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Effect of processing on nutritional and anti-nutritional composition of false sesame (*Ceratotheca sesamoides*) and common bean leaves (*Phaseolus vulgaris*)

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Abstract

The effects of blanching and drying on micro-nutrients: β-Carotene, Vitamin C, Folic acid, Iron (Fe), Zinc (Zn), Phosphorus (P) and anti-nutrients: Tannins and Oxalates composition of False Sesame Leaves (FSL) and Common Bean Leaves (CBL) were investigated. Vegetables preferences and preservation technologies used were assessed using questionnaire. Micronutrients content: β-Carotene, Vitamin C, and folic acid were analyzed using HPLC method while Fe, Zn were determined using Atomic Absorption Spectrophotometer (AAS) and Phosphorus was determined using UV-VIS Spectrophotometer. The oxalate and tannin were determined by titration and Folin Ciocalteu method. Several vegetables were identified, FSL (95.9%) and CBL (100%) being one of them. In vegetable processing, boiling (76.9%) and sun drying (15%) were reported in Bahi and Mbeya Rural Districts respectively. Sun drying was the commonly used method in both districts. Folic acid and β- Carotene were not detected in both vegetables. The vitamin C content in fresh FSL and CBL was 16.28mg/100g and 5.48mg/ 100g, yet the content was significantly reduced ($p<0.05$) by blanching and sun drying. False sesame leaves contained P (700mg/kg), Fe (115.75 ± 2.23mg/kg) and Zn (14.13mg/kg) whereas in CBL P was 600mg/kg Fe (652.76mg/kg) and Zn (41.04 ± 0.28mg/kg) respectively. Levels of P, Fe and Zn were significantly ($p<0.05$) increased by sun drying respectively. On the other hand, tannin and oxalate content in blanched and sun dried leaves were lower than in fresh leaves. Sun drying of FSL and CBL while covering after blanching further reduces tannins and oxalates, thus it is recommended as an effective method in anti-nutrients elimination.

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Introduction

False sesame (*Ceratotheca sesamoides*) and Common bean (*Phaseolus vulgaris*) leaves (FSL and CBL) make an imperative part of the Central and Southern zone of Tanzanians people diet. These vegetables are famous due to their indignity and availability in these respective areas. False sesame and CBL contain nutrients such as vitamins and minerals (Barros & Prudencio, 2016; Fasakin, 2004), that enrich the human body including protection against diseases like anemia, scurvy, night blindness and others. Prior to consumption, FSL and CBL are subjected to a number of processing techniques such as blanching and drying for preservation purposes. Blanching process is important since it helps in inactivation of enzymes which may cause changes in flavor, texture and color of the vegetables during storage as well as reducing anti-nutritional factors (Egbuonu & Nzewi, 2016; Mosha *et al.*, 1995). Drying as one of preservation techniques increases the shelf life of vegetables by creating unfavorable condition for microbial growth (Kiharaso *et al.*, 2017). Notwithstanding the mentioned benefits, processing methods may positively or negatively influence nutrients content of vegetables. According to Miglio *et al.* (2008) carotenoids were affected certainly thus there was an increase of 14% in boiled vegetables while drying resulted in micronutrients loss (Tsado *et al.*, 2015). Its loss is associated with the sensitivity to heat, light, oxygen, pH of the solvent and/or combinations of all these (Lee & Kader, 2000). In addition to that, FSL and CBL seem to contain anti-nutritional factors such as tannin and oxalate that may affect the bio-availability of the nutrients.

Despite the fact that, these vegetables are locally available and may contribute in combating micronutrients deficiencies, Fe and vitamin A deficiency are still prevailing in Mbeya Rural and Bah districts (URT-MoHCDGEC, 2015). In addition, evaluation of micronutrient and anti-nutritional content of the vegetables in the districts have not yet been documented. Moreover, the effects of the processing methods on the chemical compositions of CBL and FSL at household level have not been investigated and documented. Therefore, the study was carried out to evaluate the effect of processing methods on vitamin A, B_9, C, Fe, Zn and P, tannin and oxalate in FSL and CBL.

Materials and methods

Materials

Description of the Study Area

This study was carried out in Mbeya rural and Bahi Districts in Mbeya and Dodoma region respectively. Two wards in each district (one village from each ward) were purposively selected based on the involvement in Agriculture to Nutrition Project whereas the farmers had been provided with Agriculture and nutritional knowledge. The selected villages were: Utengule usongwe ward; Mbalizi and Nsalala ward; Nsalala village (Mbeya rural District); Bahi ward; Bahi sokoni village and Zanka ward; Mayamaya village (Bahi District) (Fig. 1.). Mbeya region is located in the Southern Highlands (latitude 8°54′ S, longitude: 33°27′ E, altitude 1697 m with an average temperature of 20.1°C and average annual rainfall 1023mm).

Mbeya region is a good producer of food crops including vegetables such as amaranth, chinese, cabbage, spinach and others. Despite of abundant food crop production, malnutrition problems are still prevailing. According to URT-MoHCDGEC (2015), 55% of children aged 6-59 months in Mbeya region were anemic. Dodoma region is located in the Central zone of Tanzania (latitude 6°10'S, longitude 35°45'E and altitude 1120 m with an average temperature of 22.6°C and the average annual rainfall of 564mm in a year). Dodoma is semiarid region hence it mostly experiences drought condition (Ephrahim & Fadhili, 2014), food crops including vegetables are grown seasonal and typically likely to be stored for dry season use. Dodoma is experiencing micronutrients deficiency problems with 48% of children aged 6-59 months reported to be anemic (URT-MoHCDGEC, 2015).

