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RESEARCH PAPER

Proximate and Mineral Compositions of Raw and Roasted Groundnut (*Arachis Hypogaea L.*) Obtained from East Hararghe Zone, Ethiopia

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Abstract

Determination of proximate and minerals composition of raw and roasted groundnut seed samples collected from Babile and Fedis woredas of East Hararghe, Ethiopia, have been performed. The proximate parameters were determined by standard method while minerals levels were analyzed using spectroscopic and/or photometric analytical methods. Wet digestion method using a mixture of HNO_3 and $HClO_4$ (5:5 V/V) was employed for digestion of groundnut samples. The proximate composition results indicated that the moisture, ash, oil, crude fiber, crude protein and total carbohydrate contents of the analyzed raw groundnut were ranged from 4.51- 5.41, 4.41-4.62, 40.2-41.71,2.62-2.80,42.21-42.30%, respectively. While the corresponding values for roasted groundnut sample were ranged from 2.01-3.98, 4.80, 37.61-38.12,2.31-2.42,43.61-45.4 and 7.19-7.21%, respectively. It was also observed that some proximate values were significantly affected by roasting. The minerals composition in the raw and roasted groundnut samples were generally ranged from 0.154-0.186, 0.175-0.301, 0.117-0.134, 1.37-1.42, 0.27-0.513, 0.197-0.237 and 0.171-0.193 mg/Kg for Fe, Zn, Ca, Mg, Na, K and P, respectively. The concentration levels of metals in groundnut were found to decrease in the order of: Mg > Na > Zn > K > P > Fe > Ca. The levels of minerals determined in the groundnut samples were found within the range of WHO permissible limit.

Keywords: groundnut, proximate, mineral analysis, wet digestion, roasting

Introduction

Peanuts or groundnuts (*Arachis hypogaea*) is an important oilseed crop grown worldwide both in tropical and temperate zones (Ayoola and Adeyeye, 2010). As it can be clearly evidenced from literatures, peanut has been commercially used mainly for oil production (Kline, 2016; List, 2016; Sanders, 2003; Smithson et al., 2018; Tu and Wu, 2019). However, apart from oil, the by-products of peanut contain many other functional compounds like proteins, fibers, polyphenols, antioxidants, vitamins and minerals which can be added as a functional ingredient into many processed foods (Akgül and Tozluoğlu, 2008; Nepote et al., 2006; Wu et al., 2009; Zhao et al., 2012). Recently it has also been revealed that peanuts are excellent source of compounds like resveratrol, phenolic acids, flavonoids and phytosterols that block the absorption of cholesterol from diet (Garcia et al., 2016; Limmongkon et al., 2017; Sanders et al., 2000; Sebei et al., 2013).

Nutritionally, groundnut seeds are rich due to the presence of oil, protein, niacin, fiber, magnesium, vitamin, manganese, and phosphorus (Davis and Dean, 2016; Fletcher and Shi, 2016). It has been reported that, groundnut seed could contains up to 44 to 56% oil and 22 to 30% protein on a dry seed basis and is a rich source of minerals (phosphorus, calcium, magnesium, and potassium) and vitamins (E, K, and B group) (Arya et al., 2016; Grosso and Guzman, 1995; Kholief, 1987; Singh and Singh, 1991). Groundnut protein is increasingly becoming important as food and feed sources, especially in developing countries where protein from animal sources are not within the means of the majority of the people (Alid et al., 1981; Arya et al., 2016; Singh and Singh, 1991). The seed has several uses as whole seed or processed to make peanut butter, oil, soups, stews and other products, while the cake made of peanut has several uses in feed and infant food formulations (Dhamsaniya et al., 2012; Francisco and Resurreccion, 2008; Nwokolo, 1996; Timbabadiya et al., 2017).

Ayoola and Adeyeye (2010) have analyzed the groundnut seeds (raw, sun-dried and roasted) for proximate composition and some nutritionally valuable minerals and found that the roasted groundnut can be considered as a good source of valuable minerals, while the raw groundnut is a good source of protein with high nutrition value. Similarly, Atasie et al., (2009) have performed a proximate analysis and physicochemical properties of groundnut variety of Pakistan and suggested that the groundnut seed possess good source of protein with high nutritive value.

