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Effect of Traditional Processing Methods on Nutritional Composition and Anti-nutritional Factors of Anchote (*Coccinia Abyssinica* (lam.) Cogn) Tubers Grown in Western Ethiopia

Habtamu Fekadu[1]*, Fekadu Beyene[1] and Gullelat Desse[2]

[1]*Wollega University, Ethiopia*
[2]*Addis Ababa University, Ethiopia*

Abstract

The raw and traditionally processed Anchote (*Coccinia abyssinica* (Lam.) Cogn.) tubers were studied and compared for their nutritional composition: moisture, crude protein, total ash, crude fiber, crude fat, utilized carbohydrate and gross energy; minerals: Ca, Fe, Mg, Zn, and P and antinutritional factors: phytate, oxalate, tannin and cyanide. Sensory preference taste of Anchote boiled after peeling and boiled before peeling was also reported. The raw, boiled after peeling and boiled before peeling Anchote tubers had respective contents (g/100g) of moisture 74.93, 81.74, and 76.73; for crude protein contents were 3.25, 2.67 and 3.14; for total ash contents were 2.19, 1.33, and 1.99; for crude fiber contents were 2.58, 3.71, and 2.77; for crude fat contents were 0.19, 0.13, and 0.14; for utilized carbohydrate contents were 16.86, 10.42 and 15.23; for gross energy contents were 82.12, 53.48 and 75.26. The raw, boiled after peeling and boiled before peeling Anchote tubers had respective contents (mg/100g) of Ca 119.50, 115.70, and 118.20; for Fe contents were 5.49, 7.60, and 6.60; for Mg contents were 79.73, 73.50, and 76.47; for Zn contents were 2.23, 2.03, and 2.20; and for P contents were 34.61, 28.12, 25.45. The raw, boiled after peeling and boiled before peeling Anchote tubers had respective contents (mg/100g) of phytate 389.30, 333.63 and 334.74; for oxalate contents were 8.23, 4.23, and 4.66; for tannin contents were 173.55, 102.36 and 121.21; for cyanide contents were 12.67, 8.16 and 11.14. This study also revealed that, there was significant ($P<0.05$) taste preference of Anchote boiled before peeling to Anchote tubers boiled after peeling, in which 66% of consumers gave priority of the preference taste for Anchote boiled before peeling.

Keywords: Anchote; Boiled; Minerals; Nutritional; Anti-nutritional; Sensory

Introduction

Anchote is the Afan Oromo name for *Coccinia abyssinica*, which is a tuber crop, belongs to the order *Cucurbitales,* family *Cucurbitaceae* [1], indigenous to Ethiopia [2]. There are about 10 species of Coccinia in Ethiopia; however, only *Coccinia abyssinica* is cultivated for human consumption [3]. The most widely used vernacular name is Anchote, spelt Ancootee in Oromo. It is also called: Ushushu (Welayita), Shushe (Dawuro), and Ajjo (Kafigna) [4]. Anchote is found both cultivated and wild [5]. The total yield of Anchote is 150-180 quintals/hectare, which is in the range of the total yield of sweet potato, and potato [6].

Anchote is endemic to the Western parts of Ethiopia [7], mainly in the Western region of Ethiopia highlands in Eestern Wollega, Western Wollega, Kelam Wollega, and Mattu [8]. Anchote is a valuable food source and according to local farmers, it helps in fast mending of broken/ fracture bones and displaced joints, as it contains high calcium, and proteins than other common and wide spread root and tuber crops [3]. Traditionally, it is also believed that, Anchote makes lactating mothers healthier and stronger [9]. Dawit and Estifanos reported that the juice prepared from tubers of Anchote has saponin as an active substance and is used to treat Gonorrhoea, Tuberculosis, and Tumor Cancer.

Like many other root, and tuber crops, Anchote is rarely eaten raw [10]. Traditionally, boiled after peeling or boiled before peeling and/ or further cooking are applied prior to consumption. Despite the pros and cons of roots and tubers, Walingo [11] recommended, the importance of proper processing before consumption in order to reduce the effect of antinutritional factors and there-by improve nutrient availability. In the case of Anchote, however, no published information is available as to which traditional processing methods are optimal to reduce the effects of the inherent antinutritional factors and to increase availability of the contained nutrients. Therefore, it is imperative to investigate which traditional methods are optimal to improve the quality of Anchote for human consumption and decrease of its risk of human health. The main objective of this research was to determine the effect of traditional processing methods on some nutritional composition, and anti-nutritional factors of Anchote (*Coccinia abyssinica* (Lam.) Cogn.) grown in Western Ethiopia.

Materials and Methods

Sample collection

A total of about 12 kilograms uninfected Anchote were collected from the 12 famers randomly selected (1 kilogram per house hold) of study site (Hara, Wayu kumba and Wayu kiltu kebeles) in Jima Arjo woreda, East Wollega Zone, Western Ethiopia. The samples were packed in polyethylene bags, kept in an ice box (to prevent moisture loss), and transported to Food Science and Bioprocess Technology Institute Research laboratory of Wollega University within three hours. Once in the laboratory, samples were mixed for composite analysis of

***Corresponding author:** Habtamu Fekadu, Wollega University, Ethiopia, E-mail: fekadu_habtamu@yahoo.com

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the study variables and washed by clean water all together. The washed tuber was grouped into two sections of nine kilograms for the first section and three kilograms for the second section. The first section was used for nutritional and anti-nutritional analysis, whereas the second section was used for sensory analysis.

