The Effect of Traditional Thermal Cooking Processes on Anthocyanins, Total Phenolic Content, Antioxidant Activities and Glycemic Index in Purple Waxy Corn

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Abstract

Purple corn (*Zea mays L.*) appears as dark purple in the husk, cob and kernel, which contain primarily anthocyanin. The traditional thermal cooking method of purple corn may probably affect the content of anthocyanin and antioxidant activities, as well as the glycemic index. Purple waxy corn fancy 111, both with and without ears, were boiled at 80, 90 and 100°C for 30 min. The proximate composition, total monomeric anthocyanin (TMA) content, total phenolic content, antioxidant activities as well as the glycemic index were all measured and determined. The results indicated there is no significant effect on proximate composition e.g. moisture content, ash, dietary fibre and protein for corn both with and without ears in any thermal process temperature. The carbohydrate content might be lesser than raw purple waxy corn due to leaching during the thermal process. The TMA content of the raw purple waxy corn contain 698.72±34.41 µg CGE/g DW. The TMA content of corn cooked with ears and without ears dropped to 321.43–371.12 and 245.10–278.54 µg CGE/g DW, respectively. Total phenolic content further decreased in 90°C cooked purple corn without ears (201.83±8.94 mg GAE/100 g DW). The higher temperature was able to cause the loss of anthocyanin content and total phenolic content which are related to DPPH assay and FRAP assay. Neither traditional thermal processing methods of purple corn with or without ears would have any effect on the glycemic index. The glycemic index for both traditional thermal processes of corn with or without ears is 95.8–97.2.

Keywords: Purple waxy corn, Traditional cooking, Anthocyanin, Antioxidant activities, Glycemic index

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1. Introduction

There is no doubt that corn is considered a crucial cereal crop my millions of people cross the planet. There are many varieties of corn grown in many areas of the world, and theses corns appear in many different colours, such as white, yellow, red, purple, brown, green and blue. Purple corn, introduced to Thailand centuries ago, is a pigmented variety of *Zea mays L.*, which was originally cultivated in parts of South America. The anthocyanin is responsible for the colour of purple corn. Cyanidin 3-glucoside is the main anthocyanin in purple corn. It is commonly accepted that such anthocyanin food colourings do not exert any toxicity, teratogenicity, or mutagenicity - rather it is believed that anthocyanins may actually assist in inhibiting mutagenesis and carcinogenicity in many in-vitro and in-vivo studies (Yang and Zhai, 2010). Accrued evidence indicates that anthocyanin pigments in corn are accountable for its great antioxidant actions and consequently they have the potential to lower the chance of colon cancer (Abdel-Aal, 2006 and Wang and Stone, 2008), avert heart ischemia–reperfusion harm and hyperlipidemia (De Pascual-Teresa, 2010 and Wallace, 2011), possess anti-inflammatory properties (Tsuda, 2003) and may in addition decrease the risk of diabetes (Ghosh and Konishi, 2007).

People in Thailand prefer to eat corn on the cob, or other types of boiled corn, together with sugar and a salt solution. Corn on the cob is most frequently prepared in boiling water. It is recognized that boiling encourages fluctuations in the physiological and chemical composition of the corn, influencing the concentration and bioavailability of bioactive compounds in foodstuff (Harakotr *et al.*, 2014). The different ways of cooking and foods preparation impact the physical and chemical properties of food in many varied ways, especially the antioxidants content and their respective properties (Miglio *et al.*, 2007). To investigate the potential changes in anthocyanins, total phenolic content, antioxidant activities and glycemic index in purple corn during direct heat treatment, it is necessary to undertake detailed examinations. This study was performed to evaluate the effects of different traditional cooking conditions of corn (with or without ears) on anthocyanins, antioxidant activities and the glycemic index of purple waxy corn.

2. Materials and methods

2.1. Material

The ear purple waxy corn 111 (*Zea mays* L.), were supplied by Pacific Seeds (Thai) company limited and sealed in a plastic bag after harvesting for 24 h, and kept at -20°C, respectively. Megazyme kit – K-AMYL 07/11 was procured from Megazyme International (Ireland). DPPH, 2, 2′-azino-bis (3-ethylbenzothiazolin-6-sulfonate) diammonium salt (ABTS), theobromine, theophylline, and bulylated hydroxytoluene (BHT) and gallic acids (GA) were acquired from Sigma Chemical Co. (USA). 6-hydroxy- 2, 5, 7, 8-tetramethylchromane-2-carboxylic acid (Trolox) were obtained from Fluka (Switzerland). All other chemicals were of analytical grade.

