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Quality characteristics of sweet potato leaves (*Ipomoea batatas* L.) as influenced by processing and storage conditions

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ABSTRACT

This study investigated the effects of blanching, drying and storage conditions on the quality characteristics of sweet potato leaves (SWPL). SWPL (unblanched and steamed blanched at 90 °C for 1 min) were oven-dried (50 °C for 72 hours), packaged in polyethylene bags, stored at ambient temperature (28±2 °C) and refrigerated (7±2 °C) for nine weeks. The rehydration ratio, beta carotene, phenolic content, mineral content, and their soup sensory properties were determined at three weeks intervals using standard methods. Rehydration ratio, beta carotene and phenolic contents ranged from 9.46-10.50, 0.10-0.70 g/100 g and 16.40-29.20 g/100 g respectively. The refrigerated blanched samples contained a greater amount of calcium (496.35) and zinc (1.64) than unblanched samples at the end of nine-week storage. The soups prepared from refrigerated blanched dried SWPL were rated similar to fresh SWPL. The combined processing methods of blanching, drying and refrigeration preserved the nutrients in SWPL with better rehydration and organoleptic properties.

Introduction

Sweet potato (*Ipomoea batatas* L.) is ranked the seventh most important crop in the world for its edible root production, but its leaves have been largely underutilized for food in many regions of the world (FAO, 2015; Suárez et al., 2020). Sweet potato leaves (SWPL) have a mild sweet taste and are predominantly consumed in the form of salad, stew and soup in Africa and Asia (Suárez et al., 2020). The cordate (heart-shaped) leaves of the sweet potato plant frequently grow on alternate, numerous lobes depending on the varieties and the young tops (10 centimetres) of cultivated varieties are mostly consumed due to their tenderness (Suárez et al., 2020). Sweet potato has been identified to have a higher annual yield than many other green vegetables, because of the multiple harvests within a year, as the plant is drought and flood-tolerant with the ability to grow in a wide range of ecological zones (Barrera and Picha, 2014). SWPL like most green vegetable leaves have traditional and herbal medicinal benefits. They have been used as a laxative and for treatments of illnesses associated with the intestine, liver and stomach (Islam, 2006). Research has indicated that consumption of SWPL rich meals enhances antioxidant activities and lowers the risk of cardiovascular diseases due to low sodium-potassium ratio (Suárez et al., 2020). It helps in immune functions modulation and weight management (Islam, 2006). SWPL is also an excellent source of water-soluble vitamins (B2, B6 and C), dietary fibres and essential fatty acids (Islam, 2006).

However, owing to the perishable nature of SWPL and a regular habit of consuming fresh leaves, large quantities of the leaves are lost during postharvest handling and commercialization. Presently, there is a growing interest in the application of appropriate processing technology such as blanching, dehydration and refrigeration for these over looked leaves in

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developing countries, towards a good economic strategy that will increase its consumption and retain its health benefits (Okpala and Ekechi, 2014). It is not uncommon that, when blanching is carried out to enhance some quality attributes of vegetables, other nutritional composition may be compromised. Also, the effect of cold storage on the quality attributes is an important issue to be considered (Neri et al., 2014). Therefore, this study focused on the influence of blanching, refrigeration and ambient conditions storage effect on SWPL quality characteristics.

Materials and methods

Raw material and sample preparation

Freshly harvested SWPL used in this research were sourced from a research farm at the University of Ibadan, Nigeria. The SWPL from sweet potato plants of about 2 months were harvested very early in the morning at around 6:30 am. The SWPL were cleaned in deionized water, sorted (to remove wilted leaves and stems), cut into thin slices (2 mm) and washed in deionized water. SWPL were divided into two equal portions with each weighing 1700 g. The first portion was blanched (90 °C for 1 minute) in hot water, cooled with running water and drained. The second portion was not blanched and both portions were dried in an oven (Sanyo Gallenkamp, OVH-300-010W UK) at 50 °C for 72 hours.