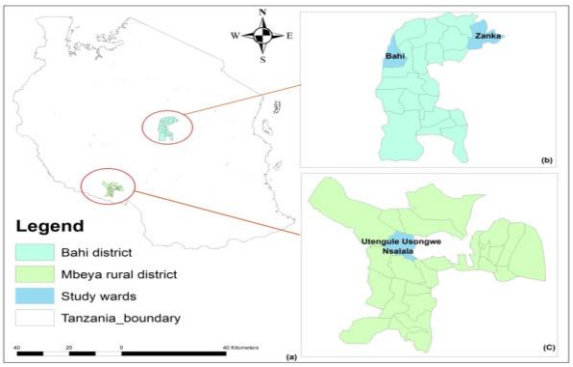

Fig. 1. A map showing study areas. A: Tanzania map B: Bahi district C: Mbeya rural district.

Information on the local practices of the vegetables

Information on vegetable preferences and preservation technologies used by locals were collected using structured questionnaire in the selected villages. A total of 74 and 69 respondents were interviewed in Bahi and Mbeya rural Districts identified as beneficiaries of Agriculture to Nutrition Project.

Vegetable Samples collection

False Sesame leaves were collected from Bahi District, Dodoma in April, 2018. Common Bean Leaves were collected from Mbeya Rural District, Mbeya region in June, 2018 (Fig. 1.). To preserve its freshness, the vegetables were kept in zip bags (unzipped) and stored in cooling box with indirect contact with ice cubes and immediately transported to the laboratory for further analysis. Vegetable samples were identified and authenticated by botanist at the Tropical Pesticides Research Institute (TPRI) Arusha, Tanzania under identification voucher "ACK 01 for False Sesame and ACK 02 for Common Bean" respectively. The vegetables were selected based on their indignity and local availability in areas (Bahi and Mbeya rural).

Methods

Vegetable sample preparation

Samples collected were stored at 4°C for one day before blanching treatments. False sesame leaves were separated from stalks and flower. False Sesame Leaves were not washed to avoid it getting slippery due to its slippery nature. Common Bean Leaves were separated from the stalks and discolored leaves were removed, and washed with deionized water. Clean cloth was then used to remove excess water. Common Bean Leaves were cut approximately half a centimeter using sharp knife and the remaining vegetable left whole. A portion of CBL, 510 g each was placed in a water bath (WBH-200, Germany) and blanched at 70°C for 3 & 5 min separately. A portion of CBL, 10g was removed for micronutrients and anti-nutritional factors analyses while the remaining portion was subjected to drying experiments. Likweise, a portion of whole FSL (510g) in a zip bag was immersed in water bath (WBH-200, Germany) and blanched at 70°C for 3 & 5 min separately (Tsado *et al.*, 2015), then a portion of FSL, 10 g was removed and put into the plate for drying purposes. Vegetables were subjected to sun drying; covered with white or black cloth and uncovered at an average temperature of 33.9°C for 3 days respectively until the weight of the sample remained constant. Fresh whole (un-blanched) vegetables were used as control.

Nutritional analysis

Determination of Carotenoids content

Carotenoid content of the CBL and FSL was determined using a method previously described by Pakistan *et al.* (2007). Two grams of the grinded CBL and FSL samples were mixed with 50mL of n-hexane (RFCL limited A-3, India) in the falcon tubes (Merck, South Africa) and shaken in the orbital incubator (Orbital S1600C, UK) for 15 min. Mixtures were filtered using Whatman filter paper no. 1 (Fisher Scientific, UK) to obtain a supernatant, which was then evaporated using water bath (WBH-200, Germany) at 50°C for 48 h and solid particles remained was re-dissolved in an aliquot of n-hexane for HPLC determination.

Beta carotene standard preparation

Beta carotene standard (Sigma-Aldrich, Germany) was freshly prepared from standard stock solution (100ppm) by mixing 10mg of β-carotene standard in 100mL n-hexane. In preparation for a standard curve, several dilutions were prepared; 80, 60, 40 and 20 ppm.

Beta carotene determination by HPLC

An aliquot (10µL) CBL, FSL and standard were set for automatic injection and into analytical HPLC

(Shimadzu LC 10AVP, Japan) coupled with C_{18} reversed phase particle size 5µm, diameter 4.6mm, length 250mm (Shimadzu, Japan). Detection wavelength was 470nm, with isocratic elution and the flow rate of 0.5mL/min, peak responses were observed at 9.1 min. High Performance Liquid Chromatogram mobile phase was prepared by mixing methanol with acetonitrile (8:2v/v).

Vitamin C determination

Vitamin C content was determined by using procedures discussed by Woollard *et al.* (2014). Five grams of vegetable sample was extracted using 30mL of distilled water and centrifuged centrifuged at 3500 rpm for 30 secs (Hettich centrifuge 0008-128-10, Germany). After centrifugation, supernatant was filtered using Whatman filter paper no. 1 (Fisher Scientific, UK). One milligram of Dithiothreitol (DDT) was added in each 1mL of filtrate; the mixture was shaken then filtrated through 0.45µm membranes (Fisher Scientific, UK).

Vitamin C standard preparation

Ascorbic acid (vit. C) Standard (Sigma-Aldrich, Germany) was prepared from stock solution made by dissolving 5mg of Ascorbic acid in 100mL of distilled water. Working solutions with different concentration were prepared; 50, 40, 30 and 10 ppm, then 10mg of Dithiothreitol was added to each standard and solutions were shaken.