Sample preparation

The first section was grouped into three lots of three kilograms each. The first lot was used for analysis as raw. The raw sample was sliced to uniform thickness 5 mm using a stainless steel knife. The second lot was used as boiled after peeling. The tuber was peeled and boiled for about three to three and half hours and sliced to uniform thickness 5 mm using a stainless steel knife. The third lot was served as boiled before peeling. The washed tuber was boiled for about three to three and half hours, peeled and sliced to uniform thickness 5 mm using a stainless steel knife. Moisture content of each lot was determined immediately after each lot was sliced into pieces. For other nutritional and antinutritional analyses, each of the three lot (control or raw, boiled after peeling, and boiled before peeling) of samples were dried at a time in oven (Gallenkamp Hotbox Oven, size 2, Gallenkamp, UK) at 60°C for 72 hours. Each dried samples were milled into fine powder using electric grinder (NIMA-8300Burman, Germany) until to pass through 0.425 mm sieve mesh size, and finally packed into airtight polyethylene plastic bags to minimize heat buildup, kept in ice box and transported to Addis Ababa University, and stored in the desiccator until required for analysis.

The second section of the samples used for sensory analysis was grouped into two lots of one and half kilograms each. The first lot was used for sensory analysis as boiled after peeling. The washed tuber was peeled (i.e. removal of the outer skin) with stainless steel knife, and boiled in traditional pot containing tap water in the ratio of 1:2 (w/v) for about three to three and half hours, and excess water was drained off as is the usual household practice. The boiled tuber was sliced to uniform thickness 50 cm using a stainless steel knife.

The second lot was served for sensory evaluation as boiled before peeling. The washed tuber was boiled in traditional pot containing tap water in the ratio of 1:2 (w/v), for about three to three and half hours and the excess water then drained off, and peeled with stainless steel knife. The boiled tuber was peeled and sliced to uniform thickness 50 cm using a stainless steel knife. Then, both Anchote tubers were evaluated by fifty consumers of 29(58%) males and 21(42%) females participants and 49 (98%) of the consumers were between the ages of 16-35 years. The consumers were recruited from staff and students of Food Science and Bioprocess Technology Institute at

Wollega University, Ethiopia. The general demographic questions and frequency of consumption of consumers were completed before sensory evaluation of the products. They were selected if they indicated that they consumed Anchote boiled before and after peeling at least once per month. Additional criteria used to screen consumers were: no food allergies and/or no frequent illness, nonsmoker, willing to evaluate Anchote and available to participate during the scheduled testing dates.

In the sensory evaluation session, the consumers were seated in an open well illuminated laboratory and about 20 grams of each two samples were presented to each consumer on a tray at ambient temperature (=25°C) within 2 hrs after boiling. The consumers were asked to indicate which of the two coded samples taste is preferred on the score card. The non-directional paired comparison test, exactly a two-sided preference (a version of paired comparison test) according to the "forced choice" technique, with the question: "Of these two samples, which one do you prefer?" was carried out with fifty consumers. The samples were served with identical container coded with 3-digit random numbers, half of the consumers were asked to taste one sample first, the others to taste it second. Necessary precautions were taken to prevent bias of tasting by ensuring that consumers rinsed their mouth with water before and after each tasting of sensory evaluation. Consumers expressed their preference taste of the boiled after peeling and boiled before peeling Anchote tubers using paired comparison test.

Nutritional and anti-nutritional content analysis

Moisture content, total ash, crude protein, crude fiber, and crude fat of the Anchote tubers were determined according to AOAC [12] using sub components 925.09, 923.03, 979.09, 962.09, and 920.39, respectively. Calcium, Iron, Magnesium and Zinc was determined according to the standard method of AOAC [12], whereas Phosphorus was determined according to AOAC [13]. Phytate was determined by the method of Latta and Eskin [14] and later modified by Vantraub and Lapteva [15]. Oxalate was analyzed by method originally employed by Ukpabi and Ejidoh [16].Tannin was determined by the method of Burns as modified by Maxson and Rooney . Cyanide was determined according to the standard method of AOAC [13]. After analysis of phytate and oxalate the molar ratio of phytate and oxalate to calcium, zinc and iron were calculated to evaluate the effect of elevated levels of phytate and oxalate in the bioavailability of dietary minerals. As the ratios are the better indicators of the bioavailability than the amounts of the mineral and the phytic acid in the diet [17].

Statistical analysis

Nutritional and ant-nutritional analyses were followed one way analysis of variance. Means were compared using Duncan's multiple range test. All the statistical analyses were performed on the results obtained using SPSS version 15.0 for windows. Also non-directional paired comparison t-test was used to analyze the responses of the consumers with regard to their preference taste for the sample. All data obtained from analysis of dry sample are presented on fresh weight basis.

Results and Discussion

Nutrient composition of raw and processed Anchote

Nutritional value is the main concern when a crop is considered as a food source. Anchote is endemic tuber crop used as a food source in parts of Western Ethiopia. The nutrient compositions of raw and processed Anchote tubers are presented in Table 1.