Storage of dehydrated sweet potato leaves

The dried SWPL were further divided into two portions; packaged in high-density polyethylene (HDPE), stored at ambient (28±2 °C) and refrigerated (7±2 °C) conditions for nine weeks. The samples were labelled as UDR (unblanched, oven-dried and stored at ambient temperature), UDF (unblanched, oven-dried and refrigerated), BDR (blanched, oven-dried and stored at ambient temperature) and BDF (blanched, oven dried and refrigerated). Samples were separately milled into powder and sieved (600 µm) for chemical analyses at the three weeks interval.

Preparation of soups from sweet potato leaves (SWPL)

The soups from each sample were prepared based on the method established by the FIIRO, Nigeria, and reported by Raji et al.(2015). The recipe used for cooking was; SWPL (200 g each), palm oil (95 ml), ground pepper (14 g), water (100 ml), crayfish (30 g), salt (6.5 g), stockfish (100 g), dry fish (50 g), onions (75 g) and seasoning (4.5 g). The cooking time for the soups was 15 minutes.

Determination of colour processed sweet potato leaves

The colour parameters (L*, a*, b*) for the SWPL were estimated using HunterLab colourimeter equipment.

Determination of rehydration ratio of dried sweet potato leaves

The rehydration ratio of each sample was done using the modified procedure of Gowen et al. (2008). Exactly 5 g of each sample (from the storage condition described above) was rehydrated in 200 ml of boiling water for 10 minutes. Water left on the outer part of rehydrated samples was drained off with soft tissue and the rehydration ratio was estimated as equilibrium mass after rehydration divided by their initial mass.

Determination of moisture content of processed sweet potato leaves

The method of AACC (2000) was used for moisture content determination and expressed in % of wet basis (w.b.).

Determination of beta carotene contents of processed sweet potato leaves

Dried SWPL (0.5 g) was ground in a mortar with successive addition of 50 ml acetone (initially refrigerated at 4 °C for 2 hr.). The paste was filtered under a vacuum until the colour disappeared. The extract was mixed with 40 mL of petroleum ether in a 500 ml separating funnel and distilled water was slightly added to remove acetone in the solution. The upper layer was then collected in a flask through a sodium sulphate filter to remove residual water. The absorbance was recorded at 450 nm wavelength and beta carotene was extrapolated from the standard equation (AOAC, 2005).

Determination of phenolic content of processed sweet potato leaves

Polyphenol extraction was carried out using 3 ml of 95% ethanol (v/v) mixed with SWPL paste (100 mg of dried SWPL in 2 ml distilled water). Polyphenol extraction was carried out using 3 ml of 95% ethanol (v/v) mixed with SWPL paste (100 mg in 2 ml distilled water). The supernatant from the centrifuged (5000 g) mixture was mixed with Folin-Ciocalteu's phenol reagent (1:1) and 2 ml of Na_2CO_3 (10%). The mixture was kept on a shaker (1 h) and absorption was determined at 700 nm. A gallic acid curve was used for estimation of phenol content (AOAC, 2005).

Determination of mineral content of processed sweet potato leaves

The mineral content of the samples was determined (method 984.27 of AOAC) after wet digestion (using sulphuric, nitric and perchloric acids). Ca, Mg, Fe and Zn were determined by Atomic absorption spectrophotometry (AAS). Flame photometry was used for K and Na determination (AOAC, 2005).

Sensory evaluation of processed sweet potato leaves soups

Sensory evaluation of the SWPL soups was done by 30 semi-trained panellists (students and staff members of the University of Ibadan who were between 18-55 years of age) who were familiar with vegetable soup since childhood. A 9-point hedonic scale technique was used and panellists were trained to use sensory evaluation procedures. The control SWPL was presented simultaneously with other samples for evaluation as described by Olatoye et al. (2018).

Statistical test

All the analyses were replicated three times and the data obtained were analyzed for ANOVA using SPSS [Version 17.0, 2002] statistical package. The mean comparison was done by Duncan's multiple range test at level $p<0.05$.

