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Effects of steaming, boiling and frozen storage on carotenoid contents of various sweet corn cultivars

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Abstract

The effects of domestic cooking methods and frozen storage on lutein, zeaxanthin, β-cryptoxanthin, β-carotene and total carotenoid contents of various corn cultivars were investigated. New hybrid small-ear corns (KKU#1WY, KKU#2WY and KKU#3YY) were analyzed for carotenoid contents compared to commercial big-ear corns (ATS5 and Hybrix3). Total carotenoid contents of fresh and cooked sweet corns ranged from 1.52-5.72 to 4.41-10.67 µg/g, respectively. Lutein and zeaxanthin were the predominant carotenoids in raw, cooked and frozen sweet corns. The cooking methods resulted in a significant increase in the concentration of total carotenoids (41.33-179.93%), lutein (35.51-232.18%), zeaxanthin (48.12-457.16%), β-cryptoxanthin (22.35-405.03%) and β-carotene (15.82-88.16%) for all cultivars, except the Hybrix3 in which the β-carotene content decreased after steaming and boiling ($p < 0.05$). Blanching prior to freezing also caused increase in corn carotenoids. All corn cultivars showed decreases in lutein, zeaxanthin, β-cryptoxanthin and β-carotene contents during frozen storage at -20°C for 1 month.

Introduction

More than 700 carotenoids can be found in fruits and vegetables. Carotenoids are not only natural pigments responsible for yellow to red colors in fruits and vegetables but they also play important roles in human health and nutrition as antioxidants (Palozza and Krinsky, 1992). Carotenoids have been reported their potentials to maintain immune functions (Hinds *et al*., 1997) and eye health (Moeller *et al*., 2000). Caroteiniods prevent cancer (Andlauer and Furst, 1999) and atherosclerosis (Dwyer *et al*., 2001). Some are precursors for the vitamin A synthesis (Humphries *et al*., 2004). Sweet corn has been widely consumed as a healthy food since it is rich in carotenoids. Lutein and zeaxanthin are major carotenoids found in sweet corn and recognized as preventive biologically active substances for deficiency diseases, especially for eye sight. The two carotenoids predominate at the macula and their loss is associated with the onset of age-related macular degeneration (ARMD) (Bone *et al*., 2000). They act as antioxidants and as blue light eye filters, protecting ocular tissues from phototoxic damage. The carotenoids contents depend on plant cultivars (Scott and Eldridge, 2005). Most vegetables are thermally cooked e.g. by steaming, boiling, and stir frying, before consumption. Cooking methods affect both physical and chemical changes resulting in an increase or decrease in phytochemical contents, particularly antioxidants present in vegetables (Zhang and Hamauzu, 2004; Turkmen *et al*., 2005). It has been reported that thermal processing increases the bioactive contents and total antioxidant activity of tomatoes (Dewanto *et al.*, 2002a) and sweet corn (Dewanto *et al*., 2002b), resulting in a higher nutritional value than the fresh produces. β-carotene and tocopherol in broccoli significantly increase upon cooking (Bernhardt and Schlich, 2006). On the other hand, Podsędek (2007) reported that processed vegetables were lower antioxidant contents than the unprocessed samples. This was probably due to the degradation of bioactives and water-absorption during processing, resulting in a dilution of the bioactives. Therefore, the aim of this study was to determine the effect of domestic cooking (steaming and boiling) on lutein, zeaxanthin, β-cryptoxanthin, β-carotene contents and to evaluate the effect of frozen storage duration on the carotenoids of various sweet corn cultivars. This study provides information for the carotenoid changes in various sweet corn cultivars due to different cooking conditions and during frozen storage. The implication of this study

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will be useful for consumers or nutritionists to select a cooking practice and to consider for an appropriate packing method during frozen storage, to retain the nutritional quality of foods.