Moisture content: Moisture content determination is an integral part of the proximate composition analysis of food. The mean moisture content of the raw Anchote was 74.93 (g/100 g), which is in agreement with the finding of EHNRI [18] (74.50 g/100 g). In addition, this is in accordance with the finding of Fufa and Urga [10] (73.00 g/100 g). The mean moisture content of Anchote tuber boiled after and before peeling had 81.74 (g/100 g) and 76.73 (g/100 g), respectively. The moisture content of Anchote boiled after peeling was significantly ($P<0.05$) higher than both boiled before peeling and raw Anchote tubers. Similarly, the mean moisture content of Anchote boiled before peeling was significantly ($P<0.05$) higher compared to mean raw Anchote. The moisture content was increased in boiled after peeling by 9.08% and in boiled before peeling 2.41% compared to raw tubers. The increased moisture content might be due to the water absorption capacity of fibers and other natural chemical components during heat treatment [19].

Treatment	Moisture Content (g/100g)	Crude Protein (g/100g)	Total Ash (g/100g)	Crude Fiber (g/100g)	Crude Fat (g/100g)	Utilizable (g/100g)	Gross Energy (Kcal/100g)
RW	74.93 ± 0.345[c]	3.25 ± 0.061[a]	2.19 ± 0.014[a]	2.58 ± 0.048[b]	0.19 ± 0.020[a]	16.86 ± 0.410[a]	82.12 ± 1.300[a]
BAP	81.74 ± 0.395[a]	2.67 ± 0.145[b]	1.33 ± 0.406[b]	3.71 ± 0.135[a]	0.13 ± 0.017[b]	10.42 ± 0.310[c]	53.48 ± 1.340[c]
BBP	76.73 ± 0.465[b]	3.14 ± 0.187[a]	1.99 ± 0.168[a]	2.77 ± 0.216[b]	0.14 ± 0.010[b]	15.23 ± 0.410[b]	75.26 ± 2.390[b]

Means not followed by the same superscript letters in the same column are significantly different (P<0.05)
NB. RW stands for Raw Anchote, BAP: for Boiled After Peeling and BBP: for Boiled Before Peeling

Table 1: Mean (± SE) nutrient composition of raw and processed Anchote samples.

Crude protein: The main functions of proteins are growth and replacement of lost tissues in the human body. It was observed that the mean raw Anchote tuber contain 3.25 g/100 g of crude protein. The result in raw Anchote is in agreement with the finding of EHNRI [18] (3.20 g/100 g). Fufa and Urga [10] reported the raw Anchote tuber contained 3.00 g/100 g crude protein. The mean crude protein content of Anchote tuber boiled after and before peeling of Anchote tuber were 2.67 g/100 g and 3.14 g/100 g, respectively. The mean crude protein content of Anchote boiled after peeling was significantly (P<0.05) lower than both boiled before peeling and raw Anchote tubers. Nevertheless, the mean crude protein content of Anchote boiled before peeling was non-significant (P>0.05) compared to mean raw Anchote. The crude protein content was decreased in boiled after peeling by 17.85% and in boiled before peeling by 3.38% compared to raw tubers. Such a reduction might have been due to protein denaturation during boiling. Consistent with this, Ekanayake et al. stated that the reduction of crude protein during boiling may be attributed to leaching and denaturation of protein caused by boiling.

Total ash: The mean total ash content of raw, boiled after peeling and boiled before peeling were 2.19 g/100 g, 1.33 g/100 g and 1.99 g/100 g, respectively. The mean total ash content boiled after peeling was significantly (p<0.05) lower than both boiled before peeling and raw Anchote tubers. Total ash content is directly proportional with inorganic element content of Anchote. Hence the samples with high percentages ash contents are expected to have high concentrations of various mineral elements, which are advantage to speed up metabolic processes and improve growth and development. The mean total ash content of raw Anchote was comparable to the finding of Fufa and Urga [10] (2.00 g/100 g). However, EHNRI [18] reported a lesser value, which was 1.10 g/100 g. The slight differences in the total ash content might be related to the soil types, stage of maturity, and agronomic practices [20]. In reference with the raw tubers, the total ash content of Anchote boiled after and before peeling decreased by 39.27% and 9.13%, respectively. The reduction of total ash may be due to leaching of the mineral compound and water absorption during boiling [21].

Crude fiber: The food fibers are defined as the sum of non starchy polysaccharides (cellulose, hemicelluloses, and pectic substances) and lignins, which are mainly components of plant cell walls. The mean crude fiber content of raw Anchote was 2.58 g/100 g. The finding of Fufa and Urga [10] and EHNRI [18] in crude fiber content of raw Anchote is relatively lower values, which is 0.60 g/100 g and 0.70 g/100 g, respectively. These variations were probably due to extent time of storage and variations in the soils [22]. The mean crude fiber contents of boiled after and boiled before peeling of Anchote were 3.71 g/100 g and 2.77 g/100 g, respectively. The mean crude fiber content of Anchote boiled after peeling was significantly (P<0.05) higher than both boiled before peeling and raw Anchote tubers. The mean crude fiber content of Anchote boiled before peeling was non-significant (P>0.05) compared to mean raw Anchote. Taking a raw Anchote tuber as a reference, the effect of traditional processing methods increased the crude fiber content by 43.79% and 7.36% in Anchote boiled after, and before peeling, respectively. These increases could be due to the fact that as samples were subjected to the boiling, and thus all soluble components might have lost in the process thereby increasing the crude fiber contents [23]. The high levels of crude fiber observed in the boiled after and before peeling of Anchote could be an advantage of traditional processing as it might help in the treatment of diseases such as obesity, diabetes, cancer and gastrointestinal disorders [24] and in digestion and prevention of colon cancer [25].

