Nutrient Composition of Raw and Steamed, Green and Purple Sweet Potato Leaf Varieties (*Ipomoea batatas*)

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ABSTRACT

In Zambia, sweet potato (*Ipomoea batatas*) leaves (SPL) provide an inexpensive and effective source of nutrients and phytochemicals with several health benefits that include improved eye health and prevention of cardiovascular diseases. This study was conducted to determine the nutrient content of two SPL varieties, called purple and green SPL, commonly sold at the Soweto market, the largest vegetable trading market in Lusaka, Zambia. The proximate, vitamin (β-carotene and vitamin C) and mineral (calcium - Ca, iron - Fe, zinc - Zn, potassium - K and phosphorous - P) composition of the raw as well as the steamed (for 10 and 15 minutes) SPL were tested. The results showed no significant differences ($p<0.05$) in the proximate composition of both raw green and purple SPL. Results from the raw samples showed that the green SPL had significantly ($p<0.05$) higher levels of P (176.1 ± 7.0 mg/100g), while the purple SPL had higher levels of vitamin C (17.7 ± 0.9 mg/100g). When steamed for 10 minutes, the P (150.6 ± 24.4 mg/100g) and vitamin C (11.8 ± 1.1 mg/100g) content of the green SPL significantly reduced, while the crude protein (23.5 ± 1.5 g/100g), Fe (13.7 ± 2.2 mg/100g), ash (17.9 ± 2.8 g/100g), Zn (1.3 ± 0.1 mg/100g) and K (4.2 ± 0.2 mg/100g) content of the purple SPL significantly reduced when steamed for 15 minutes ($p<0.05$). The mean β-carotene content of the green SPL increased from 476 to 490 µg/100g upon steaming for 15 minutes, suggesting the release of carotenoids from their cellular matrix upon cooking. Overall, the retention of nutrients in the green SPL was higher than that observed in the purple SPL when steamed. Considering the substantial increase in β-carotene upon steaming, further research should focus on the effects of other domestic cooking methods and nutrient bioavailability. If recommended temperature-time combinations are used for cooking, with sufficient amounts consequently being consumed, SPL have the potential to improve the nutritional status of the Zambian people.

INTRODUCTION

Sweet potato (*Ipomoea batatas*), is a herbaceous creeping plant that has smooth, lightly moderate green leaves which may contain a considerable amount of purple pigmentation along its veins (Antia., 2006). The plant originated from Central America and is grown on a large scale in China (Ishida et al., 2000). Globally, the sweet potato is a popular food crop in many countries and consumed as a vegetable, for its underground tubers (Yoshimoto et al., 2002). Yet, sweet potato leaves (SPL) are an economic source of micronutrients for the human body (Antia., 2006). They are high in potassium (K), beta-carotene, dietary fiber, lutein

and zeaxanthin (Islam et al., 2002). As with many vegetables, SPL are rich in carotenoids, and although their nutrient content varies depending on the cultivar and the method of production, the nutrient content can be compared to other dark green leafy vegetables such as spinach and yellow colored fruits and vegetables such as pumpkin leaves, rossel and oranges (Ishida et al., 2000, Mataa 2020). Additionally, several reports have shown that SPL contain higher levels of protein compared to other dark green vegetables such as spinach (Antia., 2006; Ishida et al., 2000,). Sweet potato leaves are occasionally cooked as a vegetable in many African countries including Kenya, Nigeria, Tanzania, and Zambia; and several parts of Asia. In Nigeria, the leaves are consumed as vegetables in yam and cocoyam porridges, while in Zambia they are consumed as a vegetable with the maize meal porridge staple commonly known as nsima (Antia., 2006). Although the leaves are popular only in some regions of Kenya, they are commonly grown in the backyard gardens or along the river valleys mainly for the local market and household consumption, with the young leaves grown from specific varieties that are cultivated only for the leaves being the most popularly sold (Kogi-Makau., 2013). It has been shown that SPL are a popular vegetable in most provinces of Zambia, with the highest consumption being in the Northern Province (Banda-Nyirenda., 2007).

