International Journal of Food Science, Nutrition and Dietetics (IJFS)
ISSN 2326-3350

Effect of Processing Methods on Nutrient Contents of Sweet Potato (*Ipomoea Batatas L. Lam.*) Varieties Grown in Ethiopia

Research Article

Nibret Mekonen*, Henok Nahusenay, Kidist Hailu

Food Sscience and Nutrition Research Directorate, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia.

Abstract

Sweet potato [*Ipomoea batatas (L.) Lam.*] is an important crop farmed in most of southern and eastern Africa, including Ethiopia, and is utilized in agriculture, food, and other sectors. The objective of this study was to see how different processing methods (boiling, frying, roasting, and steaming) altered the proximate composition, vitamin C, and mineral content of four popular Ethiopian sweet potato cultivars: Tulla, kulfo, Hawassa 83, and Hawassa 09. UV-Vis and AAS methods were used to determine vitamin C and menial contents, respectively. AOAC methods were used to analyze the proximate composition. The results revealed that there were significant ($p<0.05$) differences in crude protein and CHO between cultivars. Total carbohydrate between varieties ranged from 45.49 to 89.28%, crude fiber (2.08 to 2.51%), crude protein (1.95 to 8.31%), fat (0.45 to 0.85%), ash (3.88 to 4.23%), and moisture (5.50 to 10.4%). Boiling, roasting, steaming, and frying sweet potato cultivars had no discernible effect on the crude protein and ash content. However, there was a statistically significant ($p<0.05$) difference in vitamin C levels between roasting and other processing methods. Furthermore, there is a significant variation in calcium and potassium levels ($p<0.05$) between the kinds. The findings revealed that there is no requirement to select processing methods that result in the least amount of nutritional loss. This means that the nutritional content of sweet potato types is better preserved after processing.

Keywords: Minerals; Proximate Composition; Sweet Potato; Vitamin C.

Introduction

Sweet potato [*Ipomoea batatas (L.) Lam.*] is a key crop in most eastern and southern African countries, including Uganda, Rwanda, Kenya, Tanzania, Ethiopia, Zambia, Mozambique, and South Africa [7]. Sweet potatoes are the world's seventh most important food crop and the world's second-largest tuber crop, behind Irish potatoes. It produces 124 million tons per year. It trails only Irish potato and cassava in terms of acreage (9.1 million ha) among root and root crops. Sweet potato is Africa's second-largest root crop after cassava, with production concentrated in East Africa [10].

For at least 20 million Ethiopians, sweet potatoes are one of the most essential crops. In terms of sweet potato production, Ethiopia is ranked fifteenth [14]. In 2010, Ethiopia produced 736,000 MT of sweet potatoes, the highest year in FAOSTAT records and the ninth most among African countries. The majority of sweet potatoes are grown in Ethiopia's southern and eastern areas. White-fleshed sweet potatoes are a staple diet for the Southern Regional State's 13 million residents. All of Ethiopia's sweet potato roots are consumed in the domestic food supply, according to the FAOSTAT study [5].

In the context of African cropping systems, sweet potato has several advantages: I it produces food in a relatively short period of time, ii) it yields reliably in sub-optimal growth conditions, iii) it requires lower labor inputs (suitable for vulnerable households), v) it serves as an alternative food source for urban populations facing rising cereal prices, and v) it provides a potential option to reduce vitamin A deficiency [17].

Antioxidants, fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron, vitamin C, and -carotene are all found in sweet potatoes [8, 11].

***Corresponding Author**:
Nibret Mekonen,
Food Sscience and Nutrition Research Directorate, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia.
Tel: 0918457605
E-mail: anibretmekonen@gmail.com

Received: March 18, 2022
Accepted: May 14, 2022
Published: May 31, 2022

Citation: Nibret Mekonen, Henok Nahusenay, Kidist Hailu. Effect of Processing Methods on Nutrient Contents of Sweet Potato (*Ipomoea Batatas L. Lam.*) Varieties Grown in Ethiopia. *Int J Food Sci Nutr Diet.* 2022;11(3):593-597.

Vitamin A insufficiency is a public health issue in Ethiopia, as it is in other countries of Sub-Saharan Africa. Vitamin A insufficiency can cause child and mother deaths, as well as a compromised immune system and blindness. Depending on the variety, 100g of sweet potato can give anywhere from 0 to 100% of the daily vitamin A requirement, which is at least 350 g for newborns and 400 g for early children (1-6 years) [6]. Sweet potato, despite its high carbohydrate content, has a low glycemic index due to the starch's limited digestion, making it good for diabetics and persons who are overweight [3, 4].