Crude fat: Anchote is low crude fat content. The mean crude fat content of the raw Anchote was 0.19 g/100 g, which is similar with the finding of Fufa and Urga [10] (0.17 g/100 g) and EHNRI [18] (0.1 g/100 g). The mean crude fat contents of boiled after peeling and boiled before peeling of Anchote tuber were 0.13 g/100 g and 0.14 g/100 g, respectively. The mean crude fat content of Anchote boiled after peeling and boiled before peeling was significantly (P<0.05) lower than raw Anchote tubers. The mean crude fat content of Anchote boiled before peeling was non-significant (P>0.05) compared to mean boiled after peeling Anchote tuber. The crude fat content was decreased in boiled after peeling by 31.58% and in boiled before peeling by 26.32% compared to raw tubers. These decreases might be attributed to their diffusion into the boiling water [23].

Utilized carbohydrate: Utilizable carbohydrate content was determined by difference. The mean utilizable carbohydrate content of the raw Anchote was 16.86 g/100 g. The mean utilizable carbohydrate content of boiled after peeling and boiled before peeling of Anchote tuber were 10.42 g/100 g and 15.23 g/100 g, respectively. The mean utilizable carbohydrate content of Anchote boiled after peeling was significantly (P<0.05) lower than the mean of both boiled before peeling and raw Anchote tuber. Similarly, the mean utilizable carbohydrate content of Anchote boiled before peeling was significantly (P<0.05) lower compared to the mean of raw Anchote tuber. The result in raw Anchote was lower than the finding of Fufa and Urga [10] (22.5 g/100 g) and EHNRI [18] (21.1 g/100 g).The utilizable carbohydrate content was decreased in boiled after peeling by 38.19% and in boiled before peeling by 9.67% compared to raw tubers. Reduction in utilizable carbohydrate content during boiling might be due to leaching of soluble carbohydrates like sugars in to the cooking water [26].

Gross energy: The gross energy was calculated by multiplying the mean values of crude proteins, crude fat and total carbohydrate by Atwater factors of 4, 9 and 4, respectively. The mean gross energy content of raw Anchote was 82.12 Kcal/100 g. The mean gross energy contents of boiled after peeling and boiled before peeling of Anchote tuber were 53.48 Kcal/100 g and 75.26 Kcal/100 g, respectively. The mean gross energy content of Anchote boiled after peeling was significantly (P<0.05) lower than the mean of both boiled before peeling and raw Anchote tuber. Similarly, the mean gross energy content of Anchote boiled before peeling was significantly (P<0.05) lower compared to the mean raw Anchote tuber. The value in raw Anchote were found to be relatively low as compared to those reported by EHNRI [18] (98.10 Kcal/100 g) and Fufa and Urga [10] (103.5 Kcal/100 g) which

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may be due to ecological factors like rain fall, Temperature, soil type. In reference with raw tubers, the gross energy content of raw Anchote after and before peeling decreased by 26.06% and 7.19%, respectively.

Mineral content of raw and processed Anchote

Minerals in the diet are responsible for several existing problems relating to human health. The human body requires more than twenty-two mineral elements that can be supplied by an appropriate diet in varying amounts for proper growth, health maintenance, and general well-being [27]. Deficiency diseases could be prevented by sufficient intake of specific nutrients/minerals that are involved in many biochemical processes. Root and tuber crops are one of important sources of minerals that are linked to prevent deficiency diseases such as Anemia and Rickets, and daily consumption of these foods is being encouraged [28]. The mineral content of raw and processed Anchote is presented in Table 2.

Calcium: Calcium is the major component of bone and assists in teeth development. Calcium concentrations are also necessary for blood coagulation and for the integrity of intracellular cement substances [29]. The calcium content of the raw Anchote was 119.5 mg/100 g. The result was comparable with the finding of EHNRI [18] (119 mg/100 g). However, Fufa and Urga [10] reported Very high calcium contents (344 mg/100 g). The mean calcium contents of boiled after peeling and boiled before peeling of Anchote tuber was 115.70 mg/100 g and 118.20 mg/100 g, respectively. The mean calcium content of Anchote boiled after peeling was significantly (P<0.05) lower than both boiled before peeling and raw Anchote tubers. The mean calcium content of Anchote boiled before peeling was non-significant (P>0.05) compared to mean raw Anchote. The calcium content was decreased in boiled after peeling by 3.18% and in boiled before peeling by 1.65% compared to raw tubers. The loss of calcium from boiling is not as such pronounced and this little reduction may be due to less leaching of the calcium to the boiling water.

Iron: The mean iron content of the raw, boiled after peeling and boiled before peeling Anchote were 5.49 mg/100 g, 7.60 mg/100 g and 6.60 g/100 g, respectively. The mean iron content of Anchote boiled after peeling was significantly (P<0.05) higher than both boiled before 9 peeling and raw Anchote tubers. The mean iron content of Anchote boiled before peeling was non-significant (P>0.05) compared to mean raw Anchote. The result in raw Anchote was comparable with the finding of Fufa and Urga [10] (5.5 mg/100 g). However, EHNRI [18] reported lower iron contents (1.30 mg/100 g). The iron content was increased in boiled after peeling by 38.43% and in boiled before peeling by 20.22% compared to raw tubers. Increase in the iron content may be due to contamination of iron from the cooking utensils known as Tuwe [17].