Materials and Methods

Materials and sample preparation

Five sweet corn cultivars of different ear size and kernels color were investigated. Three cultivars (KKU#1WY, KKU#2WY, KKU#3YY) were new small-ear sweet-corn hybrids, bred by the Plant Breeding Research Center for Sustainable Agriculture, Khon Kaen University, Thailand, and the other two are commercial hybrids (ATS5 and Hybrix5). Table 1 shows physical characteristics of each corn variety. The plants were field grown in May 2010 using conventional production practices and self-pollinated based on controlled pollination methods. Each corn variety was hand harvested at 18-20 day after pollination (DAP). The corns were hand husked, desilked, and graded for uniformity and well-filled kernels. The corn tips were cut off and only the full kernel parts were cut into halves before cooking. The weight of small ear 80-100 g of cob and big ear 230-250 g of cob.

Cooking treatments

The 2 domestic cooking methods for corn used in Thailand, boiling and steaming, were employed. In a preliminary study, the small-ear corns needed to be boiled and steamed for 6 and 8 min, respectively, to obtained clear transparent texture indicating a well-done cooking. The cooking time for boiling and steaming of commercial big-ear corns were 8 and 10 min, respectively.

Boiling: 10 corn ears of each variety of sweet corn were boiled in 10 L tap water in a stainless-steel pot with a covered lid. The cooking time was 6 min for the KKU#1WY, KKU#2WY, KKU#3YY cultivars and 8 min for the ATS5 and Hybrix5 cultivars. The cooking times were different because each corn variety was different ear size; KKU#1WY, KKU#2WY, KKU#3YY were small ear and ATS5 and Hybrix5 were big ear. The heating water was kept boiling over the cooking period. Then the corns were cooled in tap water.

Steaming: Single layer of 10 corn ears was steamed in a domestic stainless steel steamer (diameter of 40 cm). The cooking time was 8 min for KKU#1WY, KKU#2WY, KKU#3YY and 10 min for ATS5 and Hybrix5. Then the corn ears were cooled in tap water.

All samples after boiling and steaming were frozen in liquid nitrogen and stored at -20±1°C until carotenoid analysis.

Table 1. Characteristics of the five sweet corn cultivars used in this study

Ear size	Kernel color	
	Bicolor (yellow-white)	Monocolor (Yellow)
Small ears (new hybrid) 80-100 g/ear	KKU#1WY, KKU#2WY	KKU#3YY
Big ears (commercial hybrid) 230-250 g/ear	-	ATS5, Hybrix5

Frozen storage of corn: 50 pieces of each variety of sweet corns were blanched in 10 L boiling water (ca. 98±1°C) for 4 min for KKU#1WY, KKU#2WY, KKU#3YY and 6 min for ATS5 and Hybrix5. Then the corns were cooled in tap water. The blanched corns were packed in polyethylene bags (5 ears/bag) and frozen at -20±1°C in domestic freezer (Sanyo, Thailand). To evaluate the effect of frozen storage, the frozen corns were sampled over 30days of storage, then dipped in liquid nitrogen and stored at -20±1°C until carotenoid analysis.

Determination of carotenoids

The extractions were performed as described by Galicia *et al.* (2009). The qualifications and quantifications of carotenoids in the corn cultivars were modified in the procedure as described by Kurilich and Juvick (1999).

Saponification and extraction: 0.5 g (fresh weight) ground corn kernel was mixed with 6 mL absolute ethanol containing 0.1% BHT (w/v) using a vortex mixer (Bohemia, USA) and placed in a water bath at 85°C for 5 min. Then the mixture was added with 120 µL of Potassium hydroxide (80% w/v) vortexing mixed to hydrolyze carotenol ester present in the sample mixture and kept at 85°C for 10 min. The mixture was vortexed every 5 min during the saponification process and immediately placed in ice bath and was added with 3 mL of cold deionized water. To partition carotenoids in the sample mixture, 3 mL of petroleum ether and diethyl ether ratio of 2:1 (v/v) was added, thoroughly mixed and centrifuged at 1400 g for 5 min. After centrifugation, the organic supernatant was collected and the remaining residue was re-extracted 3 times. The supernatant of organic layers were combined in a 10 mL test tube and dried under gas nitrogen stream. The residue was kept at -20°C and reconstituted in 500 µL of mobile phase before HPLC analysis.