Samples preparation for HPLC analysis

Samples and standards were prepared for HPLC injection by mixing with the mobile phase followed with an addition of 1g Dithiothreitol (Sigma-Aldrich, USA), mixture was stirred until dissolved, and then pH adjustment to 2.5 with concentrated Phosphoric acid. Solution was diluted to 1L with distilled water, and filter through 0.45µm membranes, an aliquot was injected in HPLC machine (Shimadzu LC 10AVP) coupled with C_{18} reversed phase particle size 5µm, diameter 4.6mm, length 250mm for determination step. HPLC mobile phase was prepared by mixing (KH_2PO_4) (SMiTH chemicals, India) (0.5%, w/v), pH 2.5, with Dithiothreitol (0.1%, w/v; prepared by adding 5g of KH_2PO_4 in 1L volumetric flask with 950mL water. High Performance Liquid Chromatogram detector was fixed at 254nm with flow rate of 0.5mL/min for 30min, followed by mobile phase for 1h to equilibrate column. Peak responses were detected at 4 min; Plotting against concentration was done electronically. The concentration of vitamin C (mg/100g) was interpolated directly from the calibration regression using LC solution software, from automated constructed calibration curve and the actual concentration of vitamin C in the sample was calculated using the formula below;

$$\text{Vitamin C} = \frac{\text{Conc.} \times \text{Dilution factor}}{\text{Weight of the sample} \times 10} \quad (1)$$

Determination of Folic acid

Folic acid analysis was done according to the method of Rahimi & Goodarzi (2011) with some modifications. Three grams of vegetables samples were extracted with 50mL of 0.1mol/L Phosphate buffer (pH 7.0) and 2-mercaptoethanol 0.1% (v/v). The mixture was shaken for 30 min in orbital incubator (S1600C, UK), and centrifuged (Hettich centrifuge 008-128-10, Germany) at 3500rpm for 15 min. The supernatant was filtered through a 0.45µm membrane before chromatography analysis.

Folic acid standard preparation

Folic acid standard (Sigma-Aldrich, Germany) was prepared by using standard stock solution of (100ppm) which was prepared by mixing 10mg of folic acid powder in 100mL of distilled water. Working solutions were prepared; 80, 60, 40p and 20ppm.

Samples preparation for HPLC analysis

Samples and standards were prepared for HPLC injection by mixing with the mobile phase, thereafter inserted into analytical HPLC machine (Shimadzu LC 10AVP, Japan) coupled with C_{18} reversed phase particle size 5µm, diameter 4.6mm, length 250mm. Samples were eluted with 5mL NaOH (0.005 mol/L) pH 10. Folic acid was detected at the wave length of detector at 254nm; sample injection was 10µL with the flow rate of 0.5mL/min.

The stationary phase was flushed with 5mL CH_4OH and 5mL de-ionized water to activate the stationary phase. Peak responses were observed at 14 min. KH_2PO_4 with pH of 3.6 (adjusted by H_3PO_4 (Loba Chemie Pvt. Ltd, India) was used as a mobile phase.

Mineral Analysis

Minerals (Fe, P and Zn) were determined by the method described by Ifeoma (2014). Two grams of sample was weighed and ashed in a Muffle furnace (Cole Parmer Box Furnace- CBFL516C, United State) overnight at a temperature of 500°C. Samples were cooled and 5mL 1N HNO_3 (Loba Chemie Pvt. Ltd, India) solution was added. Sample was evaporated to dryness and returned to the furnace and heated at 400°C for 15 min until a perfectly greyish white color was observed. Ashes were cooled and 40mL of 1N HCl (Loba Chemie Pvt. Ltd, India) solution was added then filtered into a 50mL volumetric flask. The crucible and filter paper was washed with additional 10mL portion of 0.1N HCl solution. Iron and Zn were determined using AAS UNICAM 919 (Hitachi High-Technologies Corporation , Japan,) at wavelength of 248.3nm for Fe and 213.9nm for Zn, P was determined using BIOMATE 6 UV-VIS Thermo scientific (UNICO spectrophotometer 2800, USA) at wavelength of 885nm and concentration were obtained.

Anti-nutritional factors determination

Oxalate content

Oxalate determination was done using titration method as described by Agbaire (2012). Sample was extracted using 75mL of 3M H_2SO_4. Mixture was shaken for 15 min in the orbital incubator (S1600C, UK). To obtain a supernatant, mixture were filtered using Whatman filter paper no. 1 then it was titrated against 0.05M KMn_4 (SMiTH chemicals, India) solution until faint pink color which persisted for 30 seconds was observed. Oxalate content was calculated by taking 1mL of 0.05 M $KMnO_4$ as equivalent to 2.2mg of oxalate (Jonathan & Funmilola, 2014).

Tannins content

Tannins content was estimated as the difference between total phenolic and non-tannin phenolic content in vegetable sample.

Total phenolic content in false sesame leaves and common bean leaves were determined in terms of Gallic acid equivalents (GAE) using Folin Ciocalteu method (Singleton, *et al.*, 1998) with slight modification. Samples were extracted using 10mL of 70% aqueous acetone. Absorbance of samples was measured at 750nm using Ultraviolet Visible Spectrophotometer (UV-Vis) (UNICO Spectrophotometer 2800 UV/VIS, - USA). Total phenolic content was then calculated based on the standard curve of Gallic acid (Loba Chemie Pvt. Ltd, India) and expressed as mg/g of Gallic Acid Equivalent (GAE). To determine non-tannin phenolic content, 2mL of the diluted juice sample was mixed with 2mL of distilled water and 200mg polyvinyl-polypirrolidone (PVPP) (Merck, SA). The mixture was vortexed (Top Mix FB15024 Fisher Scientific, UK), left for 15 min at 4°C and then centrifuged for 10 min at 3000rpm. Non-tannin phenolic content in the supernatant was determined in the way similar to the total phenolic content.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 20 was used to analyze the results obtained from the study survey. All the analyses on chemical compositions were carried out in duplicate and expressed as mean concentration using Analysis of Variance (ANOVA). Means were compared by Duncan's multiple range test, and separated by least significant difference (LSD) test using GenStat software edition 15th and the significance was accepted at $p<0.05$.