Magnesium: The mean magnesium content of the raw, boiled after peeling and boiled before peeling of Anchote tubers were 79.83 mg/100 g, 73.50 mg/100 g and 76.47 mg/100 g, respectively. The magnesium content of Anchote boiled after peeling was significantly (P<0.05) lower than both boiled before peeling and raw Anchote tubers. Similarly, the mean magnesium content of Anchote boiled before peeling was significantly (P<0.05) different compared to mean raw Anchote. The mean value in raw Anchote was agreed with the finding of Fufa and Urga [10] (80 mg/100 g). The magnesium content was reduced in boiled after peeling by 7.93% and in boiled before peeling by 4.21% compared to raw tubers. The reduction of magnesium from boiling might be due to magnesium oxalate is less soluble than the potassium and sodium salts [30], this may be the possible reason to observed reduction in magnesium level upon boiling.

Zinc: The zinc content of raw Anchote tuber with a mean value was 2.23 mg/100 g, which is in accordance with the finding of Fufa and Urga [10] 1.8 mg/100 gm. The mean zinc content of boiled after peeling and boiled before peeling of Anchote tuber was 2.03 mg/100 g and 2.20 mg/100 g, respectively. The zinc content of Anchote boiled after peeling was significantly (P<0.05) lower than raw Anchote tubers. The zinc content of Anchote boiled before peeling was non-significant (P>0.05) compared to both mean boiled after peeling and raw Anchote. The mean zinc content was reduced in boiled after peeling by 8.97% and in boiled before peeling by 1.35% compared to raw tubers.

Phosphorus: The phosphorus content of the raw Anchote was 34.61 mg/100 gm. The phosphorus content of boiled after peeling and boiled before peeling of Anchote tuber was 28.12 mg/100 g and 25.45 mg/100 g, respectively. The phosphorus content of Anchote boiled before peeling was significantly (P<0.05) lower than both boiled after peeling and raw Anchote tubers. In the same way, the mean phosphorus content of Anchote boiled after peeling was significantly (P<0.05) different compared to mean raw Anchote tubers. The mean phosphorus content was reduced in boiled after peeling by 18.75% and in boiled before peeling by 26.47% compared to raw tubers. The losses of phosphors content in tuber due to leaching on boiling might occur up to 25% [31] this may be the possible reason to observed reduction in magnesium level in this study.

Anti-nutritional factors content of raw and processed Anchote

Anti-nutrients are known to reduce the maximum utilization of nutrients especially proteins, vitamins, and minerals [32]. So that, the levels of anti-nutritional factors in the Anchote tubers are important in the assessment of its nutritional status. Some anti-nutritional factors (phytate, oxalate, tannin and cyanide) content of the raw and processed Anchote tuber is shown in Table 3.

Phytate: The raw Anchote tuber contained 389.30 mg/100 g phytate. The phytate content of Anchote boiled after peeling and before peeling had 333.63 mg/100 g and 334.74 mg/100 g, respectively. The phytate content of Anchote boiled after peeling was significantly (P<0.05) lower than both boiled before peeling and raw Anchote tubers. Similarly, the mean phytate content of Anchote boiled before peeling was significantly (P<0.05) lower than raw Anchote tuber. The mean phytate content was reduced in boiled after peeling by 14.30% and in boiled before peeling by 14.01% compared to raw tubers. The evident reduction in phytate during cooking may be caused by leaching into the

Treatment	Calcium (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)	Zinc (mg/100g)	Phosphorus (mg/100g)
RW	119.50 ± 0.36^{a}	5.49 ± 0.39^{a}	79.73 ± 0.85^{a}	2.23 ± 0.12^{a}	34.61 ± 0.70^{a}
BAP	115.70 ± 0.21^{b}	7.60 ± 0.19^{b}	73.50 ± 0.92^{c}	2.03 ± 0.06^{b}	28.12 ± 0.08^{b}
BBP	118.20 ± 1.49^{a}	6.60 ± 0.32^{a}	76.47 ± 0.61^{b}	2.20 ± 0.10^{ab}	25.45 ± 0.25^{c}

Means not followed by the same superscript letters in the same column are significantly different (P<0.05)
NB. RW stands for Raw Anchote, BAP: for Boiled After Peeling and BBP: for Boiled Before Peeling

Table 2: Mean (± SE) mineral content of raw and processed Anchote samples.

Treatment	Phytate (mg/100g)	Oxalate (mg/100g)	Tannin (mg/100g)	Cyanide (mg/100g)
RW	389.30 ± 0.39[a]	8.23 ± 0.09[a]	173.55 ± 0.35[a]	12.67 ± 0.22[a]
BAP	333.63 ± 0.29[c]	4.23 ± 0.02[c]	102.36 ± 0.46[c]	8.16 ± 0.07[c]
BBP	334.74 ± 0.42[b]	4.66 ± 0.17[b]	121.21 ± 0.11[b]	11.14 ± 0.17[b]

Means not followed by the same superscript letters in the same column are significantly different (P<0.05)
NB. RW stands for Raw Anchote, BAP: for Boiled After Peeling and BBP: for Boiled Before Peeling

Table 3: Mean (± SE) anti-nutritional factors content of raw and processed Anchote.

cooking medium, degeneration by heat or the formation of insoluble complexes between phytate and other components, such as phytate-protein and phytate-protein-mineral complexes [33]. The reduction of phytate during processing Anchote tuber is expected to enhance the bioavailability of proteins and dietary minerals of the tubers and at the same time the lower level of phytate may have some health promotional activities. Currently there is evidence that dietary phytate at low level may have beneficial role as an antioxidant, anticarcinogens and likely play an important role in controlling hypercholesterolemia and atherosclerosis [34]. Because Anchote may provide a substantial portion of phytate, the nutritional consequences of phytate in Anchote should be investigated.