Carotenoid analysis: The analytical chromatographic separations of carotenoids were performed in a Shimadzu HPLC system (Shimadzu, Kyoto, Japan) equipped with a SIL-10AD VP auto-injector, SCL-10A VP system controller (Shimadzu), LC-10AT VP liquid chromatography (Shimadzu)

and a SPD-10A VP UV-vis detector (Shimadzu). 20 µL of extract was injected into a YMC C30 5 µm, 4.6 × 250 mm carotenoid column, (Waters, Milford, MA, USA) connected to Security Guard Cartridges C18 guard column (Phenomenex, USA). Separation of carotenoids was accomplished by isocratic mobile phase system consisting of acetonitrile: dichloromethane:methanol (70:20:10 (v/v)), at a mobile phase flow rate of 1 mL/min. The effluent was monitored spectronically at a wavelength of 450 nm.

Identification and quantification: Lutein (Chromadex, Canada), zeaxanthin (Chromadex, Canada), β-cryptoxanthin (Sigma-alorich, USA) and β-carotene (Sigma-Aldrich, USA) standards were used for identification and quantification of carotenoids present in the sample solution. The identification of carotenoids was carried out by comparison of their retention times. The quantification of each carotenoid was carried out from calculation of the peak area of eluted carotenoid to corresponding standard. The actual concentrations of the standard carotenoids were measured spectronically using the following $A^{1\%}1cm$ value: lutein, 2550 in ethanol, zeaxanthin, 2348 in PE, β-cryptoxanthin, 2386 in PE and β-carotene, 2592 in PE. Carotenoid concentrations were expressed as µg/100 g fresh weight (FW) of corn kernels.

Statistical analysis

Data were reported as mean ± SD. Two-way ANOVA and Least Square Difference (LSD) were performed to identify differences among means at significance of 95% using the Statistix version 8 (Analytical Software, USA).

Results and Discussion

The effects of domestic cooking methods and frozen storage on carotenoids changes of small-ear hybrid corn were investigated compared to the ATS5 and Hybrix5 which are commercial big-ear hybrid corn.

Carotenoid contents of the uncooked sweet corns

The bicolor (yellow-white kernel) cultivars (KKU#1WY and KKU#2WY) were lighter in overall color compared to the monocolor (yellow kernel) cultivars (KKU#33YY, ATS5 and Hybrix5). The monocolor cultivars had higher total carotenoid content than that of the bicolor cultivars (Table 2). The HPLC chromatogram shows the key carotenoids separated from the ATS5 samples (Figure 1) compared to the standards. The other cultivars showed the same profiles, indicating that the lutein, zeaxanthin and β-cryptoxanthin were the major

Table 2. Carotenoid contents of the uncooked sweet corn cultivars

variety	carotenoid content (µg/100 g FW)				
	Lutein	Zeaxanthin	β-Cryptoxanthin	β-carotene	Total carotenoids
KKU#1WY	107.6±0.0 c	82.3±0.1 de	5.1±0.0 d	nd	195.0±0.5 c
KKU#2WY	96.7±0.2 c	49.8±0.1 e	5.7±0.0 d	nd	152.3±0.5 c
KKU#3YY	240.6±0.5 b	174.8±1.3 bc	9.6±0.0 c	4.5±0.0 c	429.5±1.2 b
ATS5	106.8±0.2 c	263.0±0.6 a	51.9±0.1 ab	7.0±0.0 b	428.8±1.1 b
Hybrix3	287.0±0.3 ab	209.0±0.3 b	63.8±0.1 a	12.5±0.0 a	572.2±1.3 a

Values are means of 6 determinations (2 replicates and 3 determinations in each replicate) + SD.
Values designated by the different letters in each column are significantly different ($p \leq 0.05$) determined by Least Square Difference (LSD)
nd means not detected.