Results and discussion

Physical properties of processed sweet potato leaves

The hunter colour values showed that L* values of SWPL ranged from 17.37 to 19.14 (Table 1). The higher the L* value, the better the sample's appearance (Lawal and Akinoso, 2019). The blanched samples had lower initial L* values (17.37) when compared with the unblanched (19.14) samples. A slight reduction in colour implied that blanching pretreatment had the ability to retain the colour of SWPL. Noticeably, all the leaves samples showed higher values at different storage periods than their initial values. This could be attributed to the degradation of chlorophyll and the increase in moisture content of the leaves or their interactions. The a* and b* values ranged from -10.73-2.47 and 1.71 to 10.18 respectively. Greenness (-a) of the SWPL showed that the leaves were fresh. The lowest value (-4.63) was obtained for BDF after 9 months of storage, while the unblanched sample had the highest value (-2.47) before storage. Therefore, blanching retained greenness and decreased yellowness in SWPL. However, the influence of refrigeration was insignificant ($p>0.05$) in the unblanched SWPL. An increase in storage period resulted in leaves with more yellow colour for UDR and UDF. This was in line with the findings of Leja et al. (2006) who reported that colour stability could be greatly increased when appropriate process combinations (temperature and time) were utilized during blanching. Also, long blanching time is known to increase the extent of leaching, while high temperature increases the rate of diffusion across the plant tissues. Similar results had been reported for *vaccinium bracteatum* leaves by Miao et al. (2020).

The rehydration ratio (RR) of the SWPL varied from 9.36-10.50 (Fig. 1). The highest RR was recorded for UDF (before storage), while the minimum value was found in BDR (9 weeks storage). However, blanching had a significant influence on the rehydration ratio of the blanched samples. The rehydration ratio values of the unblanched samples were comparatively higher than their respective blanched samples at the same storage conditions and time. This was corroborated by the findings of Okpala & Ekechi (2014) who reported a higher rehydration ratio of blanched and unblanched West African pepper. Cellular rupture and collapse of vacuole structures commonly observed in vegetable leaves subjected to blanching and drying are mainly responsible for their lower hydrophilic properties (Gowen et al., 2008).

Moisture, phenolic and beta-carotene content of processed sweet potato leaves

Moisture, phenolic and beta-carotene content of processed SWPL is shown in Table 2. The moisture content of dried samples ranged from 8.11-19.47%. The increase in moisture content of the samples was significantly influenced by both blanching and storage conditions. The value was significantly higher ($p<0.05$) in blanched leaves by 50.55% prior to storage. Generally, the moisture content of the samples increased as the storage period increased regardless of the storage condition. Variation in moisture content might be ascribed to the pretreatment which conferred stronger bonding forces in the blanched leaves. The moderately high moisture content of the blanched leaves could be an asset for the retention of volatiles, pigments and minerals in food products. However, moderate re-absorption of moisture by the samples might be a result of the high humidity of the cold storage environment (Raji et al., 2015).

Table 1. Colour of processed sweet potato leaves

Samples	Weeks 0	3	6	9
L*				
UDR	19.14^{b}±0.06	24.86^{a}±0.05	18.59^{b}±0.03	20.27^{b}±0.06
UDF	19.14^{b}±0.06	22.66^{a}±0.04	18.85^{b}±0.04	17.99^{b}±0.04
BDR	17.37^{c}±0.04	21.38^{a}±0.03	18.46^{bc}±0.05	19.39^{b}±0.04
BDF	17.37^{c}±0.04	20.47^{b}±0.06	18.11^{c}±0.02	24.24^{a}±0.03
a*				
UDR	-2.47^{c}±0.03	-3.19^{a}±0.01	-2.68^{b}±0.07	-2.99^{a}±0.04
UDF	-2.47^{b}±0.03	-3.02^{a}±0.04	-2.63^{a}±0.05	-2.80^{a}±0.05
BDR	-2.94^{b}±0.06	-4.25^{a}±0.03	-2.85^{b}±0.02	-3.22^{b}±0.03
BDF	-2.94^{c}±0.06	-3.65^{b}±0.02	-2.95^{c}±0.03	-4.63^{a}±0.06
b*				
UDR	3.27^{c}±0.05	5.06^{a}±0.03	2.99^{c}±0.06	3.85^{b}±0.07
UDF	3.27^{b}±0.04	4.78^{a}±0.08	3.12^{b}±0.03	3.26^{b}±0.01
BDR	1.97^{b}±0.06	1.93^{b}±0.06	2.46^{a}±0.05	2.89^{a}±0.04
BDF	1.97^{b}±0.07	1.71^{b}±0.05	2.54^{a}±0.04	2.15^{a}±0.06