Sweet potato leaves (SPL) are available most of the year because the plant is less sensitive to drought, tolerant to heavy rains, requires low inputs and grows in a wide range of ecological zones, with a short cooking time (Sun et al., 2014). The plant is a favorable crop as it can be harvested several times a year with much higher yields than other green leafy vegetables. In addition, when compared to other dark green leafy vegetables, the sweet potato plant is more tolerant to pests, diseases and high moisture conditions, characteristics which, could potentially increase food security (Sun et al., 2014).

Prior research on nutrition profiling of SPL (Antia., 2006; Ishida et al., 2000; Mwanri., 2011) provided the foundation for this current work which sought to provide scientific data on the commonly consumed SPL varieties in Zambia. Nutritional value of agricultural products can vary significantly with geographical location, agricultural practices and genetics (Amarteifio et al., 2010). At present, there is limited research in the area of the nutrient composition of SPL found in Zambia and to our knowledge, there have been no studies carried out to characterize the Zambian SPL varieties based on nutrient composition. This study therefore, sought to quantify the nutrient content of green and purple SPL varieties commonly grown in Lusaka, Zambia, as well as determine the effect of heat treatment by steaming on the nutrients in two SPL varieties. Steaming is a mild cooking process which can result in nutrient losses in vegetable products. Thus, we envisage that the knowledge generated from this study may be used to provide advice and develop guidelines for household use.

MATERIALS AND METHODS

Collection of samples. Two SPL varieties (locally referred to only as green and purple) commonly grown in Zambia were obtained from traders at the Soweto market, the largest vegetable trading center in Lusaka immediately after delivery by farmers. Nine batches of equal size were purposively procured from nine different prominent traders in the market. Upon purchase, the SPL were packed in ventilated bags and transported in cool boxes to the Food Science and Nutrition Laboratory at the University of Zambia without exposure to direct sunlight to prevent nutrient loss (Islam 2014).
Sample preparation. The leaves were thoroughly washed in tap water to remove adhering soil and were allowed to drain at room temperature. To confirm that all the excess washing water was drained off, samples were weighed four to five times at intervals of 10 minutes until a constant weight was obtained.

Steaming of the leaves. Each batch of the two SPL varieties was divided into three portions that were analyzed as raw and steamed (for 10 and 15 minutes) samples, respectively. The leaves for the steaming treatment were placed on a rack 5cm above the heated water at 95°C in a water bath, which was kept closed to steam the samples for either 10 or 15

minutes depending on the portion that was being analyzed. After steaming, the samples were left to cool slowly at room temperature prior to drying.

Drying and preparation of SPL for nutrient analysis. The raw and steamed SPL were allowed to dry on trays in a food dehydrator (Excalibur Model 4926T) at 60°C for 24 hours or until the moisture content was less than 6% (Ranganna., 1986). The samples were then ground with a mortar and pestle to a powder fine enough to pass through a 60 mesh sieve (250 microns). The ground samples were stored at 5°C in well labeled air-tight containers prior to further analysis.

Proximate analysis. Proximate composition of SPL involved analysis of moisture, crude fat, crude protein, total ash and crude fiber using AOAC., (2005) official methods of 934.01, 920.39 (A), 984 (A – D), 942.05 and 978.10, respectively.