The relation between the proximate composition of groundnut and the highest percentage kernel damage assessment and kernel weight loss during the storage period have also been documented (Musa et al., 2010). The effect of roasting and storage on the proximate composition of groundnut have demonstrated. For instance, Damame et al. (1990) have demonstrated that the heat treatments significantly decreased methionine, tryptophan and in vitro protein digestibility (IVPD) and, increased the soluble proteins and acid value of kernel oil. Likewise, (Venkatachalam and Sathe, (2006) have revealed that the contents of the total pyrazines and most of the peanut flavor-related pyrazines were higher in the kernels after subjected to roasting and peanut oil and flavor extraction.

With increasing consumer preference for high quality edible oils and the desire to increase groundnut export to the world market, there is the need to investigate the quality of groundnut seeds for their proximate composition and possible heavy metals content. The major alarming contaminations in groundnut seeds have an important issue for many years because of their adverse effects on human health and series treat to food safety (Baluka et al., 2017; Blair and Lamb, 2017; Massie et al., 2015). Therefore, this study was aimed to determine selected proximate (moisture content, ash content, crude fiber, oil content, crude protein and total carbohydrate) and minerals composition (Na, K, Ca, Mg, Fe, Zn and P) of raw and roasted groundnut samples obtain from Babile and Fedis Woredas of East Hararghe zone in Ethiopia.

Materials and Methods

Description of the study area

Hararghe is located in the Eastern part of Ethiopia at a distance of about 525 km from the capital Addis Ababa. Babile is a woreda in Eastern Hararghe and lies between 8°09’ N and 9°23’ N latitude, and 42°15’ and 42°53’E longitude having an altitude ranging from 950 to 2000 meters above sea level. Fedis is also one of the weredas in East Hararghe which lies between 8°22’ and 9°14’N latitude and 42°02’ and 42°19’E longitude with altitude ranging from 500 to 2100 meters above sea level. The geographical location of the study area is indicated in Figure 1.

Instruments and Apparatus

Electronic blending device (Moulinex, France) was used for grinding and homogenizing the sample. A 100 mL round bottom flasks fitted with reflux condensers were used in Kjeldahl apparatus hot plate to digest the dried and powdered raw and roasted groundnut samples. Borosilicate volumetric flasks (25, 50 and 100 mL) were used during dilution and preservation of samples and preparation of metals standard solutions. In addition, Analytical balance with 0.0001 sensitivity (AA-200DS, Denver instrument company) was used for weighing powered groundnut samples, electrical oven, test tubes, digestion flask, mortar and pestle, Bunsen burner, hot plate, aluminum block, filter paper, measuring cylinders, beakers, polyethylene plastic bags and sample bottles were used during sample preparation and analysis procedures. UV spectroscopy was used to determine levels of P (phosphorus) while Flame Atomic Absorption Spectrophotometer (Buck Scientific Model 210VGP AAS, USA) equipped with deuterium arc background corrector and with air-acetylene flame were used for the elemental analysis of groundnut samples.

