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Nutritional composition, antinutritional factors and effect of boiling on nutritional composition of Anchote (*Coccinia abyssinica*) tubers

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Abstract

The raw and boiled 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. The raw, boiled after peeling and boiled before peeling Anchote tubers had respective contents (g/100 g) of moisture 74.93, 81.74, and 76.73; for crude protein contents were 3.25, 2.67 and 3.14; of 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/100 g) 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..

Keywords: Anchote, Boiled after peeling, Boiled before peeling, Effects of processing, Nutritional composition, Anti-nutritional factors.

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 names are 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 Western 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 widespread root and tuber crops.[3] Traditionally, it is also believed that, Anchote makes lactating mothers healthier and stronger.[7]

Dawit and Estifanos[8] 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 otherroots, and tuber crops, Anchote are rarely eaten raw.[9] Traditionally, boiled after peeling or boiled before peeling and/ or further cooking are applied prior to consumption. Such processing can have both detrimental and beneficial effects of the nutrient content of food. The presumed purpose of such processing is to make Anchote more palatable, digestible, to inactivate enzyme inhibitors, and other antinutritional factors to qualify it for human consumption. Even though, boiling may result in improvements of some nutritional values of Anchote, nutrients may be lost during such heat treatment either by degradation of nutrients or leached into the cooking medium.[10]

In the case of Anchote, however, no published information is available as to which traditional processing methods are optimized 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 effectiveness of traditional processing methods on nutritional composition, and anti-nutritional factors of Anchote (*Coccinia abyssinica* Lam. Cogn.) tubers grown in Western Ethiopia.

Materials and methods

Sample collection

A total of about 9 kilograms uninfected Anchote were collected from the 9 famers randomly selected (1 kilogram per household) of the 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 the Wollega University within three hours. Once in the laboratory, samples were mixed for composite analysis of the study variables and washed with clean water all together. The washed tuber was grouped into three lots of nutritional and anti-nutritional analysis.

Sample preparation

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.

The 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 lots (control or raw, boiled after peeling, and boiled before peeling) of samples were dried at a time in the oven (Gallenkamp Hotbox Oven, size 2, Gallenkamp, UK) at 60 ºC for 72 hours. Each dried samples were milled into fine powder using an electric grinder (NIMA-8300 Burman, Germany) until to pass through 0.425 mm sieve mesh size, and finally packed into airtight polyethylene plastic bags to minimize heat build-up, kept in ice box and transported to Addis Ababa University, and stored in the desiccator until required for analysis.

Nutritional content analysis

Determination of moisture content

The moisture content of the Anchote samples was determined according to AOAC[11] sub component 925.09 by oven drying method. A clean, empty aluminum dishes, and its lids (made of porcelain) were dried in drying oven (DHG- 9055A) at 100ºC for 1 hour, and cooled in a desiccator (CSN-SIMAX) for about 30 min, and weighed. The samples prepared for each treatment in triplicates were mixed thoroughly, and about 5.0 g of Anchote samples was weighed in triplicate. The dishes and their contents were placed in the drying oven, and dried for 3 hrs at 105ºC. After drying, the samples were cooled in a desiccator for30 min, and re-weighed until constant weight obtained.

Determination of crude protein content

The Protein content of the Anchote samples was determined according to AOAC[11] sub component 979.09 by the Kjeldahl method in which digestion, distillation and titration were involved. About 0.5 g of Anchote samples of each treatment in triplicates was taken in a Tecator tube, and 6 ml of the acid mixture of concentrated ortho-phosphoric acid, and concentrated sulfuric acid (5 parts of concentrated ortho-phosphoric acid, and 100 parts of concentrated sulfuric acid) was added and mixed thoroughly. And then, 3.5 ml of 30% hydrogen peroxide was added step by step. As soon as the violent reaction had ceased, the tubes were shaken for a few minutes, and placed back into the rack. A 3.0 g of the catalyst mixture (ground 0.5 g of copper sulfate with 100 g of potassium sulfate) was added into each tube, and allowed to stand for about 10 min before digestion. The mixture was digested in the digester stove (HYP-1008 eight holes) at 370ºC for4 hrs. The digestion was continued for about 1 hr until a clear solution was obtained. The tubes in the rack were transferred into the fume hood for cooling, a 15 ml of distilled water was added to dissolve the precipitate and to avoid further precipitation of sulfate in the solution.