Sweet potatoes are commonly consumed in Ethiopia by boiling, steaming, roasting, or frying them [5]. It is vital to obtain knowledge about the loss of nutrients in various processing processes in order to make effective use of nutrients from sweet potatoes. As a result, the goal of this research is to find out how nutrients vary between cultivars and how different processing methods affect nutrient loss.

Materials And Methods

Collection and preparation of samples

A total of four varieties of fresh sweet potato, namely Kulfo (yellow), Tulla (yellow), H-83 (white) and H-09 (white) were collected from the Hawassa Agricultural Research Center. The collected samples of fresh sweet potato varieties were washed with clean tap water and rinsed with distilled water. The peeled and unpeeled sweet potatoes were cut into pieces and cooked using the following methods:

Raw (control): Samples were peeled using a kitchen knife, cut into cubes of about 2.5 cm, washed using distilled water, and then ground using a mortar and pestle, ready for crude protein, crude fat, crude fiber, moisture, ash, and mineral content analyses.

Boiling (moist heat): 600 g of unpeeled fresh sweet potato was rinsed in distilled water, immersed in 750 mL water, and cooked for 45-55 minutes in a covered saucepan.

Roasting: Unpeeled sweet potatoes were roasted for 20-22 minutes on hot charcoal, with the sample being moved frequently to ensure equal roasting.

Steaming: Wrapped in banana leaves, unpeeled sweet potatoes were cooked for 55-60 minutes.

Frying: Manual peeling with a kitchen knife was used, as was mechanical chipping with a chipping machine and deep oil frying with vegetable oil at 140 to 150°C for 10 to 12 minutes.

Proximate analysis

The proximate analysis of both fresh (raw) and processed sweet potato variety samples was performed in triplicate using the AOAC 2005 protocol.

Determination of moisture content: Using a 202-1B drying oven at 105°C for 1 hour, the moisture content of maize cultivars was evaluated using the AOAC (2005) 925.10 technique. 2 g of pulverized maize sample was placed in a crucible and dried for one hour at 130°C, then chilled in a desiccator at room temperature before being weighed.

% Moisture content = (Weight loss of maize/ Weight of the orginal maize) × 100

Determination of ash content: Ash content was determined by the method of AOAC (2005) 923.03 using box-type resistance (SX2-4-1 OGJ) muffle furnace at 550°C for overnight.

%Ash content = (Weight of ash/ Weight of the orginal maize) × 100

Determination of fat content: Using a soxtecTM 8000 extraction device, the AOAC 920.39 technique was used to determine the crude fat content. To prevent sample loss, three grams of ground sample were weighed into the soxtec extraction thimble, and cotton was utilized as a stopper. The aluminum cups with thimbles were placed in the Soxtec extraction machine, which was then filled with 50 mL of petroleum ether. The fume hood's water temperature, water flow rate, and flow rate were all set correctly. For boiling, rising, and recovery time, the soxtec extraction time was modified to 15 minutes, 30 minutes, and 10 minutes, respectively. The extracted and residual solvents were then weighed after being dried in an oven and chilled in desiccators.

% Crude fat content = (Extracted fat of maize/ weight of maize sample) × 100

Determination of crude protein: The Kjeldahl technique was used to evaluate the crude protein content of maize variety samples (FOSS Analytical AB 2003). 0.5 g of ground sample was weighed in a Kjeldahl digestion tube, and 2 Kjeltabs CT 3.5 (or 7 g K_2SO_4 + 0.210 g $CuSO_4$ x $5H_2O$ + 0.210 g TiO_2) were added, followed by 15 mL of concentrated H_2SO_4. The combination was carefully heated for 60 minutes inside the fume hood, then cooled for 15 minutes. After distillation, the crude protein value was calculated automatically using the Kjeldahl technique.

Determination of crude fiber: The crude fiber of maize varieties was determined using the Fibertec^{TM} 8000 auto-fibre analysis system, and the percentage of crude fiber was calculated as follows.

% Crude fiber = (W2 - (W3+C)/W1) × 100

Where, W1 is weight of sample, W2 is weight of (crucible + residue), W3 is weight of (crucible + ash residue) and C is blank.

Determination of carbohydrate content: Carbohydrate content was determined by difference, that means 100% other proximate chemical compositions, using the following formula: Carbohydrate content (%CHO) = 100 (% crude protein +% fat +% ash +% moisture content +% fiber).