Vitamin and mineral analysis. Vitamin C content was determined using 50 mg of ascorbic acid dissolved in oxalic acid as a standard (Klein and Perry., 2006). Chloroform with some added oxalic acid was used to extract vitamin C from the SPL samples. Titration with dichloro-phenol-indophenol (DPI) solution under continuous agitation produced a light pink end point and the vitamin C content of the SPL samples were calculated using ascorbic acid standard curve. Determination of beta-carotene was done according to the method of de Carvalho et al., (2012). Beta-carotene was extracted from the SPL using acetone and then partitioned using hexane. Absorbance of the hexane fraction was measured using a spectrophotometer at 450 nm after which the total carotenoid content was calculated using the following equation:

$$\text{Total carotenoid content } (\mu/g) = \frac{A \times \text{Volume} \times 10^4}{\text{Sample weight (g)} \times A^{1\%}\ 1\text{cm}}$$

Where:

A = absorbance;

Volume = total volume of extract(25ml);

$A^{1\%}{}_{1cm}$ = absorption coefficient of β-carotene in PE.

Minerals were extracted from ash using hydrochloric acid (HCL) and measured using an atomic absorption spectrophotometer (AAS) (AOAC., 2005). Ca, Fe and Zn were measured using AAS, while P was determined by adding molybdate reagent to the HCL acid extract and allowed to stand in the dark for 20 minutes to develop color. Absorbance was read at 660 nm on the AAS.

Statistical analysis. Statistical analysis was performed using the Statistical Package for Social Scientists (SPSS). Experimental results were expressed as mean values ± standard error, where number of replications (n) was nine (9 vegetable samples). Differences in the means of nutrient content of the two SPL varieties were tested using paired and independent t-tests. Differences were considered statistically significant at $p<0.05$.

RESULTS

Proximate composition. Results of the proximate composition of the raw and steamed green and purple SPL are presented in Table 1. The contents of moisture, crude protein, total ash, crude fat and crude fiber in the two varieties in raw form were not significantly different ($p>0.05$). The moisture and crude fat content before and after steaming did not change significantly in both SPL varieties. However, the crude protein content of the green SPL significantly ($p<0.05$) reduced after steaming for 10 and 15 minutes respectively. The crude fiber significantly reduced after steaming for 10 min for the green SPL while ash significantly reduced after steaming for 10 and 15 minutes for both SPLs (Table 1) ($p<0.05$). Conversely, the crude protein of the purple and crude fiber of the green SPL were unaffected by steaming at 10 and 15 minutes respectively.

Mineral Composition. For the mineral content of the raw and steamed green and purple SPL, no significant differences in the Ca, Fe, Zn and K contents of the two varieties in raw form were observed (Table 2) except for P (green: 176.1±7.0 mg/100g; purple: 137.3±10.4 mg/100g), which was significantly higher in the green SPL variety ($p<0.05$).The Ca content of the green and purple SPL varieties was unaffected by steaming at both 10 and 15 minutes. The Fe content of the green (24.0±0.5 mg/100g) and purple (23.9±5.3 mg/100g) SPL was

significantly reduced after steaming for both 10 and 15 minutes (Table 2) ($p<0.05$). The Zn content of the green SPL (1.5±0.1 mg/100g) was unaffected by steaming for 10 minutes and significantly affected after steaming for 15 minutes ($p<0.05$), while that of the purple SPL was significantly reduced from 1.5±0.2 mg/100 to 1.3±0.1 mg/100 when steamed for 15 minutes. Further, steaming reduced the K content of both the green and purple SPL. When steamed for 10 minutes, the K content in the green SPL significantly reduced from 5.0±0.3 mg/100g to 4.5±0.3 mg/100g ($p<0.05$). Steaming for 10 minutes significantly reduced the K content of the purple SPL ($p<0.05$), and a further reduction was observed when steamed for 15 minutes. The P content in the green SPL (176.1±7.0 mg/100g) was not significantly affected by steaming, while steaming for 10 minutes significantly reduced the P content of the purple SPL from 137.3±10.4 mg/100g to 124.4±6.3 mg/100g ($p<0.05$).