A 250 ml conical flask containing 25 ml of the boric acid-indicator solution was placed under the condenser of the distiller (KDN-102F, nitrogen analyzer distillation device) with its tips immersed into the solution. The digested and diluted solution was transferred into the sample compartment of the distiller. The tubes were rinsed with two portions of about 5 ml distiller water, and the rinses were added into the solution. A 25 ml of 40% sodium hydroxide solution was added into the compartment, and washed down with a small amount of water, and the steam switched on. A 100 ml solution of the sample was distilled, and then the receiver was lowered so that the tip of the condenser is above the surface of the distillate. The distillation was continued until a total volume of 150 ml is collected. The tip was rinsed with a few milliliters of distilled water before the receiver was removed. The distillate solution was titrated with 0.1 N hydrochloric acid to a reddish color, and the amount of hydrochloric acid was recorded.

Determination of total ash content

Total ash content Anchote samples were determined according to AOAC[11] using sub component 923.03 by incineration of known weights of the samples in a muffle furnace (Carbolite CSF 1200) at 550ºC until a white ash was obtained. About 2.0 g of Anchote samples of each treatment in triplicates was added into each dish. The dishes were placed on a hot plate under a fume hood, and the temperature was slowly increased by smoking ceases, and the samples become thoroughly charred. The charred samples were placed inside the Muffle Furnace (Carbolite CSF 1200), and ashed at 550ºC for 3 hrs. The charred samples were removed from a Muffle Furnace and cooled, seem to be clean and white in appearance. Few drops of de-ionized water and concentrated nitric acid were added, dried, and return to a Muffle Furnace and checked until traces of carbon are fully ashed. Finally taken out of the Muffle Furnace placing immediately in a desiccator till cooled to room temperature, and each dish plus ash was re-weighed. Weight of total ash was calculated by difference, and expressed as percentage of samples. .

Determination of crude fiber content

Crude fiber content Anchote samples were determined according to AOAC[11] using sub component 962.09 in which the steps of digestion, filtration, washing, drying and combustion was involved. About 1.50 g of Anchote samples of each treatment (raw or control, boiled after peeling, and boiled before peeling) in triplicates were placed into a 600 ml beaker, and about 200 ml of 1.25% H_2SO_4 was added, and boiled gently exactly for 30 minutes placing a watch glass over the mouth of the beaker. During boiling, the level of the sample solution was kept constant with hot distilled water. After 30 minutes boiling, 20 ml of 28% KOH was added and boiled gently for a further 30 minute, with occasional stirring.

The bottom of a sintered glass crucible was covered with 10 mm sand layer, and wetted with a little distilled water. The solution was poured from beaker into sintered glass crucible, and then the vacuum pump was turned on. The wall of the beaker was rinsed with hot distilled water several times; washings were transferred to crucible, and filtered.

The residue in the crucible was washed with hot distilled water, and filtered (repeated twice). The residue was washed with 1% H_2SO_4 and filtered, and then washed with hot distilled Water, and filtered; and again washed with 1% NaOH and filtered. The residue was washed with hot distilled water and filtered and again washed with 1% H_2SO_4 and filtered. Finally the residue was washed with water- free acetone.

The crucible with its content was dried for 2 hours in an electric drying oven at 130ºC and cooled for 30 min in the Desiccator (with fresh granular silica gel desiccant), and then Weighed. The crucible was transferred to a Muffle Furnace (Gallenkamp, size 3) and incinerated for 30 min at550ºC. Finally, it was cool in the Desiccators, and re-weighed.

Determination of crude fat content

The crude fat content of Anchote samples was determined according to AOAC [11] official using sub component

920.39 in a soxhlet extractor. The cleaned extraction flasks with boiling chips were dried in Oven Drying (DHG-9055A) at 90ºC for 1 hour, cooled in desiccators (with granular silica gel desiccants) for 30 minutes, and then weighed. The bottom of the extraction thimble was covered with about 2 cm layer of fat free cotton. About 2.0 g of Anchote samples of each treatment (Raw or control, boiled after peeling, and boiled before peeling) in triplicates were added into the extraction thimbles, and then covered with about 2 cm layer of fat free Cotton. The thimbles with the sample content were placed into Soxhlet (Shanghai Qianjian Instrument Co., Ltd) extraction chamber. The cooling water was switched on, and a 50 ml of Diethyl Ether was added to the extraction flask through the condenser. The extraction was conducted for about 3 hrs. The extraction flasks with their content were removed from the extraction chamber and placed in the drying oven at 90 ºC for about 30 min, cooled to room temperature in the Desiccator for about 30 minutes and re-weighed the flask with the extract.

Determination of utilizable carbohydrates

Utilizable Carbohydrate content was calculated by difference. The mathematical expression is as follows: 100 – (% moisture + % crude protein + % crude fiber + % total ash+ % crude fat).