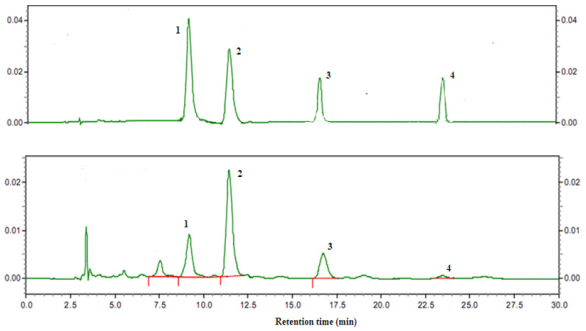

Figure 1. HPLC Chromatogram of standards (upper) and ATS5 sweet corn (lower) Peak1: lutein; 2: zeaxanthin; 3: β-cryptoxanthin and 4: β-carotene

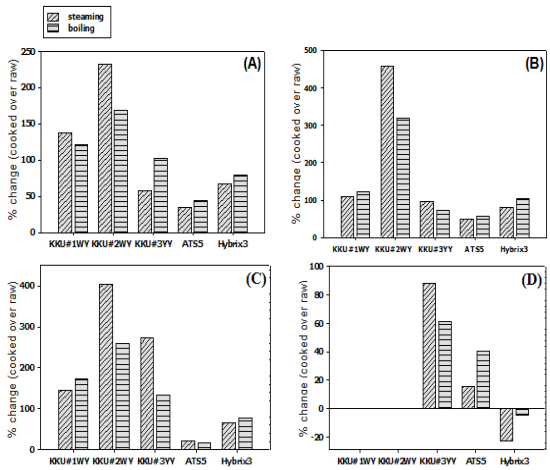

Figure 2. The effect of steaming ( ) and boiling ( ) on percentage changes of lutein (A); zeaxanthin (B); β-cryptoxanthin (C) and β-carotene (D) over raw (uncooked) sweet corn cultivars.

carotenoids found in all sweet corn cultivars. Scott and Eldridge (2005) found that major carotenoids in sweet corn were lutein and zeaxanthin, and to a lesser extent, α-, β-cryptoxanthin, α-, and β-carotene. The carotenoid contents in fresh sweet corn were different, depending on cultivars. The monocolor cultivars had much higher lutein, zeaxanthin and β-cryptoxanthin than the bicolor cultivars. However, ATS5 and KKU#3YY showed no significant

Table 3. Effect of different frozen storage time on carotenoid contents in three sweet corn cultivars

