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Effect of Processing Methods on Nutritional and Anti-nutritional Value of Amaranth Grain; and Potential Future Application of Amaranth Grain in Injera Making

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Abstract

Despite of its multiple values, cultivation of grain amaranth has not received much attention. Processing and utilization of the grain in Ethiopia is currently low. This research was initiated to study the effect of processing methods (soaking and roasting) on nutritional and anti-nutritional value of amaranth grain; and potential future application of amaranth grain in *injera* making. The experiment was laid out as a randomized complete design and replicated three times per treatment. The outcome of the study revealed that as the amaranth grain has good nutritional qualities and concurrently less amount of tannin and phytic acid. The crude fat, ash, fiber and protein contents of raw amaranth was 7.33%, 2.97%, 3.67 % and 13.07% respectively. The results revealed that, processing methods had significantly affected the nutritional qualities. The proximate compositions, minerals and anti-nutrients of the soaked amaranth was slightly lower than the roasted. In this study, roasting reduced crude protein content 3.44% and iron by 1.84mg/100g. Furthermore, soaking significantly reduces the anti-nutrients than roasting though it had effect on some nutritional qualities. Soaking reduced the phytates and tannin contents by 29.67mg/100g (11.85%) and 3.39mg/100g (49.62%) respectively. The *injera* griddled from amaranths grain had good colour, high number and evenly distributed of eyes and non-sticky and soft texture which makes it promising to replace teff for injera making.

Keywords: Amaranths, Anti-nutrient, *injera*, nutritional qualities, and processing methods

Amaranths are an herb spread in all continents and are characterized by good adaptability. It was cultivated by Aztecs since 5000 to 7000 years ago (Svirskis, 2003). Amaranth growing area extended from the south-west of the present USA, Africa, India and China through Central America to Argentina (Dhellot *et al.* 2006).

In many countries, the three types of amaranth most widely used for grain are: *Amaranthus cruentus* L., *Amaranthus hypochondriacus* L. and *Amaranthus caudatus* L. (Pablo *et al.* 2011). A collection including over 250 amaranth varieties and breeding lines has been accrued at the Russian Plant Production Institute (Gromov 1995). Over the period of many years, more than ten amaranth seed samples originated in various countries of the world have been investigated. In those years, three earliest amaranth varieties, characterized by a different seed, leaf and stem color and some other morphological traits, have been selected and developed. They are 'Raudonukai' (growing season 100-120 days, red leaves, black seeds), 'Geltonukai' (growing season 120-130 days, yellowish green leaves, yellow seeds) and 'Rausvukai' (growing season 120-150 days, reddish leaves, white seeds) (Svirskis 2003).

Individual plants of amaranth grow more than 2 m in height and mature up to 50,000 seeds, and the length of their inflorescences are more than 1 m, 0.5 - 3.0 kg of seeds is enough to sow one hectare. It has advantageous features like growing in marginal and infertile soils and adaptability to diverse agro-climatic conditions (Svirskis, 2003). The crop can well withstand drought heat and is hardly attacked by pests (Muyonga *et al.* 2008).

Grain amaranth is rich in proteins, lipids, energy, and fibre (Muyonga *et al.* 2008). The protein of amaranth grain has superior amino acid profile compared to proteins found in most other plant foods. Likewise, amaranth grains contain twice the level of calcium in milk, five times the level of iron in wheat, higher sodium, potassium, and vitamins A, E, C, and folic acid than cereal grains (Becker *et al.* 1981). According to Shimelis and Martha (2012), the total carbohydrate content of amaranth excluding its crude fiber is 33.67% (i.e. 66.33% carbohydrate including fiber) and Monica *et al.* (2011) reported the carbohydrate content of amaranth is 62.9%. Amaranth starch has higher water-binding capacity, higher sorption capacity at higher water activity values, as well as higher solubility, higher swelling power and enzyme susceptibility (Singhal and Kulkarni, 1990).