Determination of gross energy

The gross energy content was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors; 16.7 kJ/g (4 kcal/g) for protein, 37.4 kJ/g (9 kcal/g) for fat and 16.7 kJ/g (4 kcal/g) for carbohydrates and expressed in calories.

Determination of calcium, iron, magnesium and zinc

Calcium, iron, magnesium, and zinc were determined according to the standard method of AOAC[11] using an Atomic Absorption Spectrophotometer (Varian Spectr AA. 20 plus). The washed silica dishes were placed in Drying Oven at 90 ºC for 15 min. The dishes were then removed, and cooled down in desiccators for about 30 minutes, when cooled to room temperature weighed. About 2.0 g of Anchote samples of each treatment was weighed into each dish, then placed on a hot plate under a fume-hood in slowly increasing temperature until smoking ceases. When the samples become thoroughly charred, the dishes, then placed in a Muffle Furnace, as near to the center as possible and a shed at 550ºC. The dishes were removed from a muffle furnace, cooled, seen to be clean, and white in appearance. Few drops of de-ionized water and concentrated nitric acid were added, dried, and return to a Muffle Furnace and checked until traces of carbon are fully ashed. Finally taken out of the muffle furnace placing immediately in a desiccator till cooled to room temperature.

The ash each sample was digested with 5 ml of 6 M HCl to wet it completely and carefully dried on a low temperature hot plate. 7 ml of 3 M HCl was added and the dish was heated on a hot plate until the solution just boils. Then it has been cooled, and filtered through a Whatman no.1 filter paper into a 50 ml volumetric flask retaining as much of the solids as possible in the dish. Again 7 ml 3 M HCl was added to the dishes, and heat until the solution just boils. Then, cooled and filtered into the volumetric flask. The dishes were then washed with water, and filtered into the volumetric flask. The filter paper was washed thoroughly and collected in the flask. Since calcium is to be determined 2.5 ml of 10 % Lanthanum chloride solution were added to the flask. Finally, diluted to the mark (50 ml) with freshly de-ionized water. The blank were prepared a blank by taking the same amount of reagents through all steps.

The Atomic Absorption Spectrophotometer used for mineral determination was calibrated using standard solutions and the reagent blank solution was run with the sample. The apparatus was set according to the instructions, and a calibration curve was prepared by plotting the absorption values against the metal concentration in µg/ml. Reading was taken from the graph, which depicted the metal concentrations that correspond to the absorption values of the samples, and the blank.

Determination of phosphorus

Phosphorous was determined by the colorimetric method using Ammonium Molybdate.[12] About 1 ml of the clear extract solution was taken from the sample solution prepared from mineral analysis (determination of Ca, Fe, Mg and Zn) and diluted to 100 ml with deionized water in a 100 ml volumetric flask. A 5 ml (triplicates) of the sample dilution was added into test tubes. A 0.5 ml of molybdate and a 0.20 ml aminonaphtholsulphonic acid was added into the test tube (sample solution) and mixed thorough step by step. A 0.20 ml aminonaphtholsulphonic acid was added into the test tube repeatedly each time until the solution becomes clear. The solution was allowed to stand for 10 minutes. The absorbance of the solution was measured at 660 nm against distilled water.

Simultaneously with sample phosphorous, standard and blank analysis was carried out. Standard and blank solutions were prepared as above, but 5 ml of working standard (reading A) and 5 ml of deionized water (reading B) in place of the sample dilution were used respectively. A standard curve was made from absorbance versus concentration.

Analysis of antinutritional factors

Determination of phytate content

Phytate was determined by the method of Latta and Eskin[13] and later modified by Vantraub and Lapteva[14]. About 0.1 g of Anchote samples of each treatment were extracted with 10 ml 2.4% HCl in a mechanical shaker (Eberbach) for 1hour at an ambient temperature and centrifuged at 3000 rpm for 30 minutes. The clear supernatant was used for phytate estimation. A 2 ml of wading reagent (containing 0.03% solution of $FeCl_3.6H_2O$ and 0.3% of sulfosalicilic acid in water) was added to 3 ml of the sample solution (supernatant) and the mixture was mixed on a Vortex (Maxi Maxi II) for 5 seconds. The absorbance of the sample solutions was measured at 500 nm using UV- VIS spectrophotometer (Beckman DU-64- spectrophotometer, USA). A standard curve was made from absorbance versus concentration and the slope and intercept were used for calculation.