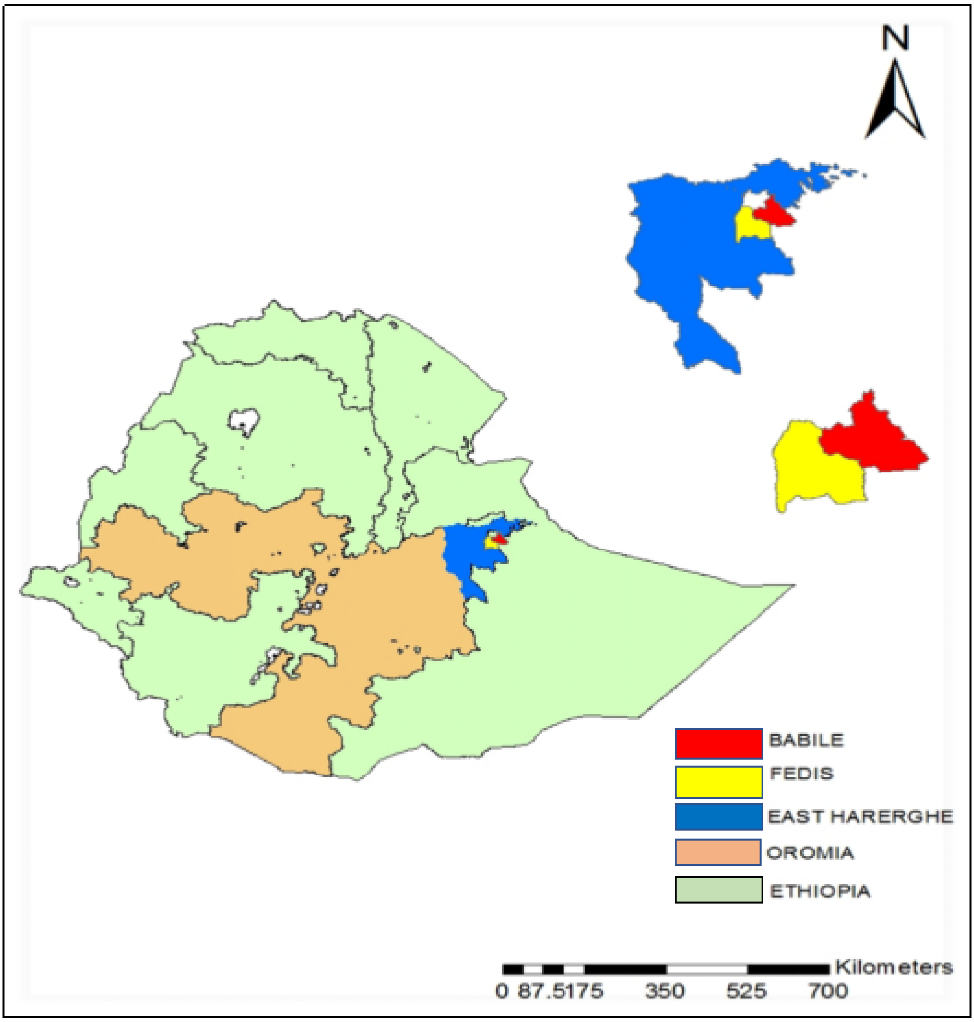

Figure 1 Location map of the study area

Chemicals and Reagents

All chemicals used were either an analytical reagent grade or laboratory reagent grade. Deionized water was used for all preparation and dilution purposes throughout the study. HNO_3 (69-72%) and $HClO_4$ (70%) (BDH Laboratory supplies) were used for digestion of raw and roasted groundnut samples. The digester used for the digestion of groundnut samples was prepared from 5:5 ratios of 70% $HClO_4$ and the (69-72%) of HNO_3. Stock standard solutions containing 1000 mg/L, in 2% HNO_3, of the elements Na, K, Ca, Mg, Fe, Zn and P were used for preparation of calibration standards and for spiking experiments.

Groundnut sample collection

The Groundnut sample seeds were collected from local market in Babile and Fedis Woredas of East Hararghe Zone. About 500 g of groundnut sample was randomly bought from three farmers after systematically identifying the farmers are from the intended sampling location. The bulk samples were then pooled together in to a single polyethylene plastic bags to get 1.5 kg of composite sample. The same procedures were repeated in the other woreda as well. The bulk groundnut samples were divided into two parts of 750 g each, one part was used for raw and second part was for roasted. A total of two for raw and two roasted groundnut samples were chosen for the proximate and mineral content analysis. Then, the collected samples were packed into clean polyethylene plastic bags, labeled and transported to Haromaya University Chemistry laboratory for further pre-treatment and analysis.

