1962; Davies, 1976) were used for each individual pigment concentration.

Table I. Major Carotenoids in Four Cultivars of Sweet Corn

	μg/100 g			
carotenoids	Jubilee	Iosweet	70-2499	Stylpak
hydrocarbon	89.0	41.4	45.0	45.6
monohydroxy	98.5	92.7	101.6	89.5
polyhydroxy	58.5	19.6	35.0	51.5
α-carotene	24.6	5.0	8.4	8.1
β-carotene	9.8	5.3	14.0	8.4
β-zeacarotene	15.7	16.8	14.5	17.0
γ-carotene	15.1	8.9	7.5	10.6
zeinoxanthin	79.2	66.0	77.2	68.9
β-cryptoxanthin	18.9	18.3	15.1	18.4

RESULTS AND DISCUSSION

The major carotenoids found in four cultivars of canned sweet corn are shown in Table I. Unlike many other vegetables, sweet corn contained monohydroxy carotenoids as a major fraction, followed by hydrocarbon and polyhydroxy carotenoids. Hydrocarbon carotenoids mainly consisted of α-carotene, β-carotene, γ-carotene, and β-zeacarotene and small amounts of ζ-carotene, neurosporene, and lycopene. β-Zeacarotene was the largest in three cultivars of Iosweet, 70-2499, and Stylpak. Monohydroxy carotenoids consisted of mainly zeinoxanthin and β-cryptoxanthin. Each of these two pigments was shown to have two or more additional stereoisomers. Zeinoxanthin, which is biologically inactive, was found to be the major pigment of sweet corn in all four cultivars studied. Petzold and Quackenbush (1960) observed a large quantity of zeinoxanthin in corn grain.

Since there has been confusion among several workers (Cholnoky et al., 1958; Szabolcs and Ronai, 1969; Petzold and Quackenbush, 1960) as to the identity of two compounds, α-cryptoxanthin (3′-hydroxy-α-carotene), which has a biological activity of provitamin A, and zeinoxanthin (3-hydroxy-α-carotene), allylic hydroxy tests by using acid–chloroform in alcoholic solution (Petracek and Zechmeister, 1956) were conducted. The confirmed structure was zeinoxanthin.

Varietal differences in carotenoid contents were observed; Jubilee sweet corn, which had more yellowish appearance, contained the largest amount of α-carotene and total carotenoid pigment, while Iosweet contained the

0021-8561/81/1429-1294$01.25/0

Table II. Provitamin A Carotenoids and Vitamin A Values of Commerical Sweet Corn

	μg/100 g					
	frozen		canned			
carotenoids	A	B	A	B	C	D
α-carotene	34.2	23.2	3.3	19.7	5.6	4.1
β-carotene	14.7	13.0	8.1	12.1	6.9	4.7
β-zeacarotene	57.7	19.1	40.6	12.6	19.9	24.4
γ-carotene	8.6	10.7	0.4	5.9	1.9	4.2
β-cryptoxanthin	8.9	11.7	3.2	8.7	17.1	11.2

vitamin A value[a]	frozen		canned			
	A	B	A	B	C	D
RE	11.5	7.5	5.3	5.9	4.8	4.4
IU	115	75	53	59	48	44

[a] RE = retinol equivalent; IU = international unit.

lowest amount of α-carotene and β-carotene. One breeding line, 70-2499, contained higher amounts of β-carotene but was lower in β-zeacarotene.

Results of commercial sample analyses (Table II) showed a rather wide range of provitamin A carotenoid content. The frozen corn sample A contained significantly high amounts of α-carotene and β-zeacarotene, while canned sample A contained lower amounts of γ-carotene and β-cryptoxanthin. Frozen corn samples are expected to have higher carotenoid contents than canned corn since canned corn receives additional heat treatment. As observed in the cultivar study, β-zeacarotene was the major hydrocarbon provitamin A carotene among all commercial samples except canned sample B. Provitamin A carotene in canned sample A consisted mainly of β-zeacarotene. Canned sample C contained the highest amount of β-cryptoxanthin. Since the variety and cultural backgrounds of commercial samples were not known, valid comparisons among samples could not be made.

The vitamin A value of food has been reported in international units (IU). However, since the dietary provitamin A carotenoids are utilized poorly compared with retinol, the expression of the total vitamin A activity of a diet as IU has had to be qualified by indicating the percentage of the activity coming from the provitamin A carotenoids. Therefore, it has been recommended that the vitamin A activity be stated as equivalent weight of retinol (NAS, 1980). By definition, one retinol equivalent (RE) is equal to 6 μg of β-carotene or 12 μg of other provitamin A carotenoids, and one RE is equal to 10 IU of β-carotene. On the basis of this calculation, the vitamin A content of commercially canned sweet corn analyzed in this study ranged from 4.4 RE (or 44 IU) to 5.9 RE (or 59 IU) with an average of 5.1 RE/100-g sample. Frozen corn samples are a little higher. Vitamin A contents in four cultivars of sweet corn samples ranged from 5.0 to 7.7 RE, with an average of 6.4 RE. All of these values are much lower than prevalent literature values that include non provitamin A carotenoids.

ACKNOWLEDGMENT

Special thanks are expressed to Dr. Ivan Stewart for his generous supply of β-cryptoxanthin crystalline.

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Received for review April 16, 1981. Accepted August 3, 1981. This study is supported in part by a grant from the Green Giant Company.