In addition, amaranth grain has been shown to exhibit antioxidant activity and this has been attributed to its content of polyphenols, anthocyanins, flavonoids, and tocopherols (Escudero *et al.* 2011). Thus, the consumption of grain amaranth is associated with health benefits in humans, including recovery of severely malnourished children and increase in the body mass index of people formerly wasted by HIV/AIDS (Tagwira *et al.* 2006). Furthermore, Amaranth oil is used for the treatment of ontological diseases, sclerosis, malfunctions of the brain and periferic blood circulation system, immune deficient states, gynecological, skin, stomach and liver diseases, wounds, bruises, bedsores, ulcers, vitamin deficiency and for disease preventive purposes (Venskutonis and Kraujalis, 2013).

A variety of heat-processing methods can be applied to grain amaranth, in preparation for consumption. Heat processing affects the level of phytochemicals (Xu *et al.* 2007), antioxidant activity (Queiroz *et al.* 2009), functional properties (Muyonga *et al.* 2001), and nutritional value (Rehman and Shah 2005) of foods. Seeds of amaranth are eaten boiled, roasted, crushed, or ground. It is used for porridge production, as well as in confectionery, pasta and candy production (Bruna *et al.* 2011). Amaranth is especially suited for mixing with other plant-derived flours (Svirskis, 2003).

Despite of its multiple values, cultivation of grain amaranth has not received much attention, and processing and utilization of the grain in Ethiopia is currently low (Martha and Shimelis, 2012). Although amaranth is familiar to the farmers in many regions in the country, a full understanding of the economic, ecological and nutritional advantages is lacking in many parts of the region. The production of amaranth flour is not practiced and it is under-utilized grain. Although a certain study had conducted, nutritional profiles such as chemical composition, mineral content, phytochemical composition and physico-chemical properties of amaranth are not well known. Furthermore, the development of value-added products from amaranth flour particularly injera is not known in Ethiopia. Thus, this research initiated to study the effect of processing methods on nutritional and anti-nutritional value of amaranth grain; and potential future application of amaranth grain in enjera making.

MATERIALS AND METHODS

Experimental Site

The laboratory analysis was conducted at the central laboratory and Department of Food Science and Postharvest Technology, Haramaya University, Ethiopia.

Experimental Materials

The study materials consisted of the white amaranths (*Amaranthus hypochondriacus* L. – white seed variety and two processing methods (roast and soak – oven dry).

Experimental Design

The effect of processing methods on nutritional and anti-nutrient content of amaranth grain was studied using Completely Randomized Design. The treatment was replicated three times. The nutritional and anti-nutrient content of amaranth grain was studied on raw, roast and soak – oven dry. The output raw data was used as a control treatment.

Sample preparation

The amaranth grain sample was obtained from Rare Agriculture Research station of Haramaya University. Representative sample was taken from the harvested amaranths. Amaranths grain was cleaned by winnowing and sieving to remove any foreign materials found in. Furthermore, the amaranths grain sample was washed with tap water to remove dust particles and rinsed with deionized water.

Roasting

The cleaned and dried amaranths grain was mild - roasted on hot oven (150 ˚C for 12 minutes) or until colour of the grain changed to golden yellow and flavour produced. The oven was opened to stir and progress checked after every two minutes. The mild - roasted grains were cooled and milled into fine flour.

Soaking

Amaranths grain was soaked in the water following (Ali *et al.* 2009). The amaranths grain was washed using deionised water. Then, the cleaned and washed grains was soaked in a volume of water 3 times the weight of seeds (3:1) for 24hrs with change of water in 12 hrs in a plastic plate at room temperature. The unimbibed liquid was drained off, and rinsed twice in distilled water. The soaked amaranths was dried on 70^{o}C. Amaranths grain sample from each treatment was separately milled into flour using a sterile electric grinder (BLENDER 7012S, model HGB7WTS3, USA) and sieved to pass through 250 µm aperture. The cleaned amaranth flour samples were packed in polyethylene plastic bags, and stored in a refrigerator temperature (4^{O}C) until analysis.