Vitamin C analysis

The analysis was carried out using [2]. The four sweet potato kinds were sliced and frozen, as were processed sweet potatoes (boiled, roasted, fried, and steamed). For further investigation, the frozen samples were freeze-dried and crushed into fine powder before being stored in a freezer at -20°C. Each of the 0.25 g freeze-dried samples was extracted with 10 mL of 3% (w/v) metaphosphoric acid and 30 minutes of shaking at 300 rpm and the extract was centrifuged for 10 minutes at 4000 rpm. The supernatant was taken and used for further investigation. In 3 percent (w/v) metaphosphoric acid, a standard curve comprising a series of known ascorbic acid solutions was produced. 1 mL of either sample extract or standard substance was added to 3 mL of 0.2 mM DCPIP and measured using UV-Vis at a 515 nm wavelength after 15 seconds of mixing. The data are given in milligrams of ascorbic acid per 100 grams of dry weight (mg/100 g DW).

Retention

The apparent retention rate was used to calculate retention. The ratio of the nutrient content in the cooked food to the nutritional content in the raw food, given on a dry weight basis, is known as apparent retention [12].

% Apparent retention = (Nutrient content per g of cooked food(dry basis)/Nutrient content per g of raw food (dry basis)) × 100

Analysis of mineral content

After dry ashing, the mineral contents (Fe, Zn, Ca, and K) of each sample were measured by Atomic Absorption Spectrometry (AAS). 5 mL concentrated HNO_3 and 5 mL concentrated HCl acid solutions were used to digest 0.5 g of each ash sample. The solution was gently stirred and cooked on a hot plate until yellow fumes were expelled and it turned clear. After that, a Millipore filter (0.4) was used to filter the solution and the volume was leveled to 50 mL with deionized water [1, 15].

Results And Discussion

The effects of processing on the proximate compositions of sweet potato varieties are shown in Table 1. The moisture content (how much water in the product) was measured in each of the processed and raw samples of sweet potato varieties. Kulfo (raw) and kulfo (steamed) had the highest moisture content (10.48%) and 10.42%, respectively. The minimum amount of moisture content is 5.5% H-09 (raw) and 4.69% H-09 (fried), respectively. Ash refers to the remaining or residual parts, mainly inorganic substances, after the total incineration of organic matter. The ash content is determined from the loss of weight, which occurs from the complete oxidation of the sample at a high temperature of 550°C ± 3°C. The ash content for raw and processed sweet potato varieties ranged from 2.18 to 5.98%.

Fat is an extractable matter from extraction with a specific solvent like n-Hexane. Crude fat is a mixture of crude fat and soluble material in the sample that provides energy in the body. The value of crude fat in sweet potato varieties in raw and processing found to be from 0.24 to 35.15%. Proteins are made up of many building blocks, known as amino acids and second ranked proximate composition next to carbohydrate [16]. The amount of crude protein in sweet potato varieties ranged from 1.95 to 8.31%. Fiber (roughage) is the part of plant-based food such as grains, fruits, vegetables, nuts and beans that the body cannot break down. The amount of crude fiber found in sweet potato varieties ranged from 1.91 to 2.51%. In general, the proximate composition of processing sweet potato varieties are in good agreement with [9]. The effect of processing on the value of vitamin C in sweet potato varieties is also represented inTable 2. The mineral contents such as Fe, Zn, Ca and K in mg/100g are resented in Table 3. Potassium (K (mg/100g)) was found to be highest than others in sweet potato varieties and zinc (Zn (mg/100)) was found to be lowest the others. [13]Have reported the values of iron, zinc, calcium and potassium in sweet potato varieties were found to be in the range of 0.25 to 0.73, 0.11 to 0.27, 24.00 to 29.97 and 300 to 326.67 mg/100g, respectively, which is in good agreements in the present study. Generally, these sweet potato varieties have good nutritional compositions.

The result of vitamin C in sweet potato varieties and processed are presented in Table 2. The vitamin C in mg/100g of Hawassa 83 and Hawassa 09were found to be 56.16 and 56.60, respectively. There is no significant difference in the value of vitamin C on different processing methods, but there is a significant difference between roasting and other methods.

Dry matter

Tulla, kulfo, Hawassa 83, and Hawassa 09 sweet potatoes were studied for dry matter content. Tulla, kulfo, Hawassa 83, and Hawassa 09 sweet potato types have dry matter content of 20.00, 19.45, 31.67, and 24.52, respectively. Hawassa 83 had the highest dry matter value, whereas Kulfo had the lowest.