2.2 Corn material

For this study, the purple waxy corn 111 was grown as a commercial product during September to November 2014 and the recommended practices for the commercial production of corn were adhered to. Corn ears were all hand-picked. For the analyses, only physiologically undamaged ears with the 200–220 g each weight were utilised. All ears and corn were kept at -20°C until further used.

2.3 Sample treatments

The traditional methods of preparing fresh corn by boiling it at different temperatures were used. Each method was carried out in triplicate. The samples were treated as follow:

(a) 5 whole, fresh purple waxy corn “fancy 111” with ear (1 kg) were boiled in 2L of tap water in a stainless-steel pan with a lid and cooked for 30 min at 80, 90 and 100°C. Once cooked, the boiled corn kernels were removed from their cobs with a sharp knife and then kept at -20°C pending analysis.

(b) 5 whole, fresh purple waxy corn “fancy 111” without ear (1 kg) were boiled in 2L tap water in a stainless-steel pan with a lid and cooked for 30 min at 80, 90 and 100°C. Once cooked, the boiled corn kernels were removed from their cobs with a sharp knife and then kept at -20°C pending analysis.

2.4 Proximate composition

The moisture content of a corn was concluded by drying the corn in an oven at 105°C until a constant weight was obtained (AOAC, 2000). The crude protein content was calculated by converting the nitrogen content determined by Kjeldahl's method (6.2×N). The fat was determined by AOAC (2000) using the Soxhlet system. Any ash content was determined by dry-ashing in a furnace at 525°C for 24 h (AOAC, 2000). The carbohydrate content was calculated by difference (Vadivel and Janardhanan, 2001). In addition, the content of amylose was determinate by using a test kit (Megazyme kit - K-AMYL 07/11).

2.5 Total anthocyanins measurement using pH differential method

Total anthocyanins were measured according to a modification of the methods described earlier (Sutharut and Sudarat, 2012). In brief, two dilutions of the sample were formulated, one for pH 1.0 using potassium chloride buffer and the other for pH 4.5 using sodium acetate buffer. Samples were diluted ten times to a finishing volume of 2 mL. The absorbance of each sample was recorded at 510 nm against distilled water as blank. The samples had no haze or sediment and thus correction at 700 nm was omitted. The monomeric anthocyanin pigment concentration (mg/L) was determined according to the following formula and expressed as Cy-3-glc equivalents:

$$\text{Monomeric anthocyanin pigment (mg/L)} = (A \times MW \times DF \times 1000)/(\varepsilon \times 1) \quad (1)$$

where A is $A = (A_{510} - A_{700})_{pH\ 1.0} - (A_{510} - A_{700})_{pH\ 4.5}$, MW is the molecular weight (g/mol) = 449.2 g/mol for Cy-3-glc, DF is the dilution factor (0.2 ml sample is diluted to 2 ml, DF = 10), and ε is the extinction coefficient ($L \times cm^{-1} \times mol^{-1}$) = 26,900 for Cy-3-glc, where L (pathlength in cm) = 1. For comparison, the same extinction coefficient was used for other standards to calculate the concentration of each anthocyanin and thus results reported is expressed as Cy-3-glc equivalents.

2.6 Determination of total phenolic content

Total phenolic content in the purple corn kernels was determined using the Folin–Ciocalteu method, with gallic acid as standard. The procedure was customised from Cuevas Montilla *et al*. (2011). Five grams of sample was mixed with 80 mL methanol and stored overnight. In the morning, the suspension was filtered through Whatman No.1 filter paper and the filtrate was diluted to 100 mL with methanol. Sample solutions were stored at 4°C in amber bottles and served as the stock solution (50 mg/mL) for subsequent analyses. Extracts of 100 µL were diluted with 500 µL of water. A volume of 700 µL of 0.2 mol/L equivalent Folin–Ciocalteu reagent was added and the mixture stood for 3 minutes at room temperature. Then 900 µL of 1 mol equivalent/L Na_2CO_3 was added and the mixture further allowed to stand for an additional 90 min, after which absorbance readings at 765 nm were taken in spectrophotometer. Acidified methanol was used as the blank. Total phenolic contents were reported in milligrams of gallic acid equivalents per 100 g of dry weight (mg GAE/100 g DW).