Sample treatment and preparation

The groundnut samples (Kernels) were washed with a running tap water to remove adsorbed soil particulates and then rinsed with deionized water. The samples were exposed to sun light for 72 hrs to dry it until constant weight was achieved. The dried groundnut sample was powdered using mortar and pestle and sieved (using 0.5 mm sieve) to obtain fine powder from raw groundnut seeds while the some portions of the samples were traditionally roasted using metal pans, get cooled and then ground using mortar and pestle and sieved (using 0.5 mm sieve) to obtain fine powder. Then the powdered raw and roasted groundnut samples were stored in a properly precleaned and dried polyethylene plastic bags until analysis.

Proximate analysis of groundnut samples

Proximate parameters such as ash content, oil content, crude protein, total carbohydrates, crude fiber and moisture content of raw and roasted groundnut samples were determined by using standard methods of Association of Official Analytical Chemists (AOAC, 1990). The moisture contents were determined by heating 2 gm of each groundnut sample at 105 °C for overnight in an oven. The ash content of the sample was determined burning 10 g of the sample in a clean dry pre-weighed crucible in a muffle furnace at about 550 ℃ for 3 hours until light gray ash was obtained. Crude fiber was determined by successively treating 2 gm of defatted sample with boiling solution of H_2SO_4 and KOH (0.26 N and 0.23 N, respectively), following with heating in an oven adjusted to 105 °C for 24 hours. Similarly, the oil content, crude protein and total carbohydrates of the samples were analyzed following the standard procedure indicated in AOAC manual.

Optimization of sample digestion procedure

Wet digestion was generally employed for the digestion of groundnut samples. The digestion procedures were optimized based on the amount of acid mixture required, digestion time and temperature required for optimal digestion procedure. Accordingly, an optimized acid mixture of 5 mL HNO_3: 5 mL $HClO_4$ by volume ratio, a digestion temperature of 160 °C and 3:00 hour digestion time was selected to digest a 0.5 g of groundnut sample as given in Table 1.

Elemental analyses of samples

Mineral contents of raw and roasted groundnut seeds were determined by Flame Atomic Absorption Spectrometry (FAAS) for magnesium, zinc, iron and calcium, flame photometry for potassium and sodium and UV spectrophotometry for phosphorus according to the standard method of Horwitz and AOAC International (2000). Prior to analysis, the instrument operating conditions were selected according to the instrument's manual provided from the manufacturer and deuterium background correction has been performed for all the analyzed metals.

Method Detection Limit (MDL) and Limit of Quantification (LOQ)

Seven blank samples (n =21) were digested following the same procedure as the samples and each of the samples were analyzed for metal (K, Na, Ca, Mg, Fe and Zn) concentrations by FAAS. The standard deviations (SD) for each element were calculated from the seven blank measurements and MDL was calculated from MDL = 3SD, while limit of quantifications for every metal of interest were determined from LOQ = 10SD following the method described by Getachew et al. (2019).

Validation of optimized procedure

The efficiency of the optimized digestion procedure was checked by calculating percentage recovery and relative standard deviation. For this procedure, spiked samples were prepared by adding a known quantity of metal standard solutions to a groundnut sample. Then, the spiked samples were digested by employing the optimized digestion condition and the concentrations of the spiked metals were determined. From the result obtained the percentage recover and percentage relative standard deviation were calculated following the procedures employed by Getachew et al. (2019) and Gebeyehu and Bayissa (2020).

Table 1. Optimization of Digestion Procedure for 0.5g groundnut sample.

