

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

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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 mineral 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

1. 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), iv) 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 α -carotene are all found in sweet potatoes [8, 11].

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.

2. Material and Methods

2.1. 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:

2.1.1. 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.

2.1.2. Boiling (Moist Heat)

600 g of unpeeled fresh sweet potato was rinsed in distilled water, immersed in 750 mL of water, and cooked for 55 minutes in a covered saucepan.

2.1.3. Roasting

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

2.1.4. Steaming

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

2.1.5. 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.

2.2. Proximate Analysis

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

2.2.1. Determination of Moisture Content

Using a 202-1B drying oven at 105°C for 1 hour, the moisture content of sweet potato samples was evaluated using the AOAC (2005) 925.10 technique. 2 g of sweet potato 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.

$$\% \text{ Moisture content} = \frac{\text{Weight loss of sweet potato}}{\text{Weight of the original sweet potato}} \times 100$$

2.2.2. 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.

$$\% \text{ Ash content} = \frac{\text{Weight of ash}}{\text{Weight of the original sweet potato}} \times 100$$

2.2.3. 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.

$$\% \text{ Crude fat content} = \frac{\text{Extracted fat of sweet potato}}{\text{weight of sweet potato}} \times 100$$

2.2.4. Determination of Crude Protein

The Kjeldahl technique was used to evaluate the crude protein content of sweet potato 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 $\text{K}_2\text{SO}_4 + 0.210 \text{ g CuSO}_4 \times 5\text{H}_2\text{O} + 0.210 \text{ g TiO}_2$) 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.

2.2.5. Determination of Crude Fiber

The crude fiber of sweet potato varieties was determined using the FibertecTM 8000 auto-fibre analysis

system, and the percentage of crude fiber was calculated as follows.

$$\% \text{ Crude fiber} = \frac{W_2 - (W_3 + C)}{W_1} \times 100$$

Where, W_1 is weight of sample, W_2 is weight of (crucible + residue), W_3 is weight of (crucible + ash residue) and C is blank.

2.2.6. 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).

2.3. Vitamin C Analysis

The analysis was carried out using Boonkasem et al. [2]. The four sweet potato varieties 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).

2.4. 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].

$$\% \text{ Apparent retention} = \frac{\text{Nutrient content per g of cooked food (dry basis)}}{\text{Nutrient content per g of raw food (dry basis)}} \times 100$$

2.5. 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].

2.6. 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 \pm 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.

3. 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 $550^{\circ}\text{C} \pm 3^{\circ}\text{C}$. 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 the study of Lyimo et al. [9]. The effect of processing on the value of vitamin C in sweet potato varieties is also represented in Table 2. The mineral contents such as Fe, Zn, Ca and K in mg/100g are presented 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. The iron, zinc, calcium, and potassium levels in sweet potato varieties in this study are similar to those found in study of Sanoussi et al. [13]. Generally, these sweet potato varieties have good nutritional compositions.