cultivar	storage day	carotenoid content (µg/100 g FW)				
		Lutein	Zeaxanthin	β-Cryptoxanthin	β-carotene	Total carotenoids
KKU#2WY	raw	96.7±0.21	49.8±0.1 k	5.7±0.0 h	nd	152.3±0.3 n
	0	333.1±0.2 fg	270.9±0.2 gh	25.8±0.0 g	nd	629.7±0.3 gh
	1	349.7±0.0 f	251.3±0.2 hij	24.9±0.0 g	nd	625.8±0.2 ghi
	2	347.4±0.03 f	233.5±02 hij	24.2±0.0 g	nd	605.1±0.6 hij
	3	354.6±0.2 ef	264.0±0.4 ghi	24.0±0.0 g	nd	642.4±0.2 gh
	4	314.7±0.1 fgh	241±0.3 hij	21.4±0.0 g	nd	577.2±0.4 hijkl
	5	276.5±0.2 h	232.2±0.1 hij	25.3±0.0 g	nd	534.0±0.1 jkl
	6	277.5±0.1 h	223.2±0.2 ij	23.3±0.0 g	nd	524.1±0.2 kl
	7	289.3±0.1 gh	241.6±0.1 hij	20.2±0.0 g	nd	551.0±0.2 ijkl
	15	267.6±0.1 h	243.5±0.1 hij	18.7±0.0 g	nd	529.9±0.1 jkl
	30	274.4±0.2 h	222.3±0.1 ij	19.9±0.0 g	nd	516.7±0.31
ATS5	raw	106.8±0.2 kl	2.63±0.6 ghi	51.9±0.1 f	11.0±0.0 b	432.8±0.8 m
	0	174.2±0.2 ij	431,4±0.3 a	87.5±0.0 c	4.1±0.0 g	697.3±0.4 g
	1	188.0±0.0 ij	420.6±0.3 a	73.7±0.0 d	4.1±0.0 g	686.4±0.4 g
	2	178.5±0.1 ij	344.8±0.3 cdef	68.0±0.0 de	4.0±0.0 gh	595.2±0.4 hijk
	3	192.9±0.2 i	359,2±0.3 bcd	68.6±0.0 de	3.8±0.0 ghi	624.5±0.3 ghi
	4	159.7±0.2 ij	341.5±0.3 cdef	61.2±0.1 e	3.4±0.0 ghi	565.9±0.4 hijkl
	5	158.7±0.2 ij	335.3±0.1 cdef	68.3±0.1 de	3.6±0.0 ghi	566.0±0.3 hijkl
	6	157.3±0.1 j	318.5±0.0 def	64.4±0.1 e	3.3±0.0 hi	543.3±0.2 jkl
	7	160.1±0.2 ij	317.1±0.5 def	64.3±0.0 e	3.1±0.0 i	545.3±0.3 jkl
	15	152.3±0.2 ijk	323.8±0.2 def	63.8±0.0 e	3.5±0.0 ghi	543.4±0.4 jkl
	30	142.0±0.1 jkl	314.2±0.2 ef	63.2±0.1 e	3.3±0.0 hi	522.6±0.02 kl
Hybrix3	raw	287.0±0.3 gh	209.0±0.3 j	0.6±0.1 e	12.5±0.0 a	572.2±0.7 hijkl
	1	499.2±0.4 ab	368.4±0.2 bc	104.0±0.0 a	9.8±0.0 c	981.6±0.5 ab
	2	521.8±0.6 a	335.2±0.3 cdef	98.7±0.1 ab	9.8±0.0 c	965.4±0.8 abc
	3	462.2±0.3 bc	393,9±0.1 ab	98.1±0.1 ab	9.5±0.0 c	963.6±0.3 abc
	4	441.4±0.2 cd	370.8±0.3 bc	92.3±0.1 bc	8.2±0.0 de	913.3±0.5 bcd
	5	462.2±0.11 bc	320,7±0.2 def	92.8±0.0 bc	8.3±0.0 d	883.3±0.2 de
	6	444.1±0.3 cd	346,6±0.4 cdef	90.3±0.1 bc	8.3±0.0 d	889.3±0.3 cde
	7	402.2±0.3 de	351.8±0.2 bcde	90.4±0.1 bc	7.8±0.0 def	852.1±0.3 def
	15	397.4±0.1 de	317.8±0.3 def	91.3±0.0 bc	7.2±0.0 f	813.6±0.1 ef
	30	407.0±0.2 d	304.8±0.3 fg	85.5±0.8 c	75±0.0 ef	804.8±0.3 f

Values are presented as means of 6 determinations (2 replicates and 3 determinations in each replicate) + SD.
Values designated by the different letters in each column and for each cultivar are significantly different ($p \leq 0.05$) determined by Least Square Difference (LSD).
nd means not detected.

difference in lutein and β-cryptoxanthin from those of the bicolor-cultivars, respectively ($p > 0.05$). The result showed no statistical difference in the total carotenoids between KKU#1WY and KKU#2WY ($p > 0.05$); however, β-carotene was not found in these bicolor corns. Hybrix3, commercial big-ear corns, had the highest contents of lutein, β-cryptoxanthin, β-carotene and total carotenoids while ATS5 had the highest zeaxanthin. Among the small-ear corns, KKU#3YY, had higher carotenoid contents than KKU#1WY and KKU#2WY. KKU#3YY was not significantly different in total carotenoids from ATS5 and in lutein and in zeaxanthin from Hybrix3 ($p > 0.05$). This agreed with Kurilich and Juvick (1999) who showed that the carotenoids among 50 corn cultivars were different. On the other hand, Scott and Eldridge (2005) reported that there was a large difference in the contents of carotenoids between types of corn (702 µg/100 g for yellow compared with 35.5 µg/100 g of fresh weight for white).