Trial No.	Reagent used	Reagent volume (mL)	Temp. (℃)	Digestion time (Min.)	Observation
Reagent volume optimization					
1	HNO_3: $HClO_4$	2 : 2	160	180	Very deep yellow
2	HNO_3 : $HClO_4$	2 : 3	160	180	Deep yellow
3	HNO_3 : $HClO_4$	3 : 3	160	180	Yellow
4	HNO_3 : $HClO_4$	3 : 4	160	180	Light yellow
5	HNO_3 : $HClO_4$	3 : 5	160	180	Clear yellow
6	HNO_3 : $HClO_4$	4 : 4	160	180	Almost clear
7	HNO_3 : $HClO_4$	4 : 6	160	180	Near clear and colorless
8	HNO_3 : $HClO_4$	5 : 5 **	160	180	clear and colorless
Temperature Optimization					
1	HNO_3 : $HClO_4$	5 : 5	60	180	Deep yellow
2	HNO_3 : $HClO_4$	5 : 5	80	180	Yellow
3	HNO_3 : $HClO_4$	5 : 5	100	180	Light yellow
4	HNO_3 : $HClO_4$	5 : 5	120	180	Clear yellow
5	HNO_3 : $HClO_4$	5 : 5	140	180	Almost clear
6	HNO_3 : $HClO_4$	5 : 5	160 **	180	Clear and colorless
7	HNO_3 : $HClO_4$	5 : 5	180	180	Clear and colorless
8	HNO_3 : $HClO_4$	5 : 5	200	180	Clear and colorless
Digestion time optimization					
1	HNO_3 : $HClO_4$	5 : 5	160	40	Very deep yellow
2	HNO_3 : $HClO_4$	5 : 5	160	60	Deep yellow
3	HNO_3 : $HClO_4$	5 : 5	160	80	Near yellow
4	HNO_3 : $HClO_4$	5 : 5	160	100	Light yellow
5	HNO_3 : $HClO_4$	5 : 5	160	120	Clear yellow
6	HNO_3 : $HClO_4$	5 : 5	160	140	Near clear and colorless
7	HNO_3 : $HClO_4$	5 : 5	160	160	Almost clear and colorless
8	HNO_3 : $HClO_4$	5 : 5	160	180 **	Clear and colorless

** The optimized conditions for the given parameters

Data analysis

All analyses were carried out in triplicates and the data were presented as mean ± standard deviations. One-way analysis of variance (ANOVA) at $P < 0.05$ was used to determine statistically significant differences in the mean concentrations of proximate and mineral compositions from raw and roasted groundnut seed samples. Pearson's correlation analysis was also applied to test the correlation between minerals in groundnut seed samples. A probability level of $P < 0.05$ was considered statistically significant. All statistical analyses were done by SPSS version 20 software for windows.

Results and Discussion

Proximate compositions of groundnut seed samples

Selected proximate parameters such as moisture contents, ash contents, oil contents, crude fiber, crude protein and total carbohydrate were determined. The result obtained is presented in Table 2. The moisture content in the groundnut seed sample were in ranged of 2.01 to 5.01% as shown Table 2. It was found out that the moisture contents of all groundnut samples (both raw and roasted) have showed significant difference at $P < 0.05$. As can be seen from Table 2, the moisture content of groundnut samples collected from Fedis woreda were relatively higher than those samples collected from Babile woreda. This could be attributed to the soil moisture difference among the two areas. It is evident that the moisture content (%) of the groundnut samples from Babile have been reduced by about 55.4% upon roasting, while a 26.4% moisture lose was observed for samples from Fedis woreda. This is a clear indication that roasting could infer a significant moisture lose in groundnut samples. It worth noting here that the groundnut samples from Fedis wereda has showed greater resistance to heat and able to maintain its moisture even after roasting. Ayoola and co-workers (2012) has reported relatively higher moisture content of 7.48% in raw sample and a higher moisture content reduction by 85.7% upon roasting.

Table 2. Proximate compositions (mean ± sd, n = 3) of raw and roasted groundnut samples

Proximate parameters	Sample type and source			
	Babile Woreda		**Fedis Woreda**	
	Raw	Roasted	Raw	Roasted
Moisture (%)	4.51±0.01	2.01±0.01	5.41±0.06	3.98±0.04
Ash content (%)	4.62±0.01	4.80±0.03	4.41±0.02	4.80±0.03
Oil content (%)	41.71±0.36	38.12±0.12	40.20±0.41	37.61±0.52
Crude Fiber (%)	2.80±0.01	2.42±0.04	2.62±0.02	2.31±0.05
Crude protein (%)	42.21±0.45	45.40±0.61	42.30±0.65	43.61±0.71
Total carbohydrate (%)	4.22±0.02	7.21±0.02	5.51±0.06	7.19±0.08

The ash contents of groundnut samples collected from both study areas were in ranged of 4.41 to 4.80 % as shown Table 2. The statistical analyses have revealed that there is significant difference in the ash content between the groundnut samples from the two locations at $P < 0.05$. The data in Table 2 shows that the values of ash contents for all samples analyzed (both raw and roasted) are almost the same. This shows that roasting of the groundnut sample does not have significant impact on the ash content of the groundnut samples. The ash contents reported by Ayoola and co-workers (2012) for both raw and roasted groundnut samples are relatively lower than the data we have reported in this study. From the result of the ash content, it can be deduced that the groundnut samples from analyzed are rich of different minerals.