Nutritional and Anti-nutritional Analysis of amaranths

Moisture content was determined by drying the samples at 105 °C for 3 hours. Crude protein content was determined by *micro*-Kjeldahl method (digester F30100184, SN 111051, VELP Scientifica; distiller F30200191, SN 111526, Europe) of nitrogen analysis (% protein = %N × 6.25) by taking about 1.0g amaranths flour (AOAC, 1995) using urea as a control in the analysis. Ash content was determined after carbonization of about 2.0g amaranths flour and ashing (525˚C) in a muffle furnace (Model: MF 120, SN: 04- 1524, Ankara-Turkey) until ashing was complete (AOAC, 1995). Crude fiber content was determined by taking amaranths flour sample (about 3.0g) as a portion of carbohydrate that resisted sulfuric acid (1.25%) and NaOH (1.25%) digestion followed by sieving (75 µm), washing, drying and ignition to subtract ash from fiber (AOAC, 1995). Crude fat was analysed by using Soxhlet extraction method. Carbohydrate content of amaranths was determined by subtracting the above proximate composition values from 100 using formula of:

$$C(\%) = 100 - (\%M + \%A + \%F + \%FB + \%P)$$

Where: C(%), % M, % P, % F, % Fb and % A) are percentage of carbohydrate, moisture content, protein, fat, fiber and ash content respectively. Energy was calculated as described by Osborne and Voogt (1978) using the Atwater factors: 1g of carbohydrates (C) provides (4 kcal), 1g of protein (P) provides (4 kcal) and 1g fat (F) provides (9 kcal).

$$\text{Energy (kcal/100)} = [9 \times \text{fat}(\%) + 4 \times \text{carbohydrade}(\%) + 4 \times \text{protein}(\%)]$$

For mineral contents, the amaranth sample was ashed as described by Zeng (2004). About 1.0 g of flour sample was carbonized (200 – 250 ˚C, 30 min in preheated muffle furnace), dry ashed at 480 ˚C for 4 hr, cooled, followed digestion with 2 mL of 5 M HNO_3 and then ashing was complete at 400 ˚C for 15 min. The ash was dissolved in 2 mL of concentrated HCl, evaporated to dryness on a sand bath, dissolved by 5 mL of 2 M HCl, filtered (Whatman No. 42 filter paper and <0.45 μm Millipore filter paper) and diluted with distilled water to 25 mL volumetric flask mark for mineral contents analysis. The Ca, Fe and Zn contents were determined by atomic absorption spectrophotometer (BUCK Scientific, MODEL 210 VGB) method using air-acetylene as a source of energy for atomization and their respective hallow cathode lamps as light sources operated as recommended for the instrument (AACC, 2000). Parameters (burner and lamp alignment, slit width and wavelength adjustment) were optimized for maximum signal intensity of the instrument based on the mode of operation of the instrument. For Ca content determination, absorbance was measured at 422.7nm after addition of 1% lanthanum (i.e., 1mL La solution/5mL) to sample and standard to suppress interferences. Calcium content was then estimated from standard solution (0.0-6.0μg Ca/mL) prepared from CaCO3. For Fe, absorbance was measured at 248.3nm and iron content was estimated from a standard calibration curve (0.01-6.00μg Fe/mL) prepared from analytical grade iron wire. For Zn, absorbance was measured at 213.8nm and zinc level was estimated from a standard calibration curve (0.024.0μg Zn/mL) prepared from ZnO. Phytic acid was determined through phytate phosphorus (Ph-p) analysis by the method described by (Wheeler and Feerel RE, 1971). Tannin was determined following the method of Price *et al.* (1978).