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

Parameters	Tulla					H-09				
	Raw	Boiled	Roasted	Steamed	Fried	Raw	Boiled	Roasted	Steamed	Fried
Crude fiber	2.51±2.45 ND	2.39±2.05 ND	1.91±2.21 ND	2.05±1.99 ND	2.28±2.06 ND	2.08±0.01 ND	2.15±0.011 ND	2.16±0.01 ND	1.99±0.03 ND	2.07±0.02 ND
Crude fat	0.58±0.00 ^{aA}	0.57±0.01 ^{aA}	0.56±0.01 ^{aA}	0.79±0.00 ^{aA}	35.1 5±0.00 ^{bA}	0.85±0.02 ^{aA}	0.59±0.03 ^{aA}	0.29±0.01 ^{aA}	0.76±0.0 ^{aA}	29.1 6±0.59 ^{bA}
Crude protein	5.66±0.36 ^{aAB}	5.27±0.15 ^{aAB}	3.91±0.13 ^{aAB}	4.04±0.12 ^{aAB}	5.89±0.09 ^{aAB}	4.56±0.13 ^{aA}	4.28±0.05 ^{aA}	4.27±0.10 ^{aA}	3.83±0.03 ^{aA}	2.21±0.09 ^{aA}
Ash	3.91±0.09 ^{bA}	3.94±0.01 ^{bA}	4.36 0.03 ^{bA}	4.45 ^{bcA}	2.18 ^{aA}	4.23±0.09 ^{baB}	4.25±0.01 ^{baB}	5.0±0.03 ^{baB}	5.98±0.17 ^{bcAB}	2.61±0.01 ^{aAB}
Moisture	9.89±0.01 ^{aA}	8.99±0.17 ^{aA}	10.31±0.18 ^{aA}	8.42±14 ^{aA}	4.72±0.08 ^{aA}	5.03±3.04 ^{aA}	7.12±0.2 ^{aA}	8.09±0.11 ^{aA}	8.56±0.02 ^{aA}	4.69±0.02 ^{aA}
CHO	78.71±0.18 ^{ba}	80.03±0.20 ^{ba}	79.9±0.11 ^{ba}	81.27±3.04 ^{ba}	49.78±0.04 ^{aA}	87.34±3.16 ^{baB}	80.37±0.29 ^{baB}	82.24±0.13 ^{baB}	79.88±0.14 ^{baB}	60.29±0.14 ^{aAB}
Energy	342.7±0.20 ^{aA}	346.4±3.16 ^{aA}	340.3±0.14 ^{aA}	348.40.20 ^{aA}	539±3.13 ^{ba}	375.3±0.14 ^{aA}	348.7±3.07 ^{aA}	343.9±0.11 ^{aA}	341.7±0.04 ^{aA}	512.5±0.04 ^{ba}

Table 1. Continued.

Parameters	H-83					Kulfo				
	Raw	Boiled	Roasted	Steamed	Fried	Raw	Boiled	Roasted	Steamed	Fried
Crude fiber	2.25±0.08 ND	2.51±0.18 ND	2.25±0.04 ND	2.36±0.06 ND	67.63±0.17 ND	2.45±0.08 ND	2.06±0.06 ND	2.14±0.08 ND	1.97±0.01 ND	2.26±0.01 ND
Crude fat	0.45±0.02 ^{aA}	0.43±0.01 ^{aA}	0.31±0.0 ^{aA}	0.24±0.02 ^{aA}	19.43±0.04 ^{ba}	2.5±0.03 ^{aA}	0.58±0.0 ^{aA}	0.58±0.0 ^{aA}	10.42±0.01 ^{aA}	30.75±0.04 ^{ba}
Crude protein	1.95±0.05 ^{aA}	3.25±0.01 ^{aA}	3.4±0.04 ^{aA}	4.00±0.0 ^{aA}	3.92±0.02 ^{aA}	0.06±0.0 ^{aC}	6.08±0.0 ^{aC}	8.12±0.03 ^{aC}	6.49±0.02 ^{aC}	6.27±0.01 ^{aC}
Ash	3.94±0.05 ^{ba}	3.42±0.03 ^{ba}	3.87±0.0 ^{ba}	3.34±0.35 ^{bcA}	2.85±0.39 ^{aA}	8.31±0.10 ^{ba}	4.85±0.0 ^{ba}	4.39±0.03 ^{ba}	4.48±0.02 ^{bcA}	3.19±0.01 ^{aA}
Moisture	8.32±0.05 ^{aA}	5.46±0.01 ^{aA}	5.96±0.04 ^{aA}	5.81±0.04 ^{aA}	5.03±0.04 ^{aA}	3.88±0.05 ^{aA}	10.1±0.11 ^{aAB}	9.28±0.02 ^{aAB}	8.42±0.11 ^{aAB}	9.9±0.88 ^{aAB}
CHO	89.28±0.13 ^{baB}	87.71±0.04 ^{baB}	85.31±0.11 ^{baB}	88.24±0.88 ^{baB}	67.63±0.17 ^{aAB}	10.48±0.02 ^{ba}	78.18±0.08 ^{ba}	75.68±0.20 ^{ba}	77.24±0.08 ^{ba}	46.64±0.04 ^{aA}
Energy	369±0.02 ^{aA}	367.7±0.08 ^{aA}	357.6±0.14 ^{aA}	371.2±0.18 ^{aA}	461.1±0.20 ^{ba}	490.6±0.2 ^{aA}	342.3±0.14 ^{aA}	340.4±0.17 ^{aA}	338.4±0.20 ^{aA}	492.4±3.16 ^{ba}