2.7 Determination of antioxidant activities

2.7.1 DPPH assay

The DPPH free radical-scavenging activity of each sample was recorded (Leong and Shui, 2002). A 0.1 mM solution of ethanolic DPPH solution was formulated. The initial absorbance of the DPPH in ethanol was recorded at 517 nm and did not alter during the course of the assay. An aliquot (0.1 mL) of each sample (with appropriate dilution if necessary)

was added to 3.0 mL of ethanolic DPPH solution. Discolorations were recorded at 517 nm following incubation for 30min at 30°C in the dark. Measurements were done at least in triplicate. The %age of DPPH· (%DPPH·sc) was computed as:

$$\%DPPH = (Ac–As) \times 100/Ac \quad (2)$$

where Ac is the absorbance of the control, and As is the absorbance of the sample. IC50 values calculated represent the concentration of a sample required to decrease the absorbance at 517 nm by 50%.

2.7.2 The Trolox equivalent antioxidant capacity (TEAC) assay

The method was conducted as earlier explained with only slight modifications (Jemai *et al*., 2009). In short, ABTS+ radical cation was generated by a reaction of 7 mmol/L ABTS and 2.45 mmol/L potassium persulfate. The reaction mixture was stood in the dark at room temperature for 24 h before usage and used within 4 days by keeping it in the dark cold room at 4°C. The previously prepared (working) solution was diluted to absorbance values between 1.0 and 1.5 AU at 734 nm with phosphate buffer solution (constant initial absorbance values need to be utilised for standard and samples). Standards and sample (from 5 to 25 µL according to reaction intensity) were blended with the (working) solution (975 µL) and diluted up to 1000 µL with deionized water. A decrease of absorbance was measured at 734 nm after 20 min. Aqueous phosphate buffer solution (1 mL, without ABTS+ solution) and Trolox (1.0–2.0 mmol/L) were used as a control and main calibrating standard, respectively.

2.8 In vitro starch digestibility tests and glycemic index estimation

The method was adapted from Sopade and Gidley (2009). To start, 500 mg of the sample were treated with 1 mL of artificial saliva which contained porcine a-amylase for 15–20 sec before 5 mL of pepsin were added and incubated at 37°C for 30 min. The digesta was neutralised with 0.02 M NaOH before adjusting the pH to 6 with 0.2 M sodium acetate buffer before adding 5 mL of pancreatin and amyloglucosidase. The mixture was incubated for four hours, whilst the glucose concentration in the digesta was measured with an Accu-Check Performa glucometer at 0-240 min for the rapid procedure. Digested starch per 100 g dry starch (DS) was calculated using Equation as described below:

$$DS = \frac{0.9 \times G_G \times 180 \times V}{W \times S\ (100 - M)} \quad (3)$$

where $G_G$is glucometer reading (mM/L), V is volume of digesta (mL), 180 is molecular weight of glucose, W is weight of sample (g), S is starch content of sample (g per100 g dry sample), M is moisture content of sample (g per100 g sample), and 0.9 is stoichiometric constant for starch from glucose contents. In vitro estimated glycemic index was calculated from the percentage of available starch hydrolyzed within 240 min.

2.9 Statistical analysis

Three individual samples from each treatment were acquired and an analysis on each sample was conducted. Data were assessed by analysis of variance (ANOVA) and Duncan's multiple range test with a probability $p \leq 0.05$ performed using SPSS version 17.0 (SPSS Institute Inc., USA).

3. Results and discussions

3.1 Effects of traditional cooking method on proximate composition and amylose content.

The data were presented in Table 1. The moisture content of all cooked purple corn kernel was not significantly different from that of raw purple corn ($p \leq 0.05$), as well as ash and dietary fiber. Protein was at its maximum level in the cooked purple corn without ear at 80°C, followed closely by the cooked purple corn without ear at 90°C (4.90% and 4.84%, respectively). Fat content was in general between 4.76–5.83% in all of the samples. There was no difference in the carbohydrate content between two thermal processing groups. However, there was a significant difference in the carbohydrate content compared to raw purple corn. The amylose content varied between 7.15–8.17%. Boiling softens their cell tissues, increasing the permeability of the cell membrane to water. The decrease in the levels of carbohydrate in boiled corn could possibly be explained by the leaching out of soluble carbohydrate which increases the percent of protein and fat composition. The purple waxy corn is a type of corn that contain lots of amylopectin instead of amylose. Normally, it was found 5–15% amylose in waxy corn (Singh *et al*., 2014).