Water absorption index (WAI) and water solubility index (WSI) of the amaranths flour was measured as described in Kaushal *et al.* (2012). 2.5 g of flour sample (w_0) was dispersed in 30 mL of distilled water, using a glass rod, in tarred centrifuge tubes; then cooked at 90°C for10 min, cooled to room temperature and centrifuged at 3000 × g for 10 min. The supernatant was poured into a pre-weighed evaporating dish to determine its solid content and the sediment was weighed (wss). The weight of dry solids was recovered by evaporating the supernatant overnight at 110°C (wds). WAI and WSI were calculated from the equations:

$$\text{WAI (g/g)} = \frac{WSS}{w_0}$$

$$\text{WSI (g/100 g)} = \frac{wds}{w_0} \times 100$$

Injera preparation

The teff and amaranths injera samples were prepared at laboratory of Food Science and Postharvest Technology Department in the same way as done traditionally in every household. Accordingly, amaranths flour was mixed with clean water in the ratio 1:2 (w/w) and 16 % of white teff starter (ersho) by the weight of the flour and was kneaded by hand in a bowl in the traditional way. The resultant dough was allowed to ferment for 48hrs at ambient temperature. After this primary fermentation, the surface water formed on the top of the dough was discarded. For every 1kg of original flour, 200ml of the fermented mixture was mixed and with 400 ml of water and brought to boil (traditionally known as 'absit' making). It was cooled to about 45 °C before it was added into the main part of the dough. The main dough was thinned by adding water equal to the original weight of the flour and stirred for 15minutes. The batter was left covered for 2 hours for secondary fermentation. After 2 hours, the absit was added to the thinned dough and mixed very well (known as batter making). The batter was left for about 30 min to rise (the second fermentation), before griddling commenced. Some more water was added to thin down and form the right batter consistency. Finally, about half a litre of batter was poured onto the hot clay griddle in a circular motion from the outside, working towards the centre. After 2-3 minutes of cooking using traditional baking equipment (eelee or mitad), the injera was removed and stored in a traditional basket container for evaluation.

Sensory quality evaluation

Sensory evaluations of teff and amaranths injera samples were evaluated using 20 semi-trained panellists. The panellists were selected from staff, graduating class of students in the Department of Food Science and Post-harvest technology. The sensory attributes: overall acceptability, colour, eye size and distribution and flavour were evaluated by 7 point hedonic scale rating from 1 (dislike very much) to 7 (like very much). Sourness, Softness and Stickiness were rating from 1 (Very sour) to 5 (Not sour), 1 (Not soft) to 5 (Very softy) and 1 (Very sticky) to 5 (Not sticky) respectively. Soon before the test session, orientation was given to the panellists on the procedure of sensory evaluation.

Data Analysis

Analysis for the nutritional and anti-nutritional data was carried out using one ways analysis of variance (ANOVA) using SAS statistical package (version 9.1, SAS Institute Inc., Cary, NC, USA). Means separation was done using the Fischer's least significant differences (LSD) at $p < 0.05$.

RESULTS AND DISCUSSION

Proximate composition of raw amaranth grain

Table 1 shows the proximate composition of white grain *Amaranthus hypochondriacus* L. The raw amaranth grain moisture content was 11.38 %; which was similar to the reported values of 11.3% by Caselato-Sousa and Amaya-Farf´an (2012). The crude protein content of raw amaranth was 13.07%. The result was in agreement with previous reports by (Venskutonis and Kraujalis, 2013). This result indicates that amaranth grain contain more nitrogenous substances. Some of the earlier works also found that amaranth grain are good sources of high quality proteins compared to the protein contents found in grains of common cereal crops (8 to 12%) (Koehler and Wieser, 2013).

The crude fat content of raw amaranth was 7.33 %. The result was corroborating with previous reports by Martha and Shimelis (2012). Fat content in amaranth grain was higher as compared to most conventional cereals such as wheat, maize and teff (Forsido *et al.* 2013). Others depending on species, fat content in amaranths grains were reported to range from 2 to 10% (Caselato-Sousa and Amaya-Farf´an, 2012). Thus, the amaranth grain studied is regarded among the variety characterized to be high in fat content.