Statistical Analysis

The data was analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0. The descriptive statistics mean and standard deviation (SD) were calculated, and the data was reported as mean ± SD. Duncan's new multiple range and two-way ANOVA were used to compare the means statistically. At a $p<0.05$ level, differences in means will be considered significant.

Conclusion

This study compares the nutritional composition of sweet potato cultivars before and after various processing methods (boiling (immersed in water and boiled), roasting (roasted over hot charcoal), steaming (wrapped in banana leaves and boiled), and frying (wrapped in banana leaves and fried) (deep oil frying with vegetable oil). The calcium and potassium content of the types differed significantly ($p<0.05$) between them, according to the findings of this study. Boiling, steaming, roasting, and frying sweet potato cultivars had no significant ($p>0.05$) effect on ash and crude fiber content. Within the variations, there is a large variability in calcium and potassium levels. On the other hand, there was a significant difference in vitamin C value ($p<0.05$) between roasting and other processing methods, and the frying procedure also altered crude fat content. In addition, it was shown that the nutritional makeup of sweet potato cultivars retains better after processing.

Acknowledgments

The Ethiopian Institute of Agricultural Research's directorate of food science and nutrition research has provided financial assistance for this project. The author wishes to convey their heartfelt gratitude for their assistance and contribution to the effective

Table 1. Effect of processing on the proximate compositions of sweet potato varieties (%).

Variety	Parameters	Crude fiber	Crude fat	Crude protein	Ash	Moisture	CHO	Energy
Tulla	Raw	2.51±2.45ND	0.58±0.00aA	5.66±0.36aAB	3.91±0.09bA	9.89±0.01aA	78.71±0.18bA	342.7 ±0.20aA
	Boiled	2.39±2.05 ND	0.57±0.01aA	5.27±0.15aAB	3.94 ±0.01bA	8.99±0.17aA	80.03±0.20bA	346.4±3.16aA
	Roasted	1.91±2.21ND	0.56±0.01aA	3.91±0.13aAB	4.36 0.03 bA	10.31±0.18aA	79.9±0.11bA	340.3±0.14aA
	Steamed	2.05±1.99 ND	0.79±0.00aA	4.04±0.12aAB	4.45bcA	8.42±14aA	81.27±3.04bA	348.40.20aA
	Fried	2.28±2.06ND	35.1 5±0.00bA	5.89±0.09aAB	2.18 aA	4.72±0.08 aA	49.78±0.04aA	539±3.13bA
H-09	Raw	2.08±0.01ND	0.85±0.02aA	4.56 ±0.13aA	4.23 ±0.09bAB	5.03±3.04 aA	87.34±3.16bAB	375.3±0.14aA
	Boiled	2.15±0.011ND	0.59±0.03aA	4.28±0.05aA	4.25 ±0.01bAB	7.12±0.2aA	80.37±0.29bAB	348.7±3.07 aA
	Roasted	2.16±0.01ND	0.29±0.01aA	4.27±0.10aA	5.0±0.03bAB	8.09±0.11aA	82.24±0.13bAB	343.9±0.11 aA
	Steamed	1.99±0.03 ND	0.76±0.0aA	3.83 ±0.03aA	5.98±0.17bcAB	8.56±0.02aA	79.88±0.14bAB	341.7±0.04aA
	Fried	2.07±0.02ND	29.1 6±0.59bA	2.21±0.09aA	2.61±0.01aAB	4.69±0.02aA	60.29±0.14aAB	512.5±0.04bA
H-83	Raw	2.25±0.08ND	0.45±0.02 aA	1.95±0.05 aA	3.94±0.05 bA	8.32±0.05aA	89.28±0.13 bAB	369 ±0.02aA
	Boiled	2.51±0.18ND	0.43±0.01 aA	3.25±0.01 aA	3.42±0.03bA	5.46±0.01aA	87.71±0.04 bAB	367.7±0.08 aA
	Roasted	2.25±0.04ND	0.31±0.0 aA	3.4±0.04 aA	3.87±0.0 b A	5.96 ±0.04aA	85.31±0.11 bAB	357.6±0.14 aA
	Steamed	2.36±0.06ND	0.24±0.02aA	4.00±0.0aA	3.34±0.35b cA	5.81±0.04aA	88.24±0.88bAB	371.2±0.18aA
	Fried	67.63±0.17 ND	19.43±0.04 bA	3.92±0.02 aA	2.85±0.39 aA	5.03±0.04 aA	67.63±0.17 aAB	461.1±0.20bA
Kulfo	Raw	2.45±0.08ND	2.5±0.03aA	0.06±0.0aC	8.31±0.10bA	3.88±0.05aA	10.48±0.02bA	490.6±0.2aA
	Boiled	2.06±0.06ND	0.58±0.0aA	6.08±0.0aC	4.85±0.0bA	10.1±0.11aAB	78.18±0.08bA	342.3±0.14aA
	Rosted	2.14±0.08ND	0.58±0.0aA	8.12±0.03aC	4.39±0.03bA	9.28±0.02aAB	75.68±0.20bA	340.4±0.17aA
	Steamed	1.97±0.01 ND	10.42±0.01aA	6.49±0.02aC	4.48±0.02bcA	8.42±0.11 aAB	77.24±0.08bA	338.4±0.20aA
	Fried	2.26±0.01ND	30.75±0.04bA	6.27±0.01aC	3.19±0.01aA	9.9±0.88 aAB	46.64±0.04aA	492.4±3.16bA