Results and discussion

Green leafy vegetables preferences

Results on the vegetable preferences in Mbeya rural and Bahi Districts are shown in Table 1a & b. Results shows that, vegetables such as CBL (100%), amaranth (91.3%), cowpeas (75.4%), pumpkin leaves (72.5%), spinach (52.2%), cabbage (20.3%), night shade (14.5%), cassava leaves (7.2%) and sweet potato leaves (4.3%) were preferred in Mbeya rural Districts (Table 1a). However, the most consumed vegetables in Mbeya rural were: CBL, amaranth, cowpeas, and pumpkin leave respectively. In Bahi District, mostly preferred vegetables were in the order of FSL>

amaranth > cowpeas leaves> pumpkin leaves > potato leaves > okra leaves > spinach > night shade > spider plant > cabbage> CBL > cassava leaves (Table 1b). However, the most consumed were FSL, amaranth, cowpea leaves and pumpkin leaves respectively. Vegetable preference was highly affected with accessibility of the vegetable itself. For instance, FSL were highly preferable (95.9%), since it was the only vegetable obtained in the wild, hence it is priceless but also indigenous to Dodoma local societies. Moreover, due to the climatic condition of the place, preserving vegetables become inevitable (Ephrahim & Fadhili, 2014). Various studies (Ifeoma, 2014; Kiharason *et al.*, 2017; Sobowale *et al.*, 2010), have reported vegetable perishability and seasonal availability specifically abundance during wet seasons and scarcity during dry season. Being one of the reasons, vegetables preservation become of importance and sun drying reported as the most common and affordable method used in drying of some Nigerian edible leafy vegetables (Mepba *et al.*, 2016).

Table 1a. Vegetable consumption in Mbeya rural District.

Attribute	Preference		
Vegetable type	Frequency (n)	(%)	n/N (%) of each cases
Amaranth	63	19.4	91.3
Beans leaves	10	3.1	14.5
Spinach	36	11.1	52.2
Pumpkin leaves	50	15.4	72.5
Potato leaves	3	0.9	4.3
Cabbage	14	4.3	20.3
Night shade	69	21.3	100
Cowpea leaves	52	16	75.4
Okra leaves	22	6.8	31.9
Cassava leaves	5	1.5	7.2
Total (N)	69	100	

Table 1b. Vegetable consumption in Bahi District.

Attribute	Preference		
Vegetable type	Frequency(n)	(%)	n/N (%) of each cases
Amaranth	69	16.5	93.2
False sesame	71	16.9	95.9
Cowpea leaves	64	15.3	86.5
Potato leaves	48	11.5	64.9
Pumpkin leaves	56	13.4	75.7
Okra leaves	33	7.9	44.6
Night shade	16	3.8	21.6
Beans leaves	1	0.2	1.4
Spinach	30	7.2	40.5
Cabbage	14	3.3	18.9
Spider plant	16	3.8	21.6
Cassava leaves	1	0.2	1.4
Total (N)	74	100	

Local Vegetable Processing Technologies used for Shelf life extension purpose

Results on the local vegetable processing technologies used for shelf life extension purpose are presented in Table 2. Results unveiled that, 23.2% of respondents boil vegetables in water for 5 min to 1h in Mbeya, while in Bahi 87.8% also boil before sun drying. In this study, it was observed that boiling vegetables (5 min to 1h) before sun drying (except for FSL) was the most common and preferable practice used in both Bahi and Mbeya Rural Districts (87% and 23.2%).

Moreover, other practices such as drying using solar dryers locally made (12.2%), covering with a cloth (6.8%), inside houses (1.4%) and drying under shade (1.4%) were observed in Bahi district. In Mbeya, use of solar dryers (23.2%) was reported. Most of people boil vegetables for such a long period of time and then dry which may destroy the nutrients composition of vegetables especially for those that are heat sensitive like vitamin C (Ilelaboye *et al.*, 2013; Wang *et al.*, 1997). Also, cooking for long time has a negative effect on the sensory qualities (Hamouz & Driskell, 2006; Miglio *et al.*, 2008; Ogliano & Ellegrini, 2008).

Nutritional Content of vegetable samples

β –carotene content of FSL and CBL

Obtained results showed that β–carotene in both FSL and CBL were below detection limit in fresh leaves. Similarly, Stadlmayr *et al.*, (2012) reported, no β-carotene observed in FSL. Presence of other nutrients but not β-carotene of Bungu *(Ceratotheca sesamoides* Endl.) leaves and seeds has been reported Fasakin (2005). Besides, β–carotene content in CBL contradict the values reported by Emmanuel (2014).

Vitamin C content of FSL and CBL

Vitamin C content of FSL and CBL are indicated in Table 3. Vitamin C content in all treated FSL was significantly reduced as compared to fresh FSL. Decrease in vit. C content was observed in blanched FSL (F1 & F2) as compared to fresh (F0), however no significant difference ($p>0.05$) between the two treatments. Decrease in vit. C content in all treated FSL ranged from 12.13mg/100 g for F1 to 0.08mg/100g for F9 respectively (Table 5).