Table 1: Proximate composition of raw and processed amaranths grain (dry matter basis)

Processing Method	Raw	Roast	Soak-oven dry
Total Ash (%)	2.97±0.03[a]	2.85±0.02[b]	2.65±0.02[c]
Crude Protein (%)	13.07±0.10[a]	9.63±0.18[c]	10.26±0.10[b]
Crude Fat (%)	7.33±0.11[a]	7.05±0.02[b]	7.03±0.02[b]
Crude Fiber (%)	3.67±0.06[a]	3.63±0.01[b]	3.64±0.02[b]
Moisture (%)	11.38±0.25[b]	10.27±0.04[c]	12.22±0.09[a]
Carbohydrate (%)	61.58±0.35[c]	66.97±0.20[a]	64.60±0.17[b]
Energy (kcal/100g)	364.56±0.78[b]	369.84±0.14[a]	362.69±0.32[c]

Where, values are mean ± SD and mean values followed by the same letter in a row are not significantly different at 5% level of significance.

The ash content of raw amaranth was 2.97 %. Similar ash content (2.9%) was reported for amaranths grains by Caselato-Sousa and Amaya Farf´an (2012). The ash contents of amaranths grains are comparable to the ash contents (2.7-3.0%) reported in grain tef (Bultosa, 2016). The crude fiber content of raw amaranth was 3.67%. The crude fiber content found was comparable to the value 3.8% (Monica *et al.* (2011). The fiber content in amaranth is higher than common cereal grains: rice, maize, sorghum and wheat. The total carbohydrate content of the raw amaranth was 61.58%. Amaranths grains are reported to contain about 60% starches (Zhu, 2017) of small size granules (1 to 3 μm in diameter) with high digestibility resembling tef starch granules (2-6 μm in diameter) (Bultosa, 2016). This favor the use of amaranths grains as tef substitute in different food formulation. The energy value of raw amaranth was 364.56 kcal/100g. The energy content found for the amaranth grain is higher than 251 kcal/100g reported by Emire and Arega (2012) but was less than the value 371 kcal/100g reported by Caselato-Sousa and Amaya-Farf´an (2012) of studies conducted on amaranths grains. The calories value found are higher than for tef grains (336 kcal/100g) (Bultosa, 2016) because amaranths grains contain high contents of proteins and fats than tef grains.

Effect of soaking and roasting on proximate composition of amaranth grains

Moisture content was significantly ($p<0.05$) influenced by processing methods. High moisture (12.22%) was observed for soaking and low (10.27%) for roasting processing method. It may be due to more water absorbed during soaking time and more water removed from the grain during roasting time. The crude protein decreased significantly ($p<0.05$) after processing as compared with raw grains. Roasting reduced the crude protein content from 13.07% to 9.63%. The decrease in protein content might be attributed to the partial oxidation of heat labile amino acids. Similar report was made by Fagbemi (2007) on toasted fluted pumpkin seed flour. In this study, soaking also reduced the crude protein to 13.07% to 10.26%. This result have agreed with Shaker *et al.* (1995) who reported that nutrients loss might be attributed to the leaching of soluble nitrogen, mineral and other nutrients into desired solution. Similar reports had been given earlier for soybean and mungbean flour as well as fluted pumpkin seed flour (Fagbemi, 2007).

Table 2: Mineral, functional and anti-nutrients contents of raw and processed amaranths grain

Method of Processing	Raw	Roast	Soak-oven dry
Ca mg/100g	73.55±0.23[a]	72.63±0.28[b]	68.07±0.12[c]
Fe mg/100g	13.42±0.30[a]	11.58±0.30[c]	12.49±0.32[b]
Zn mg/100g	5.16±0.05[a]	4.89±0.06[b]	4.36±0.17[c]
Phytates (mg/100g)	250.32±0.06[a]	242.25±0.49[b]	220.65±0.06[c]
Tannin (mg/100g)	6.63±0.01[a]	5.25±0.02[b]	3.34±0.01[c]
WAI(g/g)	1.2	—	
WSI (%)	1.5	—	

Where, values are mean ± SD and mean values followed by the same letter in a row are not significantly different at 5% level of significance.