The oil contents of the groundnut samples collected from both study areas were in ranged of 37.61 to 41.71 % as shown Table 2. The oil contents of the groundnut samples from Babile woreda were 41.71 and 38.12% for raw and roasted groundnut samples, respectively, while the corresponding oil contents of the groundnut samples from Fedis woreda were 40.20 and 37.61% for raw and roasted groundnut samples, respectively. From the data obtained, it can be seen that the oil contents of the groundnut samples were not significantly differ both in raw and roasted samples. The data obtained from this study is very comparable with the literature values reported by Ayoola and co-workers (2012). However, a relatively lower ash content was reported by Atasie and co-workers (2009).

The crude fiber contents of the groundnut samples collected from both study areas were in ranged of 2.31 to 2.80 % as shown Table 2. The crude fiber obtained have showed statistically significant difference at $P < 0.05$ among the analyzed samples. Crude fiber contents obtained in groundnut samples from the two locations are very comparable. The results of this study have showed that the groundnut seeds of this cultivar maintain good crude fiber percentage both in raw and roasted form as the data obtained very similar to nutrient data base standard released by USDA (USDA, 2018). However, the data obtained in this study are relatively lower than what has been reported (3.8%) by Atasie and co-workers (2009).

The crude protein contents of the groundnut samples collected from both study areas were in ranged of 42.21 to 45.50 % as shown Table 2. The data obtained were happened to be significantly differ at $P < 0.05$. The crude protein contents of all the samples analyzed (both raw and roasted) have showed a relatively higher percentage values compared with the literature values as well as the USDA nutrient database standard (USDA, 2018; Atasie et al., 2009; Ayoola et al., 2012; Grosso and Guzman, 1995b).

The total carbohydrates values of the groundnut samples analyzed were in the range of 4.22 to 7.21% (Table 2). From the data, we can see that the total carbohydrate content of the raw groundnut sample is relatively lower than the roasted groundnut sample. Similar reports have shown relatively higher carbohydrate contents of the roasted groundnut samples (Ayoola et al., 2012). However, the carbohydrate content of the groundnut samples analyzed in this study were found to be significantly lower than values given in USDA nutrient database standard (USDA, 2018).

Determination of mineral contents in groundnut samples

Method Detection limit and Quantification limit

Limit of Detection (LOD) and limit of quantification (LOQ) of all minerals of interests were calculated from the response of five replicates of the calibration reagent blank. The limits of detection were calculated as three times the standard deviation of the blank (3σblank, n = 7), and limits of quantitation was calculated as ten times the standard deviation of the blank (10σblank, n = 7). The values of limits of detection and quantitation for each mineral as shown in Table 3.

Table 3. Instrument detection limit, Method detection limit, and Limit of quantification (in mg/Kg) for the determination of metals in groundnut samples.

Metals	IDL	SD blank		MDL		LOQ	
		BR	FR	BR	FR	BR	FR
Fe	0.006	0.020	0.008	0.010	0.014	0.021	0.031
Zn	0.001	0.007	0.010	0.022	0.030	0.062	0.050
Ca	0.001	0.018	0.008	0.014	0.024	0.018	0.079
Mg	0.0003	0.018	0.008	0.054	0.024	0.081	0.080
Na	0.0002	0.070	0.080	0.011	0.014	0.016	0.018
K	0.003	0.020	0.025	0.012	0.011	0.020	0.025

Where, BR = Babile raw and FR = Fedis raw groundnut seed samples.