Determination of oxalate content

Oxalate was analyzed using the method originally employed by Ukpabi and Ejidoh[15] in which the procedures involve three steps: digestion, precipitation, and permanganate titration. About 2.0 g of Anchote samples of each treatment in triplicates were suspended in 190 ml de-ionized water contained in a 250 ml volumetric flask; 10 ml of 6 M HCl was added and the suspension digested at the boiling point of water for 1 h that followed by cooling. Then made up to 250 ml and filtered.

Duplicate portion of 125 ml of filtrate were measured into a beaker and four drops of methyl red indicator added, followed by the addition of concentrated NH_4OH solution drop wise until the test solution changes from salmon pink color to faint yellow color (pH 4-4.5). Each portion was then heated to 90ºC, cooled and filtered to remove precipitate containing ferrous ion. The filtrate was then again heated to 90ºC and 10 ml of 5% $CaCl_2$ solution was then added while being stirred constantly. After heating it was cooled and left overnight in refrigerator. The solution was then centrifuged at a speed of 2500 rpm for 5 min the supernatant was decanted and the precipitate completely dissolved in 10 ml of 20% (v/v) H_2SO_4 solution. At this point the total filtrate resulting from digestion of 2 g of flour was made up to 300 ml. aliquots of 125 ml of filtrate were heated until near boiling, and then titrated against 0.05 M standard $KMnO_4$ solution to a faint pink color which persists for 30 seconds.

Determination of condensed tannin content

Tannin content was determined by the method of Burns[16] as modified by Maxson and Rooney[17], using catechin as the tannin standard. About 2.0 g of Anchote samples of each treatment in triplicates was weighed in a screw cap test tube and extracted with 10ml of 1% HCl in methanol for 24 hours at room temperature with mechanical shaking. After 24 hours, shaking the solution was centrifuged at 1000 RPM for 5 minutes. A 1ml of supernatant was taken and mixed with 5 ml of vanillin-HCl reagent (prepared by combining equal volume of 8% concentrated HCl in methanol and 4% Vanillin in methanol).

D-catechin was used as a standard for the condensed tannin determination. A 40 mg of D- catechin was weighed and dissolved in 1000 ml of 1% HCl in methanol, which was used as stock solution. A 0, 12, 24, 36, 48 and 60 ml of stock solution was taken in the test tube and the volume of each test tube was adjusted to 1 ml with 1% HCl in methanol. A 5 ml of vanillin-HCl reagent was added into each test tube. After 20 minutes, the absorbance of sample solutions and the standard solution were measured at 500 NM by using water to zero the spectrophotometer, and the calibration curve was constructed from the series of standard solution. A standard curve was made from absorbance versus concentration and the slope and intercept were used for calculation.

Determination of cyanide content

The cyanide content of Anchote samples was determined according to the official standard method of AOAC[18], by Silver Nitrate titrimetric methods, in which the steps of distillation and titration was involved. About 10 g of Anchote samples of each treatment in triplicates was weighed into a flask and soaked in 100 ml of distilled water in separate 500 ml round bottom flask for 2 hrs. The Kjeldahl flask was adjusted before detailing the tip of delivery tube below surface of liquid and 100 ml distilled water was added. Thereafter, the mixtures in the flask were heated by steam distillation. The released cyanide was collected in a conical flask containing in 20 ml 0.01N $AgNO_3$ acidified with 1 ml concentrated HNO_3. When the gas has passed over, the distillate was filtered through the sintered glass crucible and rinsed the test tube with little water. The distillate was then titrated against excess $AgNO_3$ with 0.02N KSCN, using ferric alum indicator. At the end point of titration, the color of the indicator changed from red to purple color. Using the relationship1 ml of 0.01 N $AgNO_3$ = 0.27 mg of cyanide.

Statistical analysis

Nutritional and anti-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.

Result and Discussion

In this section, the results of the study are presented and discussed in detail to address the objectives of the research. All data obtained from analysis of dry sample are presented on fresh weight basis.

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 4.1.

Moisture content

The mean moisture content of the raw Anchote was 74.93 (g/100 g), which is in agreement with the finding of EHNRI[19] (74.50 g/100 g) and Fufa and Urga[20] (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 boiling after peeling by 9.08% and in boiling 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.[21]

Crude protein

It was observed that the mean raw Anchote tuber contains 3.25 g/100 g of crude protein. The result in raw Anchote is in agreement with the finding of EHNRI[19] (3.20 g/100 g). Fufa and Urga[20] 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 (Table 1). 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. Neverthless, 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*[21], stated that the reduction of crude protein during boiling may be attributed to leaching and denaturation of protein caused by boiling.