Crude fat in both soaked and roasted grains is significantly different ($p<0.05$) from raw sample, this may be due to oxidation of fats during dry heating. Soaking resulted in a significant decrease ($p<0.05$) in total ash content from 2.97% to 2.65%. This occurred probably because soluble minerals leached into the processing water which was decanted. This result agreed with the research of Fox and Cameron (1984) and Edem *et al.* (1994) that soluble minerals leach by dissolving into water which is normally decanted.

The amount of Water absorption index (WAI) and Water solubility index (WSI) of the white raw amaranths was 1.2 g/g and 1.50 % respectively (Table 3). Amaranth has generally been reported to have high solubility index (Menegassi *et al.* 2011). Higher WSI means there is high degradation of starch and leads to much numbers of soluble molecules in a food (Hernández-Díaz *et al.* 2007). Water solubility index is related to the presence of soluble molecules and is a measure of starch degradation. Water absorption index plays an important role in the food preparation as it influences other functional and sensory properties (Sreerama *et al.* 2012).

Table 3: Result of sensory evaluation

Sample	Teff Injera(control)	Amaranths Injera
Sourness	4.50±0.69[a]	4.45±0.51[a]
Softness	4.10±0.85[a]	4.00±0.65[a]
Stickiness	4.15±0.75[a]	4.30±0.80[a]
Flavour	6.00±0.79[a]	6.00±0.86[a]
Colour	6.00±0.86[a]	5.40±1.47[b]
Eye size and distribution	5.90±0.72[a]	5.65±0.99[a]
Overall acceptability	5.85±0.67[a]	5.75±1.07[a]

Where, values are mean ± SD and mean values followed by the same letter in a row are not significantly different at 5% level of significance.

Mineral contents of raw amaranths

The Calcium content of raw amaranths was 73.55mg/100g. The obtained result was appeared less than the report of (Martha and Shimelis, 2012) which was 76.18 mg calcium/100g. Adequate Ca nutrition is important for bone and tooth structures development, muscle functioning, blood clotting and to reduce the incidence of osteoporosis (Gharibzahedi and Jafari, 2017). The recommended adequate Ca intake is between 210-1300 mg per day for different age groups (Otten *et al.* 2006). If assumed, the Ca in the amaranth grain is 100% bioavailable; the current amaranth grain can contribute 7.4% to the daily value for an individual whose daily Ca requirement is 1000 mg.

The Iron content of raw amaranths was 13.42mg/100g. Fe content found is higher than the typical value (7.6 mg/100g) reported for amaranth grains (Caselato-Sousa and Amaya-Farf´an, 2012). The Fe content found in amaranth grains are almost similar to the Fe content reported in grain teff (Bultosa, 2016). The Fe dietary reference intakes requirement from age 1 to 50 years is in the range of 7 to 18 mg per day and during pregnancy is 27 mg per day (WHO, 2004). If assumed Fe is 100% bioavailable from amaranths grains, consumption of 100 g can almost meet the daily iron human nutrition requirements. However, because of Fe inhibitors like phytate, polyphenols (catechol, galloyl, condensed tannins and hydrolyseable tannins), fibers and calcium present in the plant based diets, Fe from plant food sources are only 5-10% bioavailable and thus amaranth grains consumption alone cannot meet the requirements (Saini *et al.* 2016).

The Zink content of the amaranth grain studied was from 5.16 mg/100g. The Zn content found was almost similar to the typical value 5.2 mg/100g Monica *et al.* (2011), but appeared high as compared to the range 0.53-1.20 mg/100g reported by Kachiguma *et al.* (2015) for amaranth grains. In low bioavailable diet, for adult males (19-65 years), females (19-65 years), pregnant and lactating females, the recommended adequate daily intake for Zn were 14.0, 9.8, 11-20 and 14.4-19.0 mg (WHO, 2004). This shows consumption of amaranths grains can contribute to Zn requirements (i.e., 200-400 g amaranth grains) but because of Zn inhibitors, adequate Zn requirements cannot be satisfied by amaranths grain foods alone.