Values (mean ± SD data) in the same row with the same small letters denote insignificant difference at p>0. UDF, UDR, BDR and BDF represent un-blanched dried and refrigerated,un-blanched dried and stored at ambient conditions, blanched dried and refrigerated and blanched dried and stored at ambient conditions, respectively. SWPL represents sweet potato leaves.

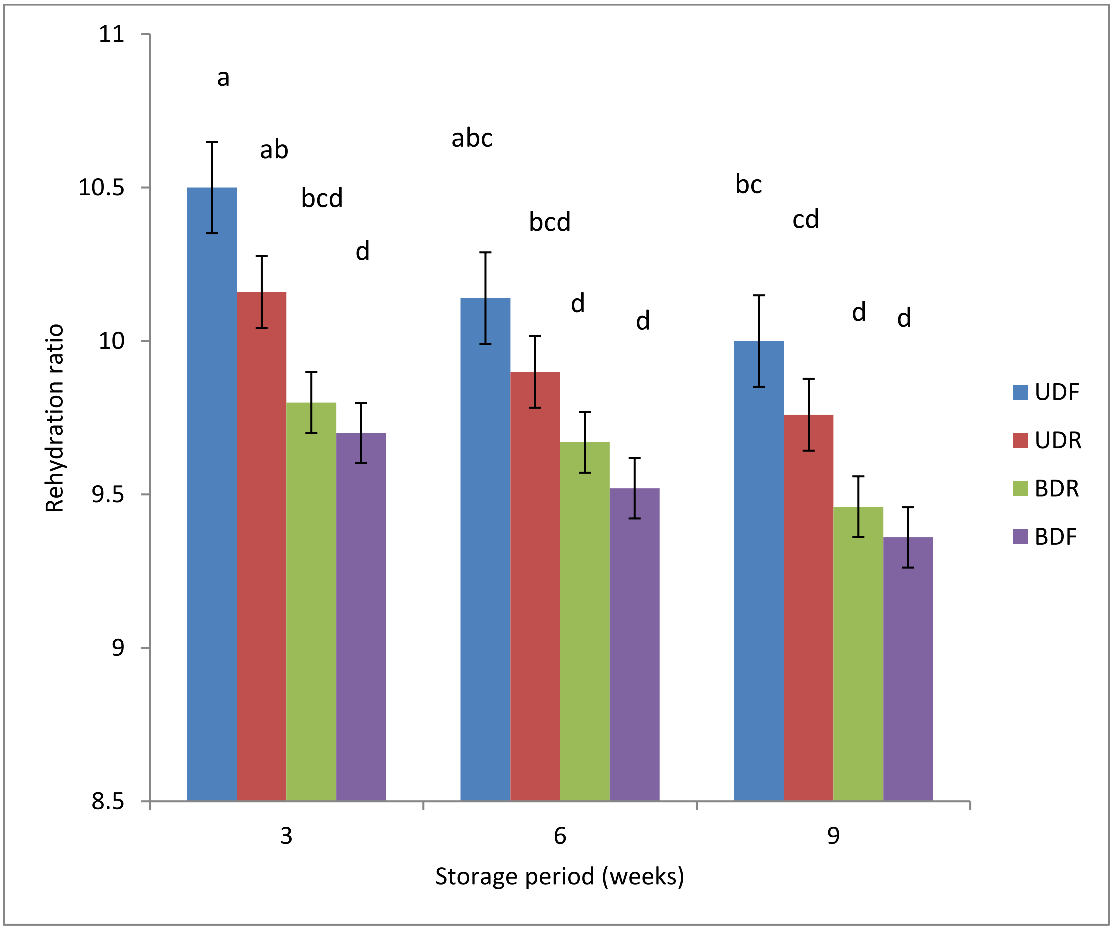

Figure 1. Rehydration ratio of processed SWPL. UDF, UDR, BDR and BDF represent un-blanched dried and refrigerated, un-blanched dried and stored at ambient conditions, blanched dried and refrigerated and blanched dried and stored at ambient conditions, respectively. SWPL represents sweet potato leaves.

Phenolic contents of SWPL ranged from 18.10-29.20 g/100 g (equivalent to garlic acid). Blanched and unblanched SWPL showed different responses to the storage treatment (Table 2). Both the blanching pretreatment and storage conditions significantly influenced the phenolic content of the samples. However, the phenolic content of the unblanched dried leaves was higher in samples before storage and showed a decrease as the storage period increased. The values observed for samples kept under refrigerated (UDF) and ambient (UDR) conditions at the ninth week of storage were lower than their initial values by 5.37 and 20.21%, respectively. However, for both blanched samples stored at refrigerated (BDR) and ambient (BDF) conditions, phenolic content increased with an increase in storage period (9 weeks) by 30.39 and 47.51%, respectively. Similarly, Leja et al. (2006) observed a 12.2% postharvest increase in the total phenolic content of white cabbage vegetables. An increase in