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

Treatment	Moisture Content (g/100 g)	Crude Protein (g/100 g)	Total Ash (g/100 g)	Crude Fiber (g/100 g)	Crude Fat (g/100 g)	Utilizable (g/100 g)	Gross Energy (Kcal/100 g)
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.

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 to 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 advantageous to speed up metabolic processes and improve growth and development.[22] The mean total ash content of raw Anchote was comparable to the finding of Fufa and Urga[20] (2.00 g/100 g). However, EHNRI[19] 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. 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.[23,24]

Crude fibre

The mean crude fibre content of raw Anchote was 2.58 g/100 g. The finding of Fufa and Urga[20] and EHNRI[19] in the 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. The mean crude fibre 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 nonsignificant ($P>0.05$) compared to mean raw Anchote. Taking a raw Anchote tuber as a reference, the effect of traditional processing methods increased the crude fibre 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 fibre contents.[25] Fibres exhibit beneficial physiological effects to the human body, as they stimulat and accelerat intestinal contraction and transit, and increased feces volume.[25]. Therefore, 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[26] and indigestion and prevention of colon cancer[27].

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 to the finding of Fufa and Urga[20] (0.17g/100 g) and EHNRI[20] (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 nonsignificant ($P>0.05$) 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.[25]

Utilized carbohydrate

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 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 sugers into the cooking water.[27]

Gross energy

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 was found to be relatively low as compared to those reported by EHNRI[19] (98.10 Kcal/100 g) and Fufa and Urga[20] (103.5 Kcal/100 g). In reference with raw tubers, the gross energy content of raw Anchote after and before peeling decreased by 26.06% and 7.19%, respectively.

Calcium

The mean calcium content of the raw Anchote was 119.5 mg/100 g. The result was comparable with the finding of EHNRI[19] (119 mg/100 g). However, Fufa and Urga[20] 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 nonsignificant (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.[28]

Iron

The mean iron content of the raw, boiled after peeling and boiled before peeling Anchote were 5.49 mg/100 g, 7.60mg/100 g and 6.60 g/100 g, respectively (Table 2). The mean iron content of Anchote boiled after peeling was significantly (P<0.05) higher than both boiled before peeling and raw Anchote tubers. The mean iron content of Anchote boiled before peeling was nonsignificant (P>0.05) compared to mean raw Anchote. The result in raw Anchote was comparable with the finding of Fufa and Urga[20] (5.5 mg/100 g). However, EHNRI[19] 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.[29] In addition, the increment could be due to peeling has been done in a knife made of stainless steel then leaching from its skin or cooking utensils.[30]

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

Treatment	Calcium (mg/100 g)	Iron (mg/100 g)	Magnesium (mg/100 g)	Zinc (mg/100 g)	Phosphorus (mg/100 g)
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.

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[20] (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[31], this may be the possible reason for the 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[20] 1.8 mg/100 gm. The mean zinc content of boiled after peeling and boiled before peeling of Anchote tuber was 2.03 mg/100g 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 nonsignificant (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%.[32]

Anti-nutritional factors content of raw and processed Anchote

Some anti-nutritional factors (phytate, oxalate, tannin and cyanide) content of the raw and processed Anchote tuber is shown in Table 3.3.

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 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 a 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 (Table 3). 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. The majority of urinary stones formed in humans is calcium oxalate stones. Currently, patients are advised to limit their intake of foods with a total intake of oxalate not exceeding 50–60 mg per day.[37-39] 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.

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

Treatment	Phytate (mg/100 g)	Oxalate (mg/100 g)	Tannin (mg/100 g)	Cyanide (mg/100 g)
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.

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 reduction 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] 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 anti-nutritional effect may be insignificant in both raw and processed tuber.

Cyanide

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.

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.[42] The amounts of cyanide produced, only plants that accumulate more than 50 to 200 mg are considered to be dangerous.[43] However, smaller amount of cyanides could have several long-term adverse effects on human health.[44] 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.[45] However, the amount remaining cyanide content might be slightly toxic to people who consume high quantities of Anchote tubers and need to be further studied.

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 antinutritional factors (Phytate, Oxalate, Tannin and Cyanide) of raw and processed Anchote tubers from western Ethiopia.

The results of this study showed that raw Anchote contains appreciable quantities 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 fibre content 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 traditionl processing methods, boiled before peeling proved to be better in some nutrient and mineral contents considered in this investigation.

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.

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Conflict of interest

I declare that this work is my original work and has not been published in any other and that all sources of materials used heve been duly aknowledge.

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