Blanching and sun drying while covering with a white (F3 & F5) and black (F4 & F6) cloths showed 4.63 – 50.60 and 6.13 – 25.25 folds protective effect to vit. C compared to fresh leaves. The results have shown that blanching (3 min) and sun-drying while covering with a white cloth (F3) retained a significant amount of vit. C compared to black cloth (F4) or drying without covering (F9) respectively. For this case, covering the vegetables with white and black color (F4-F8) showed insignificant variation ($p>0.05$) in the content of vit. C. On the other hand, comparing with fresh FSL (F0), F3 and F4 had 0.02 – 0.25 folds retention of vit. C. Furthermore, substantial loss in vit C (99.51%) was observed in un-blanched, uncovered sun dried FSL (F9) in comparison with fresh FSL (F0) Table 3. Similar findings by Ndawula *et al.* (2004) reported 84.54% loss of vit. C in fruits and cowpea leaves under open sun drying. Furthermore, Ndawula *et al.* (2004) reported alterations in vegetable vit. C content caused by open-sun drying, vis queen-covered and polyethylene-covered solar-dryers. These observations are in agreement with those reported by Babalola *et al.* (2010) that showed significant ($p<0.05$) reduction of vit. C in blanched and dried samples, whereas sun drying had the most effect compared to other treatments. Vitamin C loss by direct sun-drying may be attributed to the direct ultra-violet rays of the sun which induce ascorbic acid degradation (Tikekar *et al.*, 2011; Tsado *et al.*, 2015) . In addition, vitamin C loss is supported by the fact that, vit. C is water soluble which is labile and unstable to heat thereby increasing time for the contact with water causes more leaching out of vit. C (Saranya *et al.*, 2017). From this study, blanching for 3 min was the most effective method for vit. C retention (74.5%) of FSL, followed by 5 min blanched (64.93%) respectively.

Table 2. Local Vegetable processing technologies used for shelf life extension purpose.

Pretreatment before drying		Bahi District			Mbeya Rural		
	Drying method	Frequency	(%)	(%) of each cases	Frequency	(%)	(%) of each cases
No treatment (Fresh vegetables)	Direct sun drying	5	55.6	6.8	0	0	0
	Solar dryer	0	0	0	1	1.9	1.4
	Covered with cloth	0	0	0	53	100	76.8
	Inside the house	1	11.1	1.4	53	100	76.8
	Under the shade	0	0	0	53	100	76.8
Boiling vegetables in water for 5 min - 1hr	Direct sun drying	50	76.9	87.7	15	100	23.2
	Solar dryer	9	13.8	12.2	0	0	23.2
	Covered with cloth	5	7.7	6.8	0	0	0
	Inside the house	0	0	1.4	0	0	0
	Under the shade	1	1.5	1.4	0	0	0

Table 3. The effect of blanching and sun drying on vitamin C composition of FSL and CBL.

Vegetable	Sample treatments	Vitamin C (mg/100g)
False sesame leaves	F0 (0 min,)	16.28 ± 3.16^{d}
	F1 (3 min)	12.13 ± 3.08^{c}
	F2 (5 min)	10.57 ± 0.7^{c}
	F3 (3 min, covered with WC)	4.05 ± 1.40^{b}
	F4 (3 min, covered with BC)	2.02 ± 0.71^{ab}
	F5 (5 min, covered with WC)	0.37 ± 0.52^{ab}
	F6 (5 min, covered with BC)	0.49 ± 0.39^{ab}
	F7 (0 min, covered with BC)	1.42 ± 0.97^{ab}
	F8 (0 min, covered with WC)	1.69 ± 0.25^{ab}
	F9 (0 min, uncovered)	0.08 ± 0.08^{a}
Common bean leaves	C0 (0 min)	5.48 ± 0.15^{e}
	C1 (3 min, cut)	0.48 ± 0.02^{b}
	C2 (3 min, whole)	1.61 ± 0.12^{d}
	C3 (5 min, cut)	0.43 ± 0.04^{b}
	C4 (5 min, whole)	1.48 ± 0.04^{c}
	C5 (3 min, whole, covered BC)	0.06 ± 0.08^{a}
	C6 (3 min, whole, covered WC)	0.13 ± 0.13^{a}
	C7 (3 min, cut, covered BC)	0.0
	C8 (3 min, cut, covered WC)	0.05 ± 0.06^{a}

Vegetable	Sample treatments	Vitamin C (mg/100g)
	C9 (5 min, cut, covered BC)	0.0
	C10 (5 min, cut, covered WC)	0.0
	C11 (5 min, whole, covered BC)	0.0
	C12 (5 min, whole, covered WC)	0.0
	C13 (0 min, covered with WC)	0.0
	C14 (0 min, covered with BC)	0.0
	C15 (0 min, uncovered)	0.0

Note: WC: White Cloth; BC: Black Cloth. Means with the same letters in a column not significantly different (p>0.05) in Duncan's Multiple Range Tests. Values are represented in Mean ± SD, (n=2).

Table 4. The effect of different processing methods on the minerals concentration.