the phenolic content of the stored blanched samples might be a result of effective enhancement of the removal of the phenolic metabolite from the proteins within the cell structures, thereby making it available over time during storage (Dolinsky et al., 2016). Suárez et al. (2020) indicated that total phenolic accumulations were linked to post-harvest senescence and temperature variation during the processing and storage of vegetables. Phenolic-rich vegetable diet had been found to improve the conditions of people suffering from cardiovascular illnesses, and this might be attributed to their antioxidant activities which were effective in trapping free radicals (Barrera and Picha, 2014). The values (18.10-29.20) recorded after storage were higher than the range (6.19-17.14g/100 g) reported by Islam (2006) for different varieties of SWPL grown in the US.

Beta carotene is the precursor of vitamin A and is highly valued in the nutrition of the young and adults, especially in the developing countries of the world. Their potential protection against numerous cancers has been documented (Leja et al., 2006). The beta carotene content for different processed and stored SWPL significantly varied from 0.10-0.70 g/100 g (Table 2). Generally, storage reduced the SWPL beta carotene to 85.71% (UDF) and 71.43% (UDR, BDR and BDF) in the ninth week. Interestingly, Barrera & Picha (2014) reported that processing did not only reduce the carotenoid content, it also enhanced its bioavailability which might compensate for the losses. The degrading effect on the beta carotene content of the edible leaves had been attributed to processing and storage methods (Erukainure et al., 2011).