Oxalate: The raw Anchote tuber contained 8.26 mg/100 g oxalate. The oxalate content of boiled after peeling and boiled before peeling of Anchote tuber had 4.23 mg/100 g and 4.66 mg/100 g, respectively. The oxalate content of Anchote boiled after peeling was significantly (P<0.05) lower than both boiled before peeling and raw Anchote tubers. Also the mean oxalate content of Anchote boiled before peeling was significantly (P<0.05) lower than raw Anchote tuber. The mean oxalate content was reduced in boiled after peeling by 48.79% and in boiled before peeling by 43.58% compared to raw Anchote tubers. The traditional processing methods were found effective methods to reduce the oxalate content in these tubers. Boiling may cause considerable cell rupture and facilitate the leakage of soluble oxalate into cooking water [35], this may be the possible reason to observed high reduction in oxalate level upon boiling.

Oxalates can have a harmful effect on human nutrition and health, especially by reducing calcium absorption and aiding the formation of kidney stones [36]. High-oxalate diets can increase the risk of renal calcium oxalate formation in certain groups of people [37]. The majority of urinary stones formed in humans are calcium oxalate stones [38]. Currently, patients are advised to limit their intake of foods with a total intake of oxalate not exceeding 50–60 mg per day [39]. The traditionally processed Anchote tubers analyzed in this study are low compared to the recommendations for patients with calcium oxalate kidney stones. Under these guidelines, processed Anchote tubers analyzed could be recommended not only for normal healthy people but also consumption for patients with a history of calcium oxalate kidney stones, assume about 1 kg of Anchote would be necessary for consumption per day. Therefore, the reduced oxalate content resulting from traditionally processed Anchote tubers could have a positive impact on the health of consumers to enhance the bioavailability of essential dietary minerals of the tubers, as well as reduce the risk of kidney stones occurring among consumers. Hence, boiling the tuber would reduce the nutritional problems that the high levels of oxa1ates could cause.

Tannin: The tannin content of raw Anchote tuber was 173.55 mg/100 g. The tannin content of boiled after peeling and boiled before peeling of Anchote tuber had 102.36 mg/100 g and 121.21 mg/100 g, respectively. The tannin content of Anchote boiled after peeling was significantly (P<0.05) lower than both boiled before peeling and raw Anchote tubers. Similarly, the mean tannin content of Anchote boiled before peeling was significantly (P<0.05) lower than raw Anchote tubers. The mean tannin content was reduced in boiled after peeling by 41.87% and in boiled before peeling by 30.12% compared to raw tubers. The decrease in the levels of tannin during heat treatment might be due to thermal degradation and denaturation of the antinutrients as well as the formation of insoluble complexes [40], this may be the possible reason observed in this study. Tannin content of most food is usually reduced by processing and this has been reported to enhance the bioavailability of iron. The toxicity effects of the tannin may not be significant since the total acceptable tannic acid daily intake for a man is 560 mg [41]. Since the tannin content of raw Anchote tuber is very low compared to its critical toxicity effect and further reduced during traditional processing, its antinutritional effect may be insignificant in both raw and processed tuber.

Cyanide: Cyanide, either in synthetic inorganic forms as in KCN or NaCN, or organic forms as in cyanogenic glucosides, is a potent specific inhibitor of several enzyme-catalyzed processes [42]. The results of the present study showed that cyanide in raw, boiled after peeling and boiled before peeling Anchote tuber were 12.67 mg/100 g, 8.16 mg/100 g, and 11.14 mg/100 g, respectively. The cyanide content of Anchote boiled after peeling was significantly (P<0.05) lower than both boiled before peeling and raw Anchote tubers. The mean cyanide content of Anchote boiled before peeling was also significantly (P<0.05) lower compared to mean raw Anchote tuber. The mean cyanide content was reduced in boiled after peeling by 35.59% and in boiled before peeling by 12.08% compared to raw tubers. It has been reported that higher intake of cyanides could result in the development of neurological disease in humans [43]. The amounts of cyanide produced, only plants that accumulate more than 50 to 200 mg are considered to be dangerous [44]. However, smaller amount of cyanides could have several long-term adverse effects on human health. The results obtained showed that the processed tuber could be considered safe with regard to cyanide poisoning due to the fact that the cyanide levels were far below the detrimental levels of 50 to 200 mg [44]. However, the amount remaining cyanide content might be slightly toxic to people who consume high quantities of Anchote tubers and need to be further study.

Molar ratios of Ca: Phy, Ox: Ca, Phy: Zn, Phy: Fe and [Ca] [Phy]/[Zn]

The molar ratios for oxalate, calcium, zinc, Iron and phytate were calculated to evaluate the effects of elevated levels of oxalate and phytate in the bioavailability of dietary minerals. Bioavailability is the ability of the body to digest and absorb the mineral in the food consumed. The calculated values are also compared with the reported critical toxicity values for these ratios. The calculated Ca: Phy, Ox: Ca, Phy: Zn, Phy: Fe and [Ca] [Phy]/ [Zn] molar ratios of raw and processed Anchote is shown in Table 4.