Vegetable	Sample treatments	Phosphorus (mg/kg)	Iron (mg/kg)	Zinc (mg/kg)
False sesame leaves (FSL)	F0 (0 min,)	700.00 ± 0.00^{c}	115.75 ± 2.23^{c}	14.13 ± 0.00^{c}
	F1 (3 min)	610.50 ± 0.71^{b}	74.81 ± 2.23^{b}	8.40 ± 0.00^{a}
	F2 (5 min)	500.00 ± 0.00^{a}	63.78 ± 0.00^{a}	8.20 ± 0.28^{a}
	F3 (3 min, covered with WC)	1594.50 ± 7.78^{e}	225.00 ± 0.00^{e}	21.93 ± 0.18^{d}
	F4 (3 min, covered with BC)	1600.00 ± 0.00^{e}	224.96 ± 0.00^{e}	21.93 ± 0.57^{d}
	F5 (5 min, covered with WC)	800.00 ± 0.00^{d}	128.35 ± 2.23^{d}	10.91 ± 0.41^{b}
	F6 (5 min, covered with BC)	800.30 ± 0.42^{d}	126.87 ±1.41^{d}	11.09 ± 0.12^{b}
	F7 (0 min, covered with BC)	3608.50 ± 0.71^{f}	663.91 ± 0.30^{f}	482.00 ±1.12^{e}
	F8 (0 min, covered with WC)	3600.00 ± 0.00^{f}	663.91 ± 0.28^{f}	483.00 ± 0.00^{e}
	F9 (0 min, uncovered)	3610.00 ± 14.14^{f}	664.30 ± 0.00^{f}	482.51 ± 0.71^{e}
Common bean leaves (CBL)	C0 (0 min)	600.00 ± 0.00^{c}	652.76 ± 0.00^{i}	41.04 ± 0.28^{f}
	C1 (3 min, cut)	250.00 ± 70.71^{b}	295.30 ± 295.3^{d}	24.33 ± 0.417^{c}
	C2 (3 min, whole)	300.00 ± 0.00^{b}	315.80 ± 0.00^{e}	29.86 ± 0.141^{d}
	C3 (5 min, cut)	165.00 ± 4.24^{a}	57.50 ± 0.00^{a}	6.42 ± 0.00^{a}
	C4 (5 min, whole)	262.00 ± 1.41^{b}	104.72 ± 0.00^{b}	15.91 ± 0.00^{b}
	C5 (3 min, whole, covered BC)	3500.05 ± 0.07^{g}	630.00 ± 0.00^{h}	312.44 ± 0.01^{i}
	C6 (3 min, whole, covered WC)	3500.30 ± 0.42^{g}	626.90 ± 9.30^{h}	311.47 ± 0.00^{i}
	C7 (3 min, cut, covered BC)	2805.00 ± 7.07^{f}	564.00 ± 0.00^{g}	225.42 ± 1.40^{h}
	C8 (3 min, cut, covered WC)	2800.00 ± 0.00^{f}	564.80 ± 2.06^{g}	225.02 ± 0.00^{h}
	C9 (5 min, cut, covered BC)	1696.85 ± 4.46^{e}	381.20 ± 0.00^{f}	79.02 ± 0.00^{g}
	C10 (5 min, cut, covered WC)	1700.15 ± 0.21^{e}	382.10 ± 0.00^{f}	81.62 ± 2.11^{g}
	C11 (5 min, whole, covered BC)	1300.00 ± 0.00^{d}	271.70 ± 0.00^{c}	37.70 ± 0.28^{e}
	C12 (5 min, whole, covered WC)	1304.00 ± 5.66^{d}	269.60 ± 0.00^{c}	38.00 ± 0.00^{e}
	C13 (0 min, covered with WC)	4550.00 ± 70.71^{h}	763.00 ± 0.00^{j}	336.37 ± 4.28^{j}
	C14 (0 min, covered with BC)	4570.00 ± 42.43^{h}	760.40 ± 0.00^{j}	338.18 ± 1.40^{j}
	C15 (0min, uncovered)	4510.00 ± 0.00^{h}	759.70 ± 0.00^{j}	338.14 ± 0.01^{j}

Note: WC: White Cloth; BC: Black Cloth. Means with the same letters in a column not significantly different (p>0.05) in Duncan's Multiple Range Tests. Values are represented in Mean ± SD, (n=2).

Table 5. The effect of blanching and drying methods on anti-nutritional factors of FSL and CBL

Vegetable	Treatment	Tannins (mg/g)	Oxalate (mg/100 g)
False Sesame Leaves (FSL)	F0 (0 min)	95.45 ± 3.17^{g}	32.62 ± 5.21^{c}
	F1 (3 min)	95.45 ± 3.17^{g}	14.77 ± 0.58^{a}
	F2 (5 min)	90.79 ± 1.95^{f}	10.70 ± 0.14^{a}
	F3 (3 min, covered with WC)	82.86 ± 0.49^{e}	11.33 ± 0.60^{a}
	F4 (3 min, covered with BC)	83.72 ± 1.71^{e}	11.05 ± 0.21^{a}
	F5 (5 min, covered with WC)	72.69 ± 0.73^{ab}	9.55 ± 0.21^{a}
	F6 (5 min, covered with BC)	71.31 ± 0.73^{a}	10.20 ± 0.14^{a}
	F7 (0 min, covered with BC)	77.69 ± 2.44^{cd}	30.79 ± 2.22^{bc}
	F8 (0 min, covered with WC)	77.17 ± 1.22^{bcd}	30.47 ± 0.29^{bc}
	F9 (0 min, uncovered)	73.90 ± 2.44^{ab}	26.24 ± 3.81^{b}
Common Bean Leaves (CBL)	C0 (0min)	519.10± 2.93^{h}	56.32 ± 2.49^{q}
	C1 (3min, cut)	165.30 ± 0.98^{f}	26.11 ± 0.96^{c}
	C2 (3 min, whole)	179.80 ± 0.98^{g}	29.19 ± 2.89^{cd}