Means within the same row followed by the same letter are not significantly different by the Duncan's new multiple range ($p > .05$). The different lowercase letters for processing method comparison and different capital letters for variety. CHO=total carbohydrates; *Energy (kcal/100 g) = [9 × fat (%) + 4 × protein (%) + 4 × carbohydrates (%)]

Table 2. The effect of processing on the value of vitamin C in sweet potato varieties.

Variety	Processing	Vitamin C (mg/100g) of processed varieties	Variety	Processing	Vitamin C (mg/100g) of processed varieties
Kulfo	Raw	39.78±0.65^{a}	Hawassa 83	Raw	56.16±0.07^{a}
	Boiling	38.38±0.03^{a}		Boiling	54.48±0.14^{a}
	Steaming	39.62±1.01^{a}		Steaming	55.7±0.56^{a}
	Roasting	1.17±0.20^{ab}		Roasting	14.32±1.57^{ab}
	Frying	27.11±0.03^{a}		Frying	31.56±1.07^{a}
Tulla	Raw	46.45±0.10^{a}	Hawassa 09	Raw	56.6±0.24^{a}
	Boiling	26.25±1.02^{a}		Boiling	29.78±1.89^{a}
	Steaming	45.22±0.65^{a}		Steaming	37.3±1.01^{a}
	Roasting	8.75±0.20^{ab}		Roasting	15.78±0.20^{ab}
	Frying	44.06±0.34^{a}		Frying	52.43±0.34^{a}

Means within the same row followed by the same letter are not significantly different by the Duncan's new multiple range ($p > .05$). The different lowercase letters for processing method comparison and different capital letters variety.

Table 3. Some mineral contents in (mg/100g) of sweet potato varieties and is product processing.

Parameters	Tulla					H-09					H-83					Kulfo				
	Raw	Boiled	Roasted	Steamed	Fried	Raw	Boiled	Roasted	Steamed	Fried	Raw	Boiled	roasted	Steamed	Fried	Raw	Boiled	roasted	Steamed	Fried
Fe	1.98ND	2.33ND	0.97ND	0.48 ND	0.43 ND	1.17 ND	1.53ND	1.88 ND	1.12ND	1.13ND	1.54 ND	0.47ND	0.46ND	0.66ND	1.37ND	1.14ND	0.53ND	0.79ND	1.57ND	0.7ND
Zn	0.28 ND	0.17ND	0.07ND	0.02ND	0.05ND	0.02ND	0.04ND	0.09ND	0.04ND	0.07ND	0.26ND	0.02ND	0.41ND	0.02ND	0.74ND	0.04ND	0.01ND	0.05ND	0.37ND	0.02ND
Ca	26.14aB	25.18aB	22.56aB	19.6aB	20.52aB	40.26aA	38.82aA	37.94 aA	37.58aA	40.26aA	23.94aB	24.06aB	23.8aB	24.84aB	26.96aB	0.04aB	23.62aB	20.66aB	21.94aB	27.94aB
K	169.08aA	168.42aA	127.42aA	126.68aA	171.74aA	28.12aBC	296.12aBC	252.98aBC	393.82aBC	231.12aBC	242.52aB	272.2aB	258.64aB	214.76aB	338.9aB	213.54aB	217.58aB	205.96aB	209.22aB	293.82aB

Means within the same row followed by the same letter are not significantly different by the Duncan's new multiple range ($p > .05$). The different lowercase letters for processing method comparison and different capital letters variety, where ND means statistically not different.

completion of this article.