As can be seen from Table 3, the method detection limit value lied in the range of 0.01 to 0.05 mg/Kg, while the LOQ values have ranged from 0.016 to 0.080 mg/Kg. The method detection limits estimated for the groundnut seed samples were low enough to detect the presence of metals of interest levels in the seed samples. The result revealed that both MDL and LOQ values were greater than instrument detection limit. Hence, the result of the analysis could be reliable.

Precision and accuracy

Validity of the current method proposed for the analysis of minerals were evaluated by means of matrix spike recovery tests. The recovery values of triplicate analysis of the matrix spike groundnut samples were calculated and the data were presented in Table 4. As can be seen from the date in Table 4, the mean percent recovery values for groundnut seed ranged between 81.5 to 110 % for all minerals. All the recovery values of groundnut seed samples were found to be within the designated acceptance range of 80 – 120% for metal analysis (Gebeyehu and Bayissa, 2020; Getachew et al., 2019). In addition, the percentage relative standard deviation of the results obtained has ranged from 0.23 to 2.46, indicating that the method used is precise enough for the determination of the intended minerals.

Table 4. Recovery and precision test results of minerals determined in raw groundnut samples obtained from Babile woreda.

Minerals	Mean metal concentrations in unspiked sample (mg/Kg)	Amount spiked value (mg/Kg)	Mean Concentration metals in spiked sample (mg/Kg)	Percent recovery (% R)	% RSD
Fe	0.160 ± 0.004	0.20	0.336 ± 0.020	88.0 ± 0.016	1.81
Zn	0.175 ± 0.007	0.30	0.446 ± 0.007	90.3 ± 0.001	0.23
Ca	0.134 ± 0.014	0.20	0.297 ± 0.018	81.5 ± 0.004	0.51
Mg	1.42 ± 0.016	0.50	1.970 ± 0.018	110 ± 0.002	0.18
Na	0.27 ± 0.096	0.30	0.598 ± 0.070	109.3 ± 0.026	2.46
K	0.217 ± 0.015	0.20	0.410 ± 0.020	96.5 ± 0.005	0.51
P	0.193 ± 0.012	0.20	0.387 ± 0.017	97 ± 0.005	0.59

Determination of levels of mineral composition of groundnut seed samples

The determined levels of minerals in groundnut samples has been reported and the data were presented as mean of a triplicate analysis (Table 5). From the statistical analysis data, it was found out that all mineral contents except for potassium (K), have showed a significant difference at $p < 0.05$.

As can be seen from Table 5, the Fe content in groundnut seed samples ranged from 0.154 to 0.186 mg/Kg. The Fe contents of the groundnut samples collected from the two areas are very comparable. It can also be seen that roasting has not affect the iron contents of the groundnut samples. The iron contents of the analyzed groundnut sample from this study were found to be much lower than the value reported by Atasie and co-workers (2009). Likewise, the levels of Zinc in the groundnut seed samples were ranged from 0.175 to 0.301 mg/Kg as shown in Table 8. The groundnut samples collected from Fedis woreda has shown a relative higher concentration of Zn when compared with those collected from Babile woreda. The levels of Zn in groundnut samples were also found to be much lower than what has been reported by Atasie and co-workers (2009).

Calcium levels in the groundnut seed sample were in ranged of 0.123 to 0.134 mg/Kg, while the corresponding values for Magnesium (Mg) were found to be in the range of 1.37 to 1.42 mg/Kg. It can be seen from the data in Table 5 that the levels of Ca were slightly decreased upon roasting the groundnut samples. However, the values of Mg were observed to almost the same for both roasted and raw groundnut samples. Similarly, sodium levels in the groundnut seed samples ranged from 0.27 to 0.513 mg/Kg, showing that it existed in relatively higher amount compared with other minerals. From the data obtained, it can be seen that the Na contents of the groundnut samples were significantly differ and its content was higher in the roasted groundnut than the raw groundnut.