Vegetable	Treatment	Tannins (mg/g)	Oxalate (mg/100 g)
	C3 (5 min, cut)	95.30± 0.49^{c}	16.72± 0.23^{b}
	C4 (5 min, whole)	136.70 ± 1.46^{e}	17.62 ± 4.70^{b}
	C5 (3 min, whole, covered BC)	112.90 ± 1.95^{d}	5.53 ± 0.26^{a}
	C6 (3 min, whole, covered WC)	112.30 ± 5.61^{d}	6.32 ± 0.23^{a}
	C7 (3 min, cut, covered BC)	68.60 ± 2.68^{a}	4.31 ± 0.68^{a}
	C8 (3 min, cut, covered WC)	77.90 ± 2.19^{b}	3.45 ± 0.00^{a}
	C9 (5 min, cut, covered BC)	64.20 ± 0.49^{a}	2.77 ± 0.53^{a}
	C10 (5 min, cut, covered WC)	63.70 ± 0.73^{a}	3.19 ± 0.16^{a}
	C11(5 min, whole, covered BC)	62.20 ± 0.49^{a}	2.70 ± 0.14^{a}
	C12 (5 min, whole, covered WC)	64.40 ± 2.19^{a}	2.40 ± 0.28^{a}
	C13 (0 min, covered with WC)	135.80 ± 12.92^{e}	37.38 ± 0.28^{e}
	C14 (0 min, covered with BC)	135.60 ± 12.92^{e}	41.01 ± 1.68^{f}
	C15 (0 min, uncovered)	80.10 ± 0.00^{b}	31.90 ± 1.56^{d}

Note: WC: White Cloth; BC: Black Cloth. Means with the same letters in a column not significantly different ($p>0.05$) in Duncan's Multiple Range Tests. Values are represented in Mean ± SD, (n=2).

Loss of vitamin C from CBL for both blanching and sun drying treatments was also observed (Table 3). Complete loss of vit. C was observed in sun dried CBL; C7, and C8 - C15, both with 0% retention as compared to fresh leaves (C0). Vitamin C losses in cut blanched (C1 & C3) was 70.62% and 91.24% respectively. On the other hand, vitamin C losses in whole blanched CBL (C2 & C4) were between 71% and 73%. Additionally, there were no significant differences ($p>0.05$) in vit. C losses observed in blanched (3 min) sundried leaves covered with different colored cloths C5 & C6). Thus color of the cloth had no protecting effect on vit. C as since it is sensitivity to heat and light (Lee & Kader, 2000). For CBL, neither single nor combined processing methods proved to be effective in vit. C retention, however to avoid further losses blanching (3 min) can be considered as at least the favorable practice to retain vitamin C.

Folic acid content of FSL and CBL

Results of folic acid content revealed that both FSL and CBL contained no folic acid. The study is in contrary with findings by Stadlmayr *et al.* (2012) where the presence of folic acid in FSL was reported. Likewise other studies on green leafy vegetables reported presence of folic acid (Hemmige & Abbey, 2017; James *et al.*, 2018; Tsado *et al.*, 2015).

Minerals composition of FSL and CBL

Phosphorus, Fe and Zn were analyzed as three important mineral elements in FSL and CBL (Table 4). Phosphorus, Fe and Zn are of public health concern thus, as they are required in very small amounts but, are very vital for development, disease prevention and wellbeing. Their absence may result into severe consequences.

From the results, sun drying treatment revealed no significant effect on P reduction in both the FSL and CBL. Moreover, lowest P content was observed in fresh FSL (F0) and CBL (C0) as compared to dried ones. Similarly, blanching of FSL significantly reduced the P content in a range between 2.78% - 28.58%. A similar trend was observed in blanched CBL (C1 – C4) with a significant reduction of 50%–72.5% in P content). Sun drying of blanched FSL cover or uncovered with white or black cloth (F3 – F9) showed 114.28% - 515.71% increase in P content (Table 4). A substantial increase in P content was also observed in un-blanched covered (F7 – F9) leaves respectively. Likewise, a substantial 216.66% - 716.66% increase in P content was observed in blanched sundried covered or uncovered with white or black cloth (C5 – C15) (Table 4). Furthermore, lowest P content was observed in CBL which was cut and blanched for 5 min (C3). No significant difference ($p>0.05$) in P content was observed in sun dried leaves while covering with black or white, thus color had no effect in P retention. Besides, differences were subject to variation in blanching time.

The results of Fe content of FSL and CBL are summarized in Table 4. Blanching of both FSL and CBL resulted in 44.89% – 35.36% reduction in Fe content. A reduction in Fe content in CBL was observed in cut, blanched 54.76%–91.1%, and whole, blanched 51.62%–83.95%.

Sun drying had no significant effect ($p>0.05$) in reducing Fe content of FSL and CBL as compared to blanching. However, dried samples showed significant increase in Fe 109.6%–573.9% for FSL and 41.62% - 116.88% for CBL compared to fresh leaves. Since Fe content was not affected by sun drying treatment, color of the cloth didn't show significant difference in Fe retention, rather the differences were subject to variation in blanching time (Table 4).

Zinc content of FSL and CBL are as indicated in Table 4. Blanching for different time significantly reduced the amount of Zn; moreover the effect of blanching time was insignificant. Fresh leaves had significant low Zn content compared to dried samples for both FSL and CBL. Zinc content was significantly reduced ($p<0.05$) in CBL cut, blanched 40.71%–84.35% (C1 & C3), and whole, blanched 27.24%–61.20% (C2 & C5) regardless of blanching time. For FSL 40.55%–41.96% decrease in Zn was observed. Mean Zn content of un-blanched covered or uncovered (F9 & C13 – C15) was 34.18 and 8.23 folds (3418.25% and 823.58%) higher for FSL and CBL compared to fresh leaves. Also, it was the highest among other treatments (Table 4). No significant difference ($p>0.05$) in Zn content was observed in all dried leaves covered with different colored cloth. Additionally, sun drying had no effects in reducing Zn in all samples.