Effect of cooking methods on carotenoid changes of sweet corns

Both cooking methods resulted in increases in carotenoid contents depending on the corn cultivars (Figure 2). However, the loss of β-carotene after steaming (22.66%) and boiling (4.40%) occurred in Hybrix3 but not in the others. The lutein content of boiled KKU#3YY was higher than that of the steamed corn ($p \leq 0.05$). The total carotenoids of boiled and steamed corns of KKU#1WY, KKU#2WY, ATS5 and Hybrix3 were not significantly different ($p > 0.05$). The small-ear corns showed greater increases in carotenoid than those of the big ear corns. Steamed and boiled KKU#2WY had the highest increases in lutein (232.18%, 169.02%), zeaxanthin (457.16%, 318.89%) and β-cryptoxanthin (405.03%, 259.69%), respectively; while steamed and boiled KKU#3YY had the highest increase in β-carotene (88.16%, 61.36), respectively. This probably was due to the difference in tissue structure and cooking time of steaming and

boiling. It has been well documented that boiling is more effective heat transfer than steaming. Boiling therefore has a shorter cooking time than steaming to reach the appropriate tenderness. The results revealed that domestic cooking may enhance availability of carotenoids.

Similar results have been reported by previous researchers that cooking enhanced bioavailability of carotenoids in carrots spinach and tomatoes (Stahl and Sies, 1992; Rock *et al*., 1998). However, while cooking increases carotenoid content, the increase was greater with steaming than boiling of KKU#1WY and KKU#2WY cultivars ($p < 0.05$). Granado *et al.* (1992) found that the carotenoid content increased after boiling. Chang *et al.* (2013) report that lutein contents of various leafy vegetables increased after boiling for 4 and 8 min while β-carotene contents increased after boiling for 8 min. It was probably caused by the improved solubility of carotenoids and their better extractability due to the heat treatment. This might be caused by leaching of carotenoid from cooked tissues into boiling water and/or due to a prolonged exposure to heat, oxygen and light (Parra *et al.*, 2007; Chuah *et al*., 2008).

However, the reduction of β-carotene in the Hybrix3 was supported by Pinheiro-Sant'Ana et al. (1998) who found that there were some degrees of α-carotene and β-carotene reduction in carrot after cooking. It was reported that water-cooking without pressure was a routine appropriate cooking method for whole carrot in large quantities (45 Kg) that provided the highest retention of α-carotene, β-carotene and total carotenoids in carrots compared to steam-cooking, water-cooking with pressure and water-cooking/baking. The authors mentioned that higher cooking-temperature was more effective on reduction of carotenoid losses than an absence of water during cooking (Pinheiro-Sant'Ana *et al*., 1998). This correlated to Bengtsson et al. (2008) who found that all-trans-β-carotene orange-fleshed sweet potatoes reduced after steaming and boiling.

Effect of frozen storage on carotenoid changes

KKU#2WY, ATS5 and Hybrix3 were blanched and frozen in a domestic freezer and then the carotenoid contents were monitored during 1-month frozen storage. All blanched sweet corn cultivars increased in lutein, zeaxanthin, β-cryptoxanthin and total carotenoid contents compared to raw sweet corns ($p \leq 0.05$; Table 3). This was on the same line as the previous results of cooking methods. The increase in lutein, zeaxanthin and β-cryptoxanthin may be due to the release of bound carotenoids from the food matrix as a result of blanching (Khachik *et al.*, 1992). The inactivation of peroxidase and lipoxygenase activities involved in carotenoid destruction could be a reason for the retention of carotenoids (Baloch *et al.*, 1977). Results revealed that thermal treatment enhanced availability of the carotenoid. However, β-carotene was not detected in KKU#2WY cultivars and significantly decreased after blanching in the others ($p \leq 0.05$). During frozen storage, total carotenoids in KKU#2WY, ATS5 and Hybrix3 ranged from 516.7 - 642.4, 522.6 - 686.4 and 804.8 - 981.6 µg/100 g FW, respectively.

The increase in total carotenoids, β-carotene and α-carotene after blanching and cooking could be associated with an increase in tissue breakdown and increased accessibility of the carotenoids to the extracting solvent during heating. The loss of other soluble solids during blanching and cooking could account for increase in the carotenoid contents (Dietz *et al*., 1988; Booth, 1992). According to Mamatha *et al.* (2012), blanching could increase the levels of lutein, zeaxanthin, and β-carotene in corn and vegetables. The contents of lutein+zeaxanthin in blanched corn, onion stalk, broccoli, and capsicum were higher by 118.55%, 60.01%, 80.64%, and 19.63% while the β-carotene contents were improved by 1.05%, 39.64%, 84.79%, and 56.85%, respectively, compared to corresponding fresh samples. In contrast, Mosha et al. (1997) reported that blanching might cause 5–13% and 16% loss of β-carotene in carrots and amaranth leaves. They stated that blanching temperature and duration of cooling for 30 min at room temperature after blanching might have a negative effect on carotenoid concentration.