Mineral content of processed sweet potato leaves

Calcium, potassium, sodium, iron, magnesium and zinc were the major minerals in the processed SWPL (Table 3). Mineral contents varied ($p<0.05$) between unblanched and blanched SWPL samples significantly: calcium (148.73-518.03 and 175.82-735.57 mg/100 g, respectively), potassium (752.82-1187.00 and 763.15-1125.67 mg/100 g, respectively), sodium (117.52-198.90 and 104.96-151.47 mg/100 g, respectively), iron (19.52-39.79 and 8.52-20.31 mg/100 g, respectively), magnesium (5.10-19.85 and 5.16-19.82 mg/100 g, respectively) and zinc (1.10-1.95 and 1.16-1.78 mg/100 g, respectively). Data obtained for minerals were significantly influenced by blanching and storage methods at a 95% confidence level. Unblanched SWPL had higher amounts of mineral content than blanched SWPL except for calcium, and this could be attributed to the precipitation of calcium from soluble calcium oxalate during blanching, while oxalates leached into the water. According to Makanjuola et al. (2013), soluble oxalate content of the green vegetable reduced significantly during blanching with a subsequent increase in calcium concentration. The increase in calcium content of blanched SWPL might make it a suitable vegetable for people with chronic renal failure to prevent renal osteodystrophy that was usually associated with low serum calcium, which could also help in blood clotting and vitamin B12 absorption (Makanjuola et al., 2013). It is interesting to note that decreased trends were observed during storage of SWPL, and at the end of the ninth week of storage, BDF showed significantly ($p<0.05$) higher mineral contents retention than UDR and BDR by 137.84 and 135.08% (for magnesium), 7.67 and 20.55% (for potassium) respectively. The reason for these observed reductions in mineral content of samples stored at ambient conditions (30 °C) could be due to uncontrolled environmental conditions. Raji et al. (2015) attributed lower mineral retention during the storage of vegetable soups to losses in ash contents. The levels of iron content in the SWPL samples were more than the recommended dietary allowance (RDA) of 8 mg/day/person reported by FAO (2015). This indicates the suitability of SWPL in diet to prevent diseases associated with iron deficiency. As regards sodium and potassium content of the SWPL samples, their ratio of sodium to potassium contents was below 1, suggesting that their consumption might prevent the development of cardiovascular diseases such as hypertension (Suárez et al., 2020).

Table 2. Moisture, phenolic and beta-carotene contents of processed sweet potato leaves

Samples	Weeks 0	3	6	9
Moisture		(%)		
UDR	8.11^{b}±0.10	11.44^{a}±0.32	11.71^{a}±0.25	12.90^{a}±0.37
UDF	8.11^{c}±0.10	10.21 ^{b}±0.20	11.07 ^{b}±0.14	14.06^{a}±0.61
BDR	12.21^{d}±0.14	14.92^{c}±0.21	16.00^{b}±0.15	19.47^{a}±0.41
BDF	12.21^{b}±0.14	13.87^{b}±0.20	12.83^{b}±0.15	16.89^{a}±0.13
Phenol		(g/100 g)		
UDR	29.20^{a}±0.13	16.40^{c}±0.15	17.00^{c}±0.11	23.30^{b}±0.11
UDF	29.20^{a}±0.08	28.80^{a}±0.14	24.30^{b}±0.15	25.30^{b}±0.21
BDR	18.10^{b}±0.11	17.40^{c}±0.12	19.80^{b}±0.14	23.60^{a}±0.15
BDF	18.10^{a}±0.07	18.00^{a}± 0.10	18.50^{a}±0.11	26.70^{a}±0.12
Beta carotene		(g/100 g)		
UDR	0.70^{a}±0.01	0.10^{c}±0.00	0.40^{b}±0.00	0.20^{c}±0.00
UDF	0.70^{a}±0.02	0.10^{b}±0.00	0.20^{b}±0.00	0.10^{b}±0.00
BDR	0.60^{a}±0.01	0.10^{c}±0.00	0.30^{b}±0.00	0.20^{bc}±0.01
BDF	0.60^{a}±0.00	0.10^{b}±0.00	0.20^{b}±0.00	0.20^{b}±0.01

Values (mean ± SD data) in the same row with the same small letters denote insignificant difference at p>0. UDF, UDR, BDR and BDF represent un-blanched dried and refrigerated, un-blanched dried and stored at ambient conditions, blanched dried and refrigerated and blanched dried and stored at ambient conditions, respectively. SWPL represents sweet potato leaves.