Similar findings were reported by Adepoju *et al.* (2015) regarding minerals; Fe, Zn, Ca, K, P and other minerals in dry Okro (*Abelmoschus esculentus*) compared to the fresh ones. Generally, it was observed that fresh leaves had lower content of minerals compared to dried samples. This is simply because fresh leaves had high amount of water content whereas same weight was taken in dry samples for analysis. More than 50% of initial weight was lost during sun drying, thus fresh leaves weigh less compared to dried samples. Reduction in mineral content can be due to leaching out of minerals during blanching in hot water. This is in agreements with findings by Ilelaboye *et al.* (2013). Likewise, Hefnawy (2011) and Wang *et al.* (1997) reported significant reduction in minerals content of leafy vegetable in response to blanching due to leaching caused by blanching. Drying treatment shows positive effect in retaining mineral content of both vegetables hence standstill as the best practice to maximize the mineral content of consumed vegetables compared when taken fresh.

Anti-nutritional factors of FSL and CBL

Results on tannin content of FSL and CBL are as represented in Table 5. Tannin content of CBL was reduced significantly with blanching whereas in FSL increasing blanching time to 5 min was more effective in reducing the tannins. Nevertheless, combined treatments (blanching and sun drying) while covering showed effect on eliminating tannins in both FSL by 12.16%-25.29% (F3-F6) and CBL by 78.25%-88.02% (C5-C12) respectively. Besides, a further reduction of up to 25.29% was observed with extended blanching time (5 min), sundried covered with black and white cloth (F5 and F6). This further suggests that sun drying has a positive effect in removal of tannins if combined with blanching for 5 min. In addition, sun drying of un-blanched and covered (F7 & F8) and uncovered (F9) had significantly reduced tannin content. In comparison, F5 and F9 exhibited similar effect in elimination of tannins thus sun drying is the best method for the removal of tannins in FSL. On the other hand, blanching for 5 min and sun drying while covered was the most effective methods with up to 88.02% reduction in tannins in CBL (C9-C12), moreover cutting, whole, color of the cover (white and black) and blanching time showed no effect (Table 5). Various studies have also reported on the effect of blanching treatment in reducing tannin content of green leafy vegetables (Dahiya & Dhawan, 2004; Egbuonu & Nzewi, 2016; Mosha *et al.*, 1995; Ogbadoyi, 2012).

Table 5 summarizes the results oxalate contents in raw and processed FSL and CBL. Significant reduction in oxalate content was observed in blanched FSL (54.72%–

67.20%), cut blanched CBL (48.17% – 68.71%) and whole blanched CBL (53.64%–70.31%) respectively. A further reduction in oxalate by 65.27% –70.72% and 66.12% – 68.73% was achieved when blanched leaves were sun dried while covered with white (F3 & F5) and black cloth (F4 & F6). In CBL, sun drying of blanched leaves while covered or uncovered with white or black cloth (C5-C12) further reduced oxalate in a range of 88.79%-95.74%, compared to fresh leaves, however no significant difference was observed between treatments (Table 5). This further suggests that combining blanching with sun drying was effective in oxalate elimination. Besides, sun-drying of un-blanched FSL covered with black (F7) or white (F8) cloth significantly reduces oxalate content with no variation between, as opposed to un-blanched, uncovered (F9). On the other hand, sun drying of un-blanched CBL covered with white (C13) or black (C14) cloth and uncovered (C15) showed 27.18% – 43.36% reduction in oxalate which is the least effect as compared to other treatments. Likewise, 31.26%-49.24% reduction in the oxalate in blanched green leafy vegetables has been reported (Ilelaboye *et al.*, 2013).

A decrease in total oxalate after boiling but also, insignificant differences in oxalate content of sun dried vegetables has been reported (Ogbadoyi, 2012). The effect of cooking methods (blanching) on mineral and anti-nutrient composition of some green leafy vegetables has been reported by Ilelaboye *et al.* (2013) with 76.7% –87.88% reduction of oxalate. Similarly, this study reported 27.18%–95.74% and 5.61%–70.72% reduction of oxalate in CBL and FSL respectively. From this study, sun drying while covering after blanching is recommended as an effective method in reducing oxalate in both FSL and CBL. This is in contrary with Mosha *et al.* (1995) who recommended blanching as an effective method for reducing the anti-nutritional factors in green vegetables.

Conclusion

Results on study survey revealed that, FSL and CBL were among the most preferred vegetables in Bahi and Mbeya rural Districts. Boiling for 5 min to an hour before drying was the common practice in the study areas. Beta-carotene and folic acid were not found in fresh FSL and CBL. False sesame leaves and CBL contained vitamin C which was mostly affected by extended blanching and sun drying treatment. Reduced blanched time and drying while covering shows effect in vitamin C retention. Sun drying while covering with cloth retains vitamin C compared to uncovered ones. Fresh leaves had significant low amount of minerals compared to dried one. Minerals were reduced significantly with extended blanching treatment. Combined treatment had significant effect in reducing tannin and oxalate content. Cut CBL reduce tannin and oxalate content more than whole sample, though the anti-nutritional reduction were parallel to vitamin C loss. Sun drying treatment had significant effect in reducing anti-nutritional content, though the reduction was not substantial. Generally, reduced blanching time and drying while covering with cloth, combined treatment and drying treatment are the best practices for vitamin C retention, anti-nutritional removal and mineral retention in FSL and CBL respectively.

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