3.2 Effects of traditional cooking method on total monomeric anthocyanin and antioxidant acitivities.

Total monomeric anthocyanin (TMA) content in purple waxy corn fancy 111 from 2 traditional cooking processes at 3 different temperatures (80, 90 and 100°C) were measured (Table 2). The raw purple waxy corn fancy 111 was also measured. The result showed the raw purple waxy corn fancy 111 contained 698.72±34.41 µg of CGE/100 g of DW of TMA. According to Collison *et al*. (2015), TMA concentration in purple corn with different growth environments and genetic backgrounds varied from 1000 to 3000 µg of CGE/100 g of DW. The range of TMA of boiled purple corns was from 245 to 371 µg of CGE/100 g of DW. The purple corn with ear processed with 80°C contained the highest TMA. TMA lossed during the thermal processing in purple corn were similar at each stage of temperature. However, the cooked purple corn without ears appeared to lose more TMA than purple corn cooked with ears. The cooking process had a significant ($p \leq 0.05$) impact on the decline of monomeric anthocyanin content compared to the raw purple corn. Besides, the higher cooking temperature can decrease the TMA content in both

ear purple corn and without ears purple corn during the cooking process. In addition, there were significant differences in TMA among the cooking process.

Anthocyanins are glycosylated anthocyanidins; sugars; mostly glucose, galactose, rhamnose, arabinose, and xylose which are attached to the 3-hydroxyl position of the anthocyanidin (3-monosides,3-biosides and 3-triosides) as well as the 5 or 7 position of flavynium ion (3, 5-diglycosides, 3, 7- diglycosides) (McGhie and Walton, 2007). Variations in chemical structure is a result of the variances in the number of hydroxyl groups in the molecule, degree of methylation of these OH groups, nature and total of sugar moiety attached to phenolic molecule and to some degree the character and quantity of aliphatic or aromatic acids attached to it. (McGhie and Walton, 2007). Degradation is in the main is the result of oxidation, cleavage of covalent bonds or enhanced oxidation reactions arising from thermal processes. Thermal degradation of anthocyanins may produce a variety of species, contingent upon the rigorousnes and nature of the heating (McGhie and Walton, 2007).

The stability of anthocyanin depends upon numerous influences, i.e. the chemical structure, pH, temperature, light intensity, presence of copigments, metallic ions, enzymes, oxygen, ascorbic acid, sugars and their degradation products, and sulfur dioxide, etc. From all these influences, it has been shown that pH and temperature mostly affect the stability of anthocyanins (Cevallos-Casals *et al*., 2004). A combination of unit operations involving heat such as blanching, pasteurisation, and duration can additionally significantly affect the anthocyanin content of fruits and vegetables. The lost anthocyanin content in corn may be due to degradation or decomposition of anthocyanin following thermal treatment which this series of experiment had set out to determine (Li *et al*., 2017). Related to the study of Yang *et al.* (2008), Thermal degradation of aqueous anthocyanins from purple corn cob followed first-order reaction kinetics at 70, 80 and 90°C. The degradation rate of aqueous anthocyanins increased with increased cooking temperatures.

The whole phenolic contents of the cooked corn with ears and without ears at different temperature were expressed as mg GAE/100 g sample and are listed in Table 2. Phenolic content for the cooked corn samples with ears and without ears as analysed ranged from 221.56 to 235.87 mg GAE/100 g DW and 201.83 to 309.44 mg GAE/100 g DW, respectively. Both processed purple corn groups had a significantly lower content of total phenolic compared to raw purple corn ($p \leq 0.05$). These results showed that phenolics were reduced when boiled by almost half of the original quantity. There are two main phenolic compounds which identified as p-coumaric acid and ferulic acid (Cuevas Montilla, *et al*., 2011). Phenolic content degradation showed a trend similar to the study of Harakotr *et al*. (2014) which described the loss of total phenolic values for purple corn treated with thermal processing. However, in some

case, cooking was found to actually cause an increase in the level of phenolic compounds in some fruit and vegetables (Dani *et al*., 2007 and Harakotr *et al*., 2014).