Table 3. Mineral contents of processed sweet potato leaves

Samples	Weeks 0	3	6	9
Ca		(g/100 g)		
UDR	518.03^{a}±0.14	211.15^{b}±0.10	193.98^{c}±0.26	148.73^{d}±0.26
UDF	518.03^{a}±0.14	427.78^{b}±0.24	364.52^{c}±0.16	360^{c}±0.31
BDR	735.57^{a}±0.23	304.92^{b}±0.18	211.12^{c}±0.17	175.82^{d}±0.50
BDF	735.57^{a}±0.23	612.6^{b}±0.23	513.78^{c}±0.20	496.35^{c}±0.37
Mg		(g/100 g)		
UDR	19.85^{a}±0.21	17.27^{a}±0.30	8.07^{b}±0.25	5.10^{c}±0.11
UDF	19.85^{a}±0.21	16.33^{b}±0.18	14.09^{b}±0.20	14.12^{b}±0.17
BDR	19.82^{a}±0.14	16.60^{b}±0.13	8.12^{c}±0.23	5.16^{d}±0.16
BDF	19.82^{a}±0.14	16.79^{b}±0.24	14.24^{c}±0.15	12.13^{d}±0.23
Na		(g/100 g)		
UDR	198.9^{a}±0.48	151.25^{b}±0.15	129.28^{c}±0.21	117.52^{d}±0.13
UDF	198.9^{a}±0.48	168.48^{b}±0.20	151.78^{c}±0.17	143.14^{d}±0.15
BDR	151.47^{a}±0.51	135.52^{b}±0.18	113.72^{c}±0.14	104.96^{c}±0.19
BDF	151.47^{a}±0.51	138.34^{b}±0.14	136.14^{b}±0.20	126.53^{c}±0.23
Fe		(g/100 g)		
UDR	39.79^{a}±0.64	34.71^{b}±0.23	27.36^{c}±0.21	19.52^{d}±0.25
UDF	39.79^{a}±0.64	37.26^{a}±0.41	25.52^{c}±0.17	34.47^{b}±0.31
BDR	20.31^{a}±0.29	16.42^{b}±0.26	13.73^{c}±0.35	8.52^{d}±0.42
BDF	20.31^{a}±0.29	19.29^{a}±0.32	18.47^{a}±0.28	18.38^{a}±0.36
K		(g/100 g)		
UDR	1187.00^{a}±0.76	947.21^{b}±0.90	839.58^{c}±0.51	752.82^{d}±0.73
UDF	1187.00^{a}±0.76	1111.28^{b}±0.81	1007.52^{c}±0.83	995.61^{c}±0.69
BDR	1125.67^{a}±0.69	950.49^{b}±0.77	843.28^{b}±0.56	763.15^{c}±0.58
BDF	1125.67^{a}±0.69	1100.03^{b}±0.66	997.17^{c}±0.48	981.73^{c}±0.50
Zn		(g/100 g)		
UDR	1.95^{a}±0.01	1.52^{a}±0.01	1.39^{a}±0.00	1.10^{b}±0.01
UDF	1.95^{a}±0.01	1.80^{a}±0.00	1.72^{a}±0.00	1.63^{a}±0.00
BDR	1.78^{a}±0.00	1.60^{a}±0.01	1.25^{a}±0.01	1.16^{b}±0.01
BDF	1.78^{a}±0.00	1.68^{a}±0.02	1.66^{a}±0.01	1.64^{a}±0.00

Values (mean ± SD data) in the same row with the same small letters denote insignificant difference at p>0.UDF, UDR, BDR and BDF represent un-blanched dried and refrigerated, un-blanched dried and stored at ambient conditions, blanched dried and refrigerated and blanched dried and stored at ambient conditions, respectively. SWPL represents sweet potato leaves.