Vitamin composition. Vitamin C content was significantly higher ($p<0.05$) in the raw purple SPL (17.7±0.9 mg/100g) than the raw green SPL (Table 2). Conversely, the raw green SPL (476.2±125.7 µg/100g) had higher β-carotene content than the raw purple SPL (395.9±93.2 µg/100g), and the difference was found to be statistically significant ($p<0.05$). The vitamin C content of both the green and the purple SPL was significantly reduced (green: 11.8±1.1 mg/100g; and purple: 15.1±2.4 mg/100g) after steaming for 10 minutes ($p<0.05$), while steaming for 15 minutes did not result in a further reduction of their vitamin C content. Although the β-carotene content was unaffected by steaming both SPL varieties, the mean of the green SPL increased from 476.2±2.7 µg/100g to 490.9±0.5 µg/100g after steaming for 15 minutes.

DISCUSSION

The main aim of this study was to determine the nutrient composition of two sweet potato leaf (SPL) varieties and the effect of heat treatment by steam on these varieties. SPL are widely consumed in Zambia and the rest of Sub-Sahara Africa and are a rich source of affordable nutrients. This study has revealed that the crude protein content of the raw SPL varieties found on the Zambian market was higher (26.4 ± 3.3 g/100g) than that recorded in some studies (2.5 g/100g; 8.5 g/100g) (Bovell-Benjamin, A. C., 2007; Haytowitz., 2012; NFNC., 2009). Other studies have reported crude protein values that widely range between 3.7 – 24.9 g/100g, some of which are similar to our findings (Antia., 2006; Ishida et al., 2000). The higher crude protein values reported here could most likely be attributed to varietal effects and soil types. Our findings indicate that SPL may be a significant source of protein for the Zambian diet. Additionally, the greater part of protein in SPL is of good quality, possessing several essential amino acids which include leucine (2.0 g/100g), isoleucine (1.1 g/100g), aspartate (2.9 g/100g), glutamate (2.7 g/ 100g), and lysine (1.3 g/100g) (Ishida et al., 2000). This further accentuates the importance of SPL as a protein source, which can be included in diets designed to address malnutrition. Further, the SPL protein content can be enriched during cooking by adding mabisi, a traditionally fermented milk, a practice widely used in the southern parts of Zambia (Moonga et al., 2019).

The ash content of the raw green and purple SPL (18.2 -20.6 g/100g) was more than 40% higher than that recorded in previous studies which ranged between 7 and 13 g/100g (Antia., 2006; Sun et al., 2014). As observed for crude protein content, the differences in ash content from previous studies could be attributed to differences in soil types and varieties. High levels of ash content in the SPL suggests that they may provide a significant amount of minerals to the Zambian diet, which would potentially contribute to the alleviation of micronutrient deficiencies.

The proximate, vitamin, and mineral composition of SPL varies according to different cultivars and production methods (Ishida et al., 2000). This is true for the crude fat composition which typically, ranges between 0 – 5.5 g/100g as reported in several different studies (Antia., 2006; Ishida et al., 2000; Yoshimoto et al., 2002). Fat content of 4.9 g/100g for SPL has been reported previously (Antia., 2006), a value that is higher than what was observed in this study. Additionally, the crude fat content of 40 different cultivars grown in

China was found to range between 2.1 – 5.3 g/100g, while two varieties of SPL cultivated in Japan had crude fat values similar to those found in our study (0.3 – 1.0 g/100g), further supporting literature which suggests that the nutrient content of SPL depends on the cultivar, soil type and method of production (Ishida et al., 2000; Sun et al., 2014). Since SPL contain high levels of the essential fatty acid α-linolenic acid which ranges between 0.8 – 1.2 mg/g depending on the cultivar according to the report by Johnson and Pace (2010), further studies must be conducted to characterize and quantify the different types of PUFAs found in the green and purple SPL of Zambia.

Factors such as genotype, nutritional composition and maturity all have an effect on the crude fiber content of SPL (Banda-Nyirenda., 2007). The crude fiber content in the green and purple SPL was much lower than other studies (Antia., 2006; Sun et al., 2014). The low fiber content may be attributed to the cultivar and genotype of the SPL.