By Duncan's new multiple range ($p>0.05$), this means within the same row followed by the same letter are not substantially different. Different lowercase letters for comparing processing methods and various capital letters for variation.

CHO=total carbohydrates; *Energy (kcal/100 g) = $[9 \times \text{fat} (\%) + 4 \times \text{protein} (\%) + 4 \times \text{carbohydrates} (\%)]$.

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 09 were 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.

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 substantially different. Distinct lowercase letters for comparing processing methods and different capital letters.

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

Parameters	Tulla					H-09				
	Raw	Boiled	Roasted	Steamed	Fried	Raw	Boiled	Roasted	Steamed	Fried
Fe	1.98 ND	2.33 ND	0.97 ND	0.48 ND	0.43 ND	1.17 ND	1.53 ND	1.88 ND	1.12 ND	1.13 ND
Zn	0.28 ND	0.17 ND	0.07 ND	0.02 ND	0.05 ND	0.02 ND	0.04 ND	0.09 ND	0.04 ND	0.07 ND
Ca	26.14 ^{aB}	25.18 ^{aB}	22.56 ^{aB}	19.6 ^{aB}	20.52 ^{aB}	40.26 ^{aA}	38.82 ^{aA}	37.94 ^{aA}	37.58 ^{aA}	40.26 ^{aA}
K	169.08 ^{aA}	168.42 ^{aA}	127.42 ^{aA}	126.68 ^{aA}	171.74 ^{aA}	28.12 ^{aBC}	296.12 ^{aBC}	252.98 ^{aBC}	393.82 ^{aBC}	231.12 ^{aBC}

Table 3. Continued.

Parameters	H-83					Kulfo				
	Raw	Boiled	roasted	Steamed	Fried	Raw	Boiled	roasted	Steamed	Fried
Fe	1.54 ND	0.47 ND	0.46 ND	0.66 ND	1.37 ND	1.14 ND	0.53 ND	0.79 ND	1.57 ND	0.7 ND
Zn	0.26 ND	0.02 ND	0.41 ND	0.02 ND	0.74 ND	0.04 ND	0.01 ND	0.05 ND	0.37 ND	0.02 ND
Ca	23.94 ^{aB}	24.06 ^{aB}	23.8 ^{aB}	24.84 ^{aB}	26.96 ^{aB}	0.04 ^{aB}	23.62 ^{aB}	20.66 ^{aB}	21.94 ^{aB}	27.94 ^{aB}
K	242.52 ^{aB}	272.2 ^{aB}	258.64 ^{aB}	214.76 ^{aB}	338.9 ^{aB}	213.54 ^{aB}	217.58 ^{aB}	205.96 ^{aB}	209.22 ^{aB}	293.82 ^{aB}

Means within the same row followed by the same letter are not significantly different by the Duncan's new multiple range ($p>0.05$). The different lowercase letters for processing method comparison and different capital letters variety, where ND means statistically not different.

Dry matter: The dry matter composition of Tulla, kulfo, Hawassa 83, and Hawassa 09 sweet potatoes was investigated. The dry matter content of the Tulla, kulfo, Hawassa 83, and Hawassa 09 sweet potato varieties is 20.00, 19.45, 31.67, and 24.52, respectively. The highest dry matter value was Hawassa 83, while the lowest was Kulfo.

4. 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. Furthermore, it was discovered that in most processing procedures, the nutritional content of sweet potato cultivars is better conserved after processing, and the roasting process is not recommended for the value of vitamin C in sweet potatoes.

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