References

[1]. Akinyele IO, Shokunbi OS. Comparative analysis of dry ashing and wet digestion methods for the determination of trace and heavy metals in food samples. Food Chem. 2015 Apr 15;173:682-4. PubMed PMID: 25466076.

[2]. Boonkasem P, Sricharoen P, Techawongstein S, Chanthai S. Determination of ascorbic acid and total phenolics related to the antioxidant activity of some local tomato (Solanum lycopersicum) varieties. Der Pharma Chemica. 2015;7(4):66-70.

[3]. Ellong EN, Billard C, Adenet S. Comparison of physicochemical, organoleptic and nutritional abilities of eight sweet potato (Ipomoea batatas) varieties. Food Nutr Sci. 2014 Jan 14;2014.

[4]. Fetuga G, Tomlins K, Henshaw F, Idowu M. Effect of variety and processing method on functional properties of traditional sweet potato flour ("elubo") and sensory acceptability of cooked paste ("amala"). Food SciNutr. 2014 Nov;2(6):682-91. PubMed PMID: 25493186.

[5]. Jones D, Gugerty MK, Anderson CL. Sweet Potato Value Chain: Ethiopia. Gates Open Res. 2019 Mar 7;3(729):729.

[6]. Kapinga R, Lemaga B, Ewell P, Zhang D, Tumwegamiire S, Agili S, et al. Increased promotion and evaluation of high β carotene sweetpotato as part of the food based approaches to combat Vitamin A deficiency in sub-Saharan Africa (SSA). International Potato Center (CIP) and PRAPACE. 2010.

[7]. Kivuva BM, Musembi FJ, Githiri SM, Yencho CG, Sibiya J. Assessment of production constraints and farmers preferences for sweet potato genotypes. J Plant Breed Genet. 2014 Apr 29;2(1):15-29.

[8]. Laurie SM, Van Jaarsveld PJ, Faber M, Philpott MF, Labuschagne MT. Trans-β-carotene, selected mineral content and potential nutritional contribution of 12 sweetpotato varieties. J Food Compos Anal. 2012 Sep 1;27(2):151-9.

[9]. Lyimo ME, Gimbi DM, Kihinga T. Effect of processing methods on nutrient contents of six sweet potato varieties grown in lake zone of Tanzania. Tanzan J Agric Sci. 2010;10(1).

[10]. Markos D, Loha G. Sweet potato agronomy research in Ethiopia: Summary of past findings and future research directions. Agric Food Sci Res. 2016;3(1):1-1.

[11]. Oloo BO, Shitandi AA, Mahungu S, Malinga JB, Ogata RB. Effects of lactic acid fermentation on the retention of β-carotene content in orange fleshed sweet potatoes. Int J Food Stud. 2014 Apr 18;3(1).

[12]. Rodriguez-Amaya DB, Kimura M. HarvestPlus handbook for carotenoid analysis. Washington: International Food Policy Research Institute (IFPRI); 2004.

[13]. Sanoussi AF, Adjatin A, Dansi A, Adebowale A, Sanni LO, Sanni A. Mineral Composition of Ten Elites Sweet Potato (Ipomoea Batatas [L] Lam) Landraces of Benin. IntJ CurrMicrobiolAppl Sci. 2016;5(1):103-15.

[14]. Tofu A, Anshebo T, Tsegaye E, Tadesse T. Summary of progress on orange-fleshed sweet potato research and development in Ethiopia. InProceedings of the 13th ISTRC Symposium 2007 Nov (pp. 728-731).

[15]. Uddin AH, Khalid RS, Alaama M, Abdualkader AM, Kasmuri A, Abbas

SA. Comparative study of three digestion methods for elemental analysis in traditional medicine products using atomic absorption spectrometry. JAnalySciTechnol. 2016 Dec;7(1):1-7.
[16]. Ullah I, Ali M, Farooqi A. Chemical and nutritional properties of some maize (Zea mays L.) varieties grown in NWFP, Pakistan. Pak JNutr. 2010;9(11):1113-7.
[17]. Watkins JL, Pogson BJ. Prospects for carotenoid biofortification targeting retention and catabolism. Trends Plant Sci. 2020 May 1;25(5):501-12.