Effects of roasting and soaking on mineral contents

Processing methods significantly influenced ($p<0.05$) the mineral contents of amaranths grain. Roasting significantly decreased ($p<0.05$) iron content. This decrease in Fe content could be attributed to the loss of pericarp during roasting. Since large percentage of total minerals are found in the bran and germ fractions in amaranth (Berghofer and Schoenlechner, 2002). Calcium and Zink content was significantly decreased ($p<0.05$) by soaking. This could be due to leaching out of minerals while soaking was used.

Phytate and tannin contents of raw amaranths

The levels of phytate and tannin in amaranth flour sample ranged from 250.32mg/100g to 220.65mg/100g and 6.63mg/100g to 3.34mg/100g respectively (Table 2). The phytate concentration obtained in this study was higher than 237.75mg/100g that was reported by Martha and Shimelis, (2012). However, the phytate concentration obtained in the present study was lower compared to the acceptable concentrations. In average, the daily intake of phytate was estimated to be 2000 – 2600 mg /100g for vegetarian diets as well as diets of inhabitants of rural areas of developing countries and 150 - 1400mg/100g for mixed diets (Reddy, 2002). But, Hurrel *et al.* (1992), reported that phytic acid intake of 4-9 mg/100g is said to decrease iron absorption by 4-5 folds in humans. Tannins affect nutritive value of food by forming a complex with protein (both substrate and enzyme) thereby inhibiting digestion and absorption (Oboh and Elusian, 2007). The tannin content obtained in this study was significantly higher than 1.49 mg/100g which was reported by Martha and Shimelis, (2012).

Effects of roasting and soaking on phytate and tannin contents

Roasting significantly ($p<0.05$) decreased phytate content of amaranths grains. The decrement of that ant-nutrient by roasting might be due to thermal degradation and denaturation of the phytochemicals as well as the formation of insoluble complexes (Kataria *et al.* 1989). Soaking significantly ($p<0.05$) decreased phytate and tannin content of amaranths grains; this could be due to the activation of endogenous phytate enzyme and the leaching out of tannin into the water. In the present study, soaking reduced the phytates and tannin contents by 29.67mg/100g (11.85%) and 3.39mg/100g (49.62%) respectively. Duhan *et al.* (2002) reported that in pigeon pea the content of phytic acid reduced further when longer the period of soaking. The loss of phytic acid in the soaked pea may have been a function of leaching of phytate ions into the soaking water under the influence of concentration gradient which governs the rate of diffusion.

Sensory Evaluation of Teff and Amaranth Injera

The sensory properties of the injera from raw amaranths and teff flour (control) are presented in Table 3. In Ethiopia where tef is a staple food, the grain is whole floured and mainly used for making a popular pancake-like local bread with 'eyes' called injera (Yetneberk, 2004). The 'eyes' of injera are honeycomb-like holes formed in its top surface, which are produced due to the production and escape of carbon dioxide during fermentation and baking/griddling.

The score given for both teff and amaranths injera was similar in all sensory attributes except of colour. *Injera* made from raw amaranths flour had white top and bottom surfaces but not as that of white teff. It has shiny surface with many and evenly spread eyes. Carbon dioxide produced during fermentation is known to play a fundamental role in the formation of cellular structure of leavened breads (Bloksma, 1990). Thus, eyes in amaranths *injera* are indicative of high carbon dioxide being produced during fermentation. Furthermore, it had no a sticky texture and thus has smooth texture. Hence, over all it was rated as good quality enjera like teff injera.

CONCLUSION

The finding of the current study indicates that amaranths grain has a good proximate composition and some essential mineral elements. The level of tannin and phytic acid in the raw and processed sample is within the acceptable limit. The processing methods used in this study; roasting and soaking had reduced the nutritional values of the amaranths and concurrently reduced the anti-nutrient content. With careful selection of good choice of processing method, the nutritional potential of amaranth can be fully harnessed. In this present study, we recommend roasting over soaking – oven drying as a choice of processing method, as this method significantly reduces the anti- nutrients and easy for processing. In conclusions, based on the chemical composition, functional properties and sensory acceptability, amaranths grain is promising to replace the teff grain in injera making.

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