As observed from the values of the ash content, SPL possess a high mineral content. Individual mineral content was high for both the raw green and purple SPL, corroborating previous studies (Alaofe., 2014; Antia., 2006; Ishida et al., 2000; Sun et al., 2014). The Ca content of the raw green (332.1 ± 16.4 mg/100g) and raw purple (343.1 ± 34.8 mg/100g) SPL was higher than that found in other studies which ranged between 28.4 – 174 mg/100g (Antia., 2006). Similar studies also reported high Ca levels of up to 1958.1 mg/100g (Sun et al., 2014). Specifically comparing the varieties in our study to other green and purple varieties studied in Tanzania, the Tanzanian varieties had much higher levels of Ca (3457 mg/100g and 4255 mg/100g, respectively) (Alaofe., 2014). Ca is an important micronutrient that is required in the formation and maintenance of bones and teeth, vascular contraction and vasodilation, muscle function, nerve transmission, intracellular signaling and hormonal secretion. Its main sources in the Zambian diet are milk, green leafy vegetables and sardines (with the local type known as kapenta). Since not every household can afford milk and kapenta, SPL may be used as an alternative source of the micronutrient Ca. With the high rates of Ca deficiency, increasing consumption of SPL as a cheap source of Ca is essential (Alaofe., 2014). Other micronutrients recorded as being highly inadequate in the Zambian diet include Fe and Zn. The raw green and purple SPL contained Fe levels that were higher than other studies (Alaofe., 2014; Antia., 2006; Ishida et al., 2000; Sun et al., 2014). However, it must be noted that plants provide non-heme Fe which has an average absorption rate of only 5%. Nevertheless, unlike Fe in cereals, absorption of Fe in SPL is not inhibited by phytates (Ishida et al., 2000). The Zn content of the raw SPL in our study was different from that recorded by previous studies (Antia., 2006; Ishida et al., 2000). The variation in mineral content could be attributed to the different soil profiles in which the SPL are grown. High concentrations of K and P were also recorded, with their values being comparable to other studies (Alaofe., 2014; Antia., 2006; Ishida et al., 2000; Sun et al., 2014).

The vitamin C content of the raw purple and green SPL varieties was much lower than other studies (Alaofe., 2014; Ishida et al., 2000). Despite the purple variety having a higher concentration of vitamin C, the low levels recorded in the current study can most likely be attributed to the different agronomic and soil conditions or differences in the analytical procedures used. When compared to other dark green leafy vegetables such as spinach, the vitamin C content from our findings compared well (Schönfeldt and Pretorius., 2011).

The β-carotene content of the two SPL varieties (476.2 ± 125.7 µg/100g for the raw green SPL, and 395.9 ± 93.2 µg/100g for the raw purple SPL) was less than that reported for other vegetables such as spinach (6288 µg/100g), pumpkin leaves (1695 µg/100g) and cowpea leaves (2249 µg/100g) (Schönfeldt and Pretorius., 2011). Higher β-carotene values of SPL have also been reported previously (2217 µg/100g) (Johnson and Pace., 2010). It has been suggested that carotenoids are sensitive to factors such as light, heat and oxygen exposure (Amorim-Carrilho et al., 2014). Non-polar solvents such as hexane used in this study have been recommended for use in the extraction of carotenes which are non-polar (Amorim-Carrilho et al., 2014).

However, exposure to light and oxygen in the laboratory may have affected the carotenoid content. Additionally, the use of an antioxidant such as ascorbic acid and pyrogallol during extraction has been recommended to minimize carotenoid losses (Amorim-Carrilho et al., 2014).