According to Table 2, the DPPH radical scavenging capacity showed the highest activities in raw purple corn which is 95.81±3.23 %IC50. There is no different IC50 value of antioxidant activities between raw purple corn and the boiled purple corn with ears in all varies thermal processing ($p \leq 0.05$) while the boiled purple corn without ear group had a low IC50 value and differed from the raw group. Antioxidant activities by DPPH assay decreased when increasing the boiling temperature. The purple corn which was treated at 80°C for 30 min, had the highest IC_{50} of both thermal process group.

An interesting discovery from this FRAP assay, raw purple corn also had the highest FRAP value of 97.25 μmol TE/g DW (Table 2). All antioxidant activities by FRAP method in purple corn was drastically decreased while increasing the temperature in thermal processing. (80–100°C). It was decreased nearly two fold compare to the FRAP assay of antioxidant activities in the raw purple corn. These results suggest that thermal process negatively influenced the ferric reducing antioxidant power of both cooked purple corn with ears or without ears.

As witnessed in the other thermally processed products, the decrease of TMA content most likely compensated for the loss of antioxidant activities in DDPH and FRAP method. This was a result of monomeric anthocyanin degradation. Pretreatment before processing, for example: peeling, trimming, chopping, slicing, crushing, pressing, and sieving was expected to affect the amount, activities, and availability of antioxidant composition (Ioannou *et al*., 2012).

3.3 Effects of traditional cooking method on in vitro starch digestibility tests and glycemic index estimation.

Glycemic index is defined as the incremental area under the glucose response curve after a standard amount of carbohydrate from a test food relative to that of a control food (either white bread or glucose) is consumed (Ludwig, 2002). The concept of glycemic index was developed to quantify the glycemic responses induced by carbohydrates in different foods (Schulze *et al*., 2004). On a “glycemic” scale of 0 to 100, the GI compares carbohydrates weight for weight in individual foods, providing a physiologic rather than structural basis for ranking glycemic potential. A food with a lower GI contains starches and sugars that are more slowly digested and absorbed, or less glycemic by nature (eg, fructose) (Brand-Miller *et al*., 2007). Predicted glycemic indices (pGI) were calculated from the 240 min degree of hydrolysis values of boiled purple corn which is no effect on the different condition and different temperature of thermal cooking (Table 2). The glycemic index for both traditional thermal process group is 95.8–97.2. These results suggest that the intestinal glucose release after consumption of boiled purple corn may be because of the amylopectin content which is a high–glycemic index starch.

Table 1 Proximate composition and amylose content on cooked purple corn kernel under different processing and cooking temperature.

Cooking process	Cooking temperature (°C)	cooking time (min)	Proximate composition						Amylose content (%)
			Moisture content (%)	Ash (%)	Dietary fibre (%)	Protein (%)	Crude fat (%)	Carbohydrate (%)	
1. Raw purple waxy corn fancy 111	-	30	57.11±2.21^{a}	0.82±0.05^{a}	3.08±0.14^{a}	4.08±0.29^{a}	4.23±0.11^{a}	30.68±0.14^{a}	7.15±0.22^{a}
2. Corn with ears of the purple waxy corn fancy 111	80	30	59.90±3.57^{a}	0.87±0.06^{a}	3.18±0.11^{a}	4.58±0.12^{a}	5.83±0.24^{b}	25.62±0.24^{b}	8.17±0.22^{a}
	90	30	59.76±0.88^{a}	0.88±0.05^{a}	3.14±0.17^{a}	4.64±0.16^{a}	5.67±0.12^{b}	25.91±0.25^{b}	7.68±0.06^{a}
	100	30	59.01±1.86^{a}	0.88±0.06^{a}	2.98±0.12^{a}	4.83±0.28^{a}	5.74±0.10^{b}	26.56±0.12^{b}	7.83±0.13^{a}
3. Corn without ears of the purple waxy corn fancy 111	80	30	60.15±1.86^{a}	0.88±0.05^{a}	3.15±0.13^{a}	4.90±0.05^{a}	5.48±0.14^{b}	25.44±0.18^{b}	7.69±0.12^{a}
	90	30	60.08±2.16^{a}	0.89±0.12^{a}	3.08±0.04^{a}	4.84±0.12^{a}	4.76±0.21^{b}	26.25±0.11^{b}	8.11±0.06^{a}
	100	30	59.35±3.44^{a}	0.88±0.08^{a}	3.09±0.07^{a}	4.78±0.28^{a}	5.32±0.08^{b}	26.58±0.05^{b}	7.81±0.08^{a}

Note: Values are means ± SD. Means in the same column with different letters are significant ($p \leqslant 0.05$) calculated by Duncan's multiple range test.