[Calcium]/[Phytate] molar ratios: The molar ratios of Ca:Phy in raw, boiled after peeled and boiled before peeled Anchote were 5.05,

Treatment	Ca:Phy (molar ratio)[1]	Ox:Ca (molar ratio)[2]	Phy:Zn (molar ratio)[3]	Phy:Fe (molar ratio)[4]	[Ca][Phy]/[Zn] (mol/kg)[5]
RW	5.05 ± 0.02[c]	0.03 ± 0.001[a]	17.35 ± 0.91[a]	5.58 ± 0.75[a]	0.52 ± 0.02[a]
BAP	5.66 ± 0.01[b]	0.02 ±0.001[b]	14.82 ± 0.54[b]	3.92 ± 0.19[b]	0.47 ± 0.01[b]
BBP	5.78 ± 0.07[a]	0.02 ± 0.001[b]	14.83 ± 0.23[b]	4.28 ± 0.15[b]	0.44 ± 0.02[b]

Means not followed by the same superscript letters in the same column are significantly different (P<0.05)
[1]mg of Calcium/molecular weight of Calcium: mg of phytate/molecular weight of phytate
[2]mg of oxalate/molecular weight of oxalate: mg of calcium/molecular weight of calcium
[3] mg of phytate/molecular weight of phytate: mg of zink/molecular weight of zink
[4]mg of phytate/molecular weight of phytate: mg of iron/molecular weight of iron
[5](mg of calcium/molecular weight of calcium) (mg of phytate/molecular weight of phytate)/ (mg of zink/molecular weight of zink) devided by 100

Table 4: Mean (± SE) calculated Ca:Phy, Ox:Ca, Phy:Zn, Phy:Fe and [Ca][Phy]/[Zn] molar ratios of raw and processed Anchote samples.

5.71, and 5.78, respectively. The mean Ca:Phy molar ratio of Anchote boiled before peeling and boiled after peeling was significantly (P<0.05) higher than raw Anchote tubers. The mean Ca:Phy molar ratio of Anchote boiled after peeling was significantly (P<0.05) lower than boiled before peeling Anchote tubers. Phytic acids markedly decrease Ca bioavailability and the Ca:Phy molar ratio has been proposed as an indicator of Ca 14 bioavailability. The Ca: Phy molar ratios >6, indicative of poor calcium bioavailability. The values in the present study were lower than the reported critical molar ratio of Ca:Phy, indicating that absorption of calcium not adversely affected by phytate in these tubers.

[Oxalate]/[Ca] molar ratios: The molar ratios of Ox:Ca obtained in raw, boiled after peeled and boiled before peeled Anchote were 0.03, 0.02, and 0.02, respectively. The Ox:Ca molar ratios of Anchote boiled after peeling and boiled before peeling was significantly (P<0.05) lower than raw Anchote tubers. The Ox:Ca molar ratios of Anchote boiled before peeling was non-significant (P>0.05) compared to mean boiled after peeling Anchote tuber. The importance of oxalate contents of an individual plant product in limiting total dietary Ca availability is of significance only when the ratio of Ox:Ca is greater than one [45]. Under this circumstance, the oxalate has potential to complex, not only the Ca contained in the plant, but also that derived from other food sources. Consumption of oxalates may result in kidney disease and a high ratio of Ox:Ca in the diet also may cause chronic calcium deficiency [46]. From the result, it was observed that, Anchote tubers had Ox:Ca values are lower than the reported critical value (1.0), which implies that a low level of oxalate could have no adverse effects on bioavailability of dietary calcium in these tubers.

[Phytate]/[Zinc] molar ratios: The Phy:Zn molar ratios of Raw, boiled after peeled and boiled before peeled Anchote were 17.35, 14.86 and 14.98 respectively. The Phy:Zn molar ratios of Anchote boiled after peeling and boiled before peeling was significantly (P<0.05) lower than raw Anchote tubers.

The Phy:Zn molar ratios of Anchote boiled before peeling was non-significant (P>0.05) compared to mean boiled after peeling Anchote tuber. The importance of foodstuffs as a source of dietary zinc depends on both the total zinc content and the level of other constituents in the diet that affect zinc bioavailability. Phytate may reduce the bioavailability of dietary zinc by forming insoluble mineral chelates at a physiological pH [47]. Zinc deficiency has been shown to be the cause of dwarfism and hypogonadism among adolescents [48]. Zinc has been described as the essential mineral most adversely affected by phytate and the phytate-to-zinc molar ratio has been proposed as an indicator of zinc bioavailability [49]. Phytate: zinc molar ratios >15, indicative of poor zinc bioavailability [50]. The values of boiled after peeling and boiled before peeling Anchote were lower than the critical molar ratios of Phy:Zn, which indicates the availability of zinc good due to traditional processed Anchote tuber.

[Phytate]/[Iron] molar ratios: The phytate:iron molar ratios of raw, boiled after peeling and boiled before peeling Anchote tuber was 5.58, 3.92 and 4.28, respectively. The phytate:iron molar ratios of Anchote boiled after peeling and boiled before peeling was significantly (P<0.05) lower than raw Anchote tubers. The phytate:iron molar ratios of Anchote boiled before peeling was non-significant (P>0.05) compared to mean boiled after peeling Anchote tuber. Phytate begins to lose its inhibitory effect on iron absorption when phytate:iron molar ratios are less than 1.0, although even ratios as low as 0.2 exert some negative effect [51]. The phytate:iron molar ratios greater than 0.15 regarded as indicative of poor iron bioavailability [52]. This result indicated that, the phytate:iron molar ratios raw and processed tubers are greater than the critical value, which implies the absorption of iron from raw and processed Anchote inhibited by phytate and as a result the bioavailability of iron is poor.