The effect of heat treatment on the nutrient composition of SPL through steaming was also evaluated. Steaming is a cooking method universally recommended for the achievement of minimal nutrient losses (Miglio et al., 2008). When vegetables are cooked using methods such as boiling that involve the addition of unspecified amounts of water, a significant loss in nutrients is observed compared to steaming at the same cooking time (Wachtel-Galoret al., 2008). Factors such as cooking time and whether or not vegetables are chopped, all affect the nutrient content (Johnson and Pace., 2010; Wachtel-Galor et al., 2008). This study showed that fiber and ash content reduced after steaming. This reduction in fiber after steaming for 10 minutes may have occurred due to an incomplete fiber digestion method, consequently resulting in the retention of a soluble portion which is affected by heating. In order to quantify specific amounts of soluble and insoluble fibers obtained from SPL, further studies must be conducted to quantify the specific contents of soluble and insoluble fibers from SPL.

The effect of steaming on individual minerals showed that Fe, K, P and Zn were reduced after steaming for 10 minutes. Other studies have shown that non-heme Fe, the form of Fe found in plant sources such as vegetables, grains and fruit, increases following exposure to heat (Chen et al., 1984; Imungi., 1983; Johnson and Pace., 2010). It has been suggested that heating speeds up the oxidative cleavage of the prophyrin ring in the non-heme Fe thereby liberating the Fe and subsequently, increasing its content (Schricker., 1982). In contrast, the results of our study showed a decrease in Fe after steaming the green and purple SPL for 10 minutes.

Steaming significantly reduced the vitamin C content of both the green and purple SPL. It is well known that vitamin C is a heat labile vitamin which is also sensitive to light, oxygen, and oxidizing agents (Gupta., 2008). The levels of deterioration generally depend on the initial content in the food matrix, storage conditions, length of storage, and the type of cooking employed. Because vitamin C is so sensitive to heat, the loss observed in this study was expected. Other studies have reported losses of up to 80% in amaranth vegetables and 66.3% in spinach when steamed for five minutes in a pressure cooker (Bernhardt and Schlich., 2006). However, it has been suggested that pre-treating the vegetables chemically (0.5% potassium metabisulfite + 0.1% magnesium oxide + 0.1% sodium bicarbonate) significantly reduces vitamin C losses during cooking (Mosha et al., 1997). Further studies to determine consumer acceptability must be conducted through sensory evaluation of the chemically treated SPL.

The effect of steaming on β-carotene varied between the two varieties, with the mean values of the green SPL increasing after heating for 15 minutes, while steaming tended to reduce the β-carotene content of the purple SPL ($p=0.087$). This variability has been seen in previous studies that determined the β-carotene content of similar vegetables. β-carotene content of broccoli is reported to have significantly increased by 32% upon steaming under atmospheric pressure (Miglio et al., 2008). This increase in β-carotene content has been attributed to the release of carotenoids from their matrix upon cooking, due to the disruption of carotenoid-protein complexes, subsequently resulting in increased extractability and higher concentrations in the cooked sample (Bernhardt and Schlich., 2006). Conversely, other studies found a decrease in β-carotene content in amaranth and SPL (Mosha et al., 1997). This decrease in carotenoid content was attributed to wilting and damage to the leaf tissues, which resulted in leaching of the nutrient (Mosha et al., 1997). Further, it has been suggested that increased activity of the enzyme lipoxygenase during the initial warming stages of steaming with the oxidation and isomerization of trans-β-carotene to its less active cis-form may also contribute to the decrease in concentration (Speek et al., 1988).

In conclusion, green and purple SPL possess high mineral and vitamin content, and appreciable levels of macronutrients. This study shows that the nutrient content of the raw green and purple SPL varieties is

similar, with only P and vitamin C being significantly different. The green SPL appear to be more beneficial when steamed as certain minerals and vitamins such as calcium and β-carotene, respectively, were more stable in this variety compared to the purple variety. The increased β-carotene content of the green SPL upon steaming suggests that these SPL have the potential to improve vitamin A status of the Zambian population if consumed in adequate amounts. Thus, increased production of the green variety is necessary. Additionally, to support increased consumption of green SPL, a countrywide study must be conducted to establish SPL consumption patterns and determine which variety is most commonly available as well as more advocacy for its consumption, and associated nutritional and health benefits.