The carotenoids decreased during frozen storage when comparison between blanched and un-blanched during frozen storage. The comparison between blanched samples before frozen and during frozen storage to the blanched samples, the losses of lutein, zeaxanthin, β-cryptoxanthin and β-carotene in KKU#2WY corns were 5.54 -17.60%, 2.56 - 17.95% and 1.74 - 27.28%, respectively but not detected lutein in this cultivar, in ATS5 corns were 7.75 - 18.52%, 2.52 - 27.18%, 15.80 - 27.86% and 0.95 - 24.04% respectively, and Hybrix3 corns were in the range of 0.25 - 24.02%, 4.30 - 17.06%, 0.95 - 18.59% and 2.59 - 29.23% respectively. The highest losses of lutein, zeaxanthin, β-cryptoxanthin and β-carotene in frozen corns were 24.02%, 27.18%, 30.08% and 29.23%, respectively (Figure 3). Frozen corn contained greater amount of carotenoids, suggesting that frozen corn might be an equivalent or superior dietary source of greater carotenoids compared to fresh corn. The positive changes of carotenoids after different processing procedures were caused by

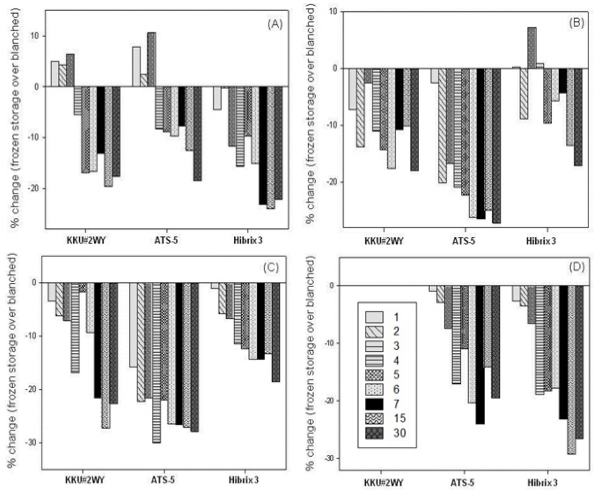

Figure 3. The effect of frozen storage periods (=1; = 2; = 3; = 4; = 5; = 6; = 7; = 15; = 30 storage days) on percentage changes of lutein (A); zeaxanthin (B); β-crytoxanthin (C) and β-carotene (D) over the blanched sweet corn cultivars

releasing the bound carotenoids from the structure matrix (Dewanto *et al.*, 2002a; Dewanto *et al.*, 2002b). This should be taken into account when comparing carotenoid stability in different types of vegetables, where their physical state and location were important factors for their thermal stability (Schieber and Carle, 2005). The variations in carotenoids of leafy cooked vegetables varied on cooking method and conditions (time and temperature), type of vegetables and the interaction between cooking methods and type of vegetables (Chang *et al.*, 2013).

Conclusions

The carotenoid contents in sweet corn depended on cultivars. The monocolor small-ear corn hybrid, KKU#3YY, had comparable carotenoid content to the commercial big ear corn. The results obtained in this study demonstrated that domestic cooking (steaming and boiling) increased the carotenoid contents in all of the five corn cultivars, highlighting the positive role of cooking on the nutritional qualities of sweet corn. The increases in lutein, zeaxanthin, β-cryptoxanthin and β-carotene after cooking were higher in the small-ear corn varieties than those of the big-ear corn varieties. It was suggested that an appropriate cooking method could preserve or improve the available carotenoid contents in sweet corns. However, the domestic freezing caused decreases in the carotenoids of corn during frozen storage. This could be an information for consumers to decide on a cooking practice to improve the nutritional quality of foods, as well as their acceptability.

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