[Calcium][Phytate]/[Zinc] molar ratios: The values of [Ca][phytate]/[Zn] millimolar ratio for raw, boiled after peeling and boiled before peeling Anchote had 0.52 mol/kg, 0.47 mol/kg, and 0.35 mol/kg, respectively. The [Ca][phytate]/[Zn] millimolar ratios of Anchote boiled after peeling and boiled before peeling was significantly (P<0.05) lower than raw Anchote tubers. The [Ca][phytate]/[Zn] millimolar ratios of Anchote boiled before peeling was non-significant (P>0.05) compared to mean boiled after peeling Anchote tuber. The potentiating effect of calcium on zinc absorption in the presence of high phytate intakes has led to the suggestion that the [Phy][Ca]/[Zn] millimolar ratio may be a better index of zinc bioavailability than the [Phy]/[Zn] molar ratio alone. High calcium levels in foods can promote the phytate-induced decrease in zinc bioavailability when the [Ca][phytate]/[Zn] millimolar ratio exceeds 0.5 mol/kg [53]. In this study, except the raw tuber, the values of [Ca][Phy]/ [Zn] millimolar ratios of both processed tubers were found less than the critical level. Therefore, traditional processing methods would appear that the possible contribution to increase zinc availability.

Sensory preference of traditional processed Anchote

Anchote tubers boiled after peeling and boiled before peeling were presented to fifty consumers panels to preference taste. Among them 33 (66%) consumers preferred tubers boiled before peeling whereas 17 (34%) consumers preferred boiled after peeling Anchote. The results were evaluated according to statistical t-test table of paired comparison test, at p<0.05 level of significance; one sample must be selected at least 33 times out of fifty consumers to be a significantly different. The Anchote boiled before peeling was selected 33 times out of fifty consumers, which meets the critical value of the table to be a significantly difference. As a result, there is a significant (P<0.05) preference of taste of Anchote boiled before peeling to Anchote tubers boiled after peeling (Figure 1).

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Conclusion

The present finding uncovered information on the nutritional composition (crude fiber, crude fat, crude protein, total ash, moisture content, utilized carbohydrate, gross energy, Zinc, Iron, Calcium, Sodium, Magnesium and Phosphorus) and anti-nutritional factors (Phytate, Oxalate, Tannin and Cyanide) of raw and processed Anchote tubers from western Ethiopia. Sensory preference taste of Anchote boiled after peeling and boiled before peeling was also reported. In addition, the relative bioavailability of the minerals was assessed by calculating molar ratios of antinutrient to the contained minerals. The results of this study showed that raw Anchote contains appreciable quantity of carbohydrate, crude Protein, crude fiber, calcium, magnesium, iron and low levels of antinutrients (Oxalate, tannin, and cynide) except phytate, when compared to other reported raw roots and tubers. As shown in this study the traditional processing methods of Anchote were very important because that increased in crude fiber content and improved the bioavailability of zinc contained in the Anchote tubers. This study also indicated that traditional processing methods decreased the crude protein, total ash, calcium, iron, zinc content of the tubers. Among the traditional processing methods, boiled before peeling proved to be better in some nutrient and mineral contents considered in this investigation.

The levels of anti-nutritional factors in Anchote are important in the assessment of its nutritional status. In this study, the raw Anchote tubers were found to contain low antinutritional factors, except phytate. Moreover, there were further reductions of the antinutritional factors during traditional processing. This implies, except phytate which might hinder iron bioavailability, traditional processing enables that the antinutritional factors in the Anchote couldn't hamper its nutritional value. Therefore, both methods of traditional preparation of Anchote were effective to significantly reduce the levels of antinutritional factors, thereby improving the bioavailability of minerals such as zinc and calcium known to be affected by these antinutrients. This study also indicated that consumer panels preferred the taste of Anchote boiled before peeling. Therefore traditional processing method of Anchote boiled before peeling is also effective technique and need to be encouraged in terms of consumer's preference of Anchote taste.

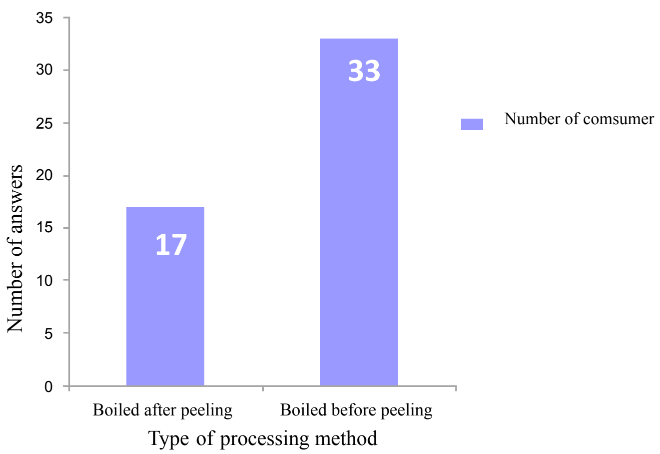

Figure 1: Results of the consumer preference taste of processed Anchote.

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