Table 1: Proximate composition of the raw and steamed green and purple sweet potato leaves (SPL).[1]

Parameter	Raw SPL		10-minute steamed SPL		15-minute steamed SPL	
	Green	Purple	Green	Purple	Green	Purple
Moisture (%)	3.2 ± 0.5^{a}	3.4 ± 0.7^{a}	2.3 ± 0.9^{a}	3.2 ± 1.3^{a}	3.0 ± 0.3^{a}	3.3 ± 0.8^{a}
Crude protein (g/100g)	26.4 ± 3.3^{a}	24.6 ± 1.7^{a}	23.5 ± 1.5^{b}	24.1 ± 1.6^{a}	22.7 ± 0.9^{c}	23.5 ± 1.5^{d}
Crude fat (g/ 100g)	0.8 ± 0.1^{a}	0.8 ± 0.0^{a}	0.8 ± 0.1^{a}	0.7 ± 0.1^{a}	0.7 ± 0.1^{a}	0.7 ± 0.0^{a}
Crude fiber (g/100g)	3.3 ± 0.6^{a}	3.1 ± 0.5^{a}	2.9 ± 0.9^{b}	2.5 ± 0.4^{b}	3.4 ± 0.7^{a}	2.4 ± 0.3^{b}
Ash (g/100g)	18.4 ± 4.8^{a}	20.7 ± 3.3^{a}	15.3 ± 2.3^{b}	19.0 ± 2.7^{d}	13.3 ±1.3^{c}	17.9 ± 2.8^{e}

[1]Values are mean ± SD of nine samples and two replicates per sample
Values with different superscripts in a row were significantly different ($p<0.05$)

Table 2: Mineral and vitamin content of the raw and steamed green and purple sweet potato leaves (SPL).[1]

Parameter	Raw SPL		10-minute steamed SPL		15-minute steamed SPL	
	Green	Purple	Green	Purple	Green	Purple
Calcium (mg/100g)	332.1 ± 16.4^{a}	343.1 ± 34.8^{a}	330.3 ± 17.1^{a}	343.0 ± 30.8^{b}	328.7 ± 20.5^{a}	342.3 ± 29.8^{a}
Iron (mg/100g)	24.4 ± 0.5^{a}	23.9 ± 5.3^{a}	14.8 ± 2.3^{b}	16.6 ± 2.6^{c}	13.9 ± 1.0^{b}	13.7 ± 2.2^{d}
Zinc (mg/100g)	1.5 ± 0.1^{a}	1.5 ± 0.2^{a}	1.4 ± 0.1^{a}	1.4 ± 0.1^{b}	1.2 ± 0.1^{c}	1.3 ± 0.1^{d}
Potassium (mg/100g)	5.0 ± 0.3^{a}	4.8 ± 0.4^{a}	4.5 ± 0.3^{b}	4.5 ± 0.4^{b}	4.3 ± 0.2^{c}	4.2 ± 0.2^{c}
Phosphorous (mg/100g)	176.1 ± 7.0^{a}	137.3 ± 10.4^{b}	150.6 ± 24.4^{a}	124.4 ± 6.3^{b}	142.1 ± 21.2^{a}	113.4 ± 9.3^{c}
Vitamin C (mg/100g)	14.6 ± 1.3^{a}	17.7 ± 0.9^{c}	11.8 ± 1.1^{b}	15.1 ± 2.4^{d}	11.0 ± 0.6^{b}	13.8 ± 1.7^{d}
β-carotene (µg/100g)	476.2 ± 125.7^{a}	395.9 ± 93.2^{b}	410.4 ± 161.0^{a}	376.6 ± 114.2^{b}	460.0 ± 171.7^{a}	355.5 ± 119.8^{b}

[1]Values are mean ± SD of nine samples and two replicates per sample
Values with different superscripts in a row were significantly different ($p<0.05$)

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