Sensory attributes processed sweet potato leaves

The mean sensory scores for the sensory attributes such as taste, colour, aroma, texture and overall acceptability were rated low for unblanched (UDR) SWPL soups when compared with fresh and blanched SWPL soups, and they varied from 2.80-4.10, 3.25-4.20, 3.45-3.95, 3.25-4.25 and 3.05-4.35 respectively. Soups prepared from fresh SWPL had the highest scores for all sensory attributes (Table 4). A higher overall acceptability rating in both refrigerated blanched and unblanched soup samples compared to the samples stored at room temperature was expected since nutrients and other chemical compositions responsible for the sensory attributes of the food are stable at refrigeration temperature (Raji et al., 2015). Refrigeration generally inactivates enzymes and organisms responsible for food deterioration. In the process molecular mobility is depressed and consequently, all chemical and biological processes are retarded at low temperatures (Raji et al., 2015). According to Makanjuola et al. (2013), appropriate blanching treatment had thermo-protective potential which inactivated enzymes and enhanced the organoleptic qualities such as flavour and texture of the vegetables. In a similar scenario, the undesirable structural and textural changes of unblanched frozen tissues of carrots during storage were mainly linked to mechanical damage associated with the ice formation and potential stresses compared with the unblanched frozen tissues of carrots with good tissue integrity (Neri et al., 2014). In comparison with the control soups prepared from fresh SWPL, the acceptability recorded for blanched dried refrigerated (BDR) soups was not statistically different, except for the texture.

Table 4. Sensory attributes processed sweet potato leaves

Samples	Taste	Colour	Flavour	Texture	Overall acceptability
UDR	$2.80^{c} \pm 0.76$	$3.25^{b} \pm 0.66$	$3.45^{ab} \pm 0.59$	$3.25^{b} \pm 0.73$	$3.05^{bc} \pm 0.45$
UDF	$3.25^{a} \pm 0.43$	$3.45^{a} \pm 0.27$	$3.40^{a} \pm 0.20$	$3.50^{a} \pm 0.28$	$3.30^{a} \pm 0.23$
BDR	$2.85^{ab} \pm 0.37$	$3.40^{a} \pm 0.33$	$3.30^{a} \pm 0.40$	$2.80^{b} \pm 0.25$	$2.65^{b} \pm 0.18$
BDF	$4.10^{a} \pm 0.24$	$3.85^{ab} \pm 0.18$	$3.50^{b} \pm 0.16$	$3.60^{b} \pm 0.22$	$4.05^{ab} \pm 0.17$
FSP	$4.10^{a} \pm 0.18$	$4.20^{a} \pm 0.26$	$3.95^{a} \pm 0.32^{a}$	$4.25^{a} \pm 0.21^{a}$	$4.35^{a} \pm 0.23^{a}$

Values (mean ± SD data) in the same column with the same small letters denote insignificant difference at p>0. UDF, UDR, BDR and BDF represent un-blanched dried and refrigerated, un-blanched dried and stored at ambient conditions, blanched dried and refrigerated and blanched dried and stored at ambient conditions, respectively. SWPL represents sweet potato leaves

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Conclusions

Sufficient to say, sweet potato leaves (SWPL) contain high amounts of major minerals required for proper body functioning. However, noticeable variations were detected between blanched and unblanched SWPL samples. Refrigeration of SWPL was found to have conferred higher nutrients retention and enhanced quality attributes of the soups. Unblanched SWPL were slightly higher in rehydration ratio than the blanched leaves. Processing and storage methods decreased the level of beta carotene for blanched and unblanched samples while they increased the phenolic content of SWPL. The soups prepared from refrigerated blanched dried SWPL were rated similar to fresh SWPL. The combined processing methods of blanching, drying and refrigeration preserved the nutrients in SWPL with better rehydration and organoleptic properties.

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He is the principal investigator, and was involved in the design concept, data acquisition, analysis, interpretation and manuscript drafting. His contribution to the work is rated 30%; Adetunji Ismael Lawal - He is a co- investigator, and was involved in the data acquisition, analysis, interpretation and manuscript drafting. Her contribution to the work is rated 25%; Akeem Olayemi Raji - He is a co-investigator and the corresponding author, he was involved in the design concept, data analysis, interpretation and manuscript drafting. His contribution to the work is rated 25%; Adejonwo Opeyemi Osifuwa - He is a graduate student attached to this research, and he was involved in the design concept, data analysis, interpretation and thesis write up. His contribution to the work is rated 20%.

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