Table 2 Total monomeric anthocyanins content, total phenolic content and antioxidant activities on cooked purple corn kernel under different

Cooking process	Cooking temperature (°C)	cooking time (min)	Total monomeric anthocyanins content (µg CGE/g DW)	Total phenolic content (mg GAE/100 g DW)	Antioxidant activities		pGI
					DPPH assay (IC50)	TEAC assay (µmol TE/g DW)	
1. Raw purple waxy corn fancy 111	-	30	698.72±34.41^{a}	576.71±23.34^{a}	95.81±3.23^{a}	97.25 ± 1.90^{a}	-
2. Corn with ears of the purple waxy corn fancy 111	80	30	371.12±21.21^{b}	235.87±13.41^{b}	91.19±2.87^{a}	54.12 ± 2.04^{b}	95.8 ± 0.5^{a}
	90	30	321.43±15.32^{b}	221.56±11.54^{b}	89.77±2.32^{a}	52.11 ± 2.17^{b}	96.2 ± 0.2^{a}
	100	30	325.78±17.54^{b}	231.51±12.59^{b}	88.97±3.10^{a}	49.51 ± 1.67^{b}	96.6 ± 0.7^{a}
3. Corn without ears of the purple waxy corn fancy 111	80	30	278.54±18.49^{c}	209.44±12.11^{c}	83.78±2.66^{b}	44.13± 1.08^{b}	97.2 ± 0.8^{a}
	90	30	265.28±22.5^{c}	201.83±8.94^{c}	83.38±3.07^{b}	43.87 ± 1.12^{b}	96.1 ± 0.4^{a}
	100	30	245.10±26.87^{c}	206.10±14.55^{c}	83.57±2.78^{b}	44.01 ± 0.87^{b}	96.1± 0.5^{a}

Note: Values are means ± SD. Means in the same column with different letters are significant ($p \leqslant 0.05$) calculated by Duncan's multiple range test.

CGE is cyanidin-3-glucoside equivalents; GAE is gallic acid equivalent; TE is trolox equivalent; pGI is prediction glycemic index

4. Conclusion

The moisture content ash and dietary fibre of all cooked purple corn kernel was no significantly different from raw purple corn. Protein was maximum in the cooked purple corn without ear at 80°C followed by the cooked purple corn without ear at 90°C (4.90% and 4.84%, respectively). Fat content was in general between 4.76–5.83% in all the samples. There was a significant difference in carbohydrate content between the two thermal processing groups ($p \leq 0.05$). The amylose content has vary from 7.15–8.17%. The raw purple waxy corn fancy 111 contained 698.72±34.41 µg of CGE/100 g of DW of TMA. The range of TMA of boiled purple corns was from 245 to 371 µg of CGE/100 g of DW. TMA losses between the thermal processing in purple corn were similar at each stage of temperature. Both processed purple corn group showed significantly lower content of total phenolic compared to raw purple corn ($p \leq 0.05$). Phenolic content for the cooked corn samples with ears and without ears analysed ranged from 221.56 to 235.87 mg GAE/100 g DW and 201.83 to 309.44 mg GAE/100 g DW, respectively. The DPPH radical scavenging capacity showed the highest activities in raw purple corn which is 95.81±3.23%IC_{50}. There is no different IC50 value of antioxidant activities between raw purple corn and the boiled purple corn with ears in all varies thermal processing ($p \leq 0.05$) while the boiled purple corn without ear group has a low IC_{50} value and differed from the raw group. Furthermore, raw purple corn also had the highest FRAP value of 97.25 µmol TE/g DW. All antioxidant activities by FRAP method in purple corn was drastically decreased while increasing the temperature in thermal processing. (80–100°C). Both traditional thermal processing of purple corn with ear and without ear would not affect the glycemic index. The glycemic index for both traditional thermal process group is 95.8–97.2.

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