The mean concentration of potassium in both roasted and raw groundnut seed samples have ranged from 0.197 to 0.237 mg/Kg. The K contents of the groundnut samples were happened to be the same for raw groundnut samples but slightly differ in the roasted groundnut samples. Phosphorus, on the other hand, have had a concentration ranged from 0.171 to 0.193 mg/Kg in the groundnut seed analyzed in this study. The P contents of the roasted groundnut samples from Babile and Fedis woredas were 0.184 and 0.171 mg/Kg respectively. From the data obtained, it can be seen that the P contents of the groundnut samples were higher in the raw groundnut as compared to the roasted groundnut samples like Ca.

Table 5. Concentrations (x ± sd, n = 3) of minerals in groundnut seed samples (mg/Kg).

Minerals	Concentration of minerals in samples			
	Babile		Fedis	
	Raw	Roasted	Raw	Roasted
Fe	0.160 ± 0.004	0.182 ± 0.016	0.154 ± 0.012	0.186 ± 0.008
Zn	0.175 ± 0.007	0.188 ± 0.054	0.299 ± 0.016	0.301 ± 0.006
Ca	0.134 ± 0.014	0.123 ± 0.008	0.128 ± 0.010	0.117 ± 0.007
Mg	1.420 ± 0.016	1.41 ± 0.012	1.370 ± 0.035	1.390 ± 0.035
Na	0.270 ± 0.009	0.39 ± 0.015	0.460 ± 0.026	0.513 ± 0.015
K	0.217 ± 0.002	0.197 ± 0.011	0.217 ± 0.015	0.237 ± 0.008
P	0.193 ± 0.004	0.184 ± 0.008	0.176 ± 0.014	0.171 ± 0.007

Pearson correlation of minerals within groundnut seed samples

The significant relationships between concentrations of minerals in raw and roasted groundnut seed samples were further substantiated by performing correlation analysis. Pearson's correlation matrices of mean level of minerals from both samples between Babile and Fedis seed were analyzed at $p < 0.05$. Accordingly, the values of Pearson correlation matrices in raw and roasted groundnut seed samples were shown in Table 6-10.

Pearson correlation for minerals in raw groundnut samples collected from Babile woreda

From the correlation analysis data (Table 6) for raw groundnut samples from Babile wored, the results of correlation coefficients showed significant positive correlation between Fe with Na, Zn with K, Ca with P and moderate positive correlation of Fe with (Zn and K), Zn with (Ca and Na), Ca with K and Na with K. The other correlations between metals were not significant. It was also found that there is high negative correlation of Fe with (Ca and P), Zn with Mg, Ca with (Na and Mg), Mg with (K and P), Na with P and there is not any moderate negative correlation of mineral elements. The high association between metals, evidenced by high positive correlation coefficient, can arise from common anthropogenic or natural sources as well as from similarity in chemical properties (Okunola et al., 2007).

Table 6. Pearson correlation for minerals in Babile raw groundnut samples

Minerals	Fe	Zn	Ca	Mg	Na	K	P
Fe	1						
Zn	0.466	1					
Ca	-0.630	0.393	1				
Mg	0.125	-0.820	-0.849	1			
Na	0.996	0.388	-0.695	0.210	1		
K	0.419	0.999*	0.441	-0.849	0.339	1	
P	-0.830	0.107	0.956	-0.657	-0.875	0.159	1

* Correlation is significant at the 0.05 level (2- tailed)

Pearson correlation for minerals in roasted groundnut samples from Babile woreda

From the correlation coefficients data given in Table 7, it can be seen that a significant positive correlation between Fe and each of Na, Zn and P; Zn with each of Na, K and P; Na with P, and K with P have been observed. A positive correlation coefficient indicates that an increase in the concentration of the first minerals would correspond to an increase in the concentration of the second minerals, thus implying a direct relationship between the concentrations of minerals.

Table 7. Pearson correlation coefficients for minerals in Babile roasted groundnut samples.

Minerals	Fe	Zn	Ca	Mg	Na	K	P
Fe	1						
Zn	0.902	1					
Ca	-0.607	-0.890	1				
Mg	-0.852	-0.542	0.10	1			
Na	0.985*	0.815	-0.462	-0.929	1		
K	0.354	0.723	-0.958	0.189	0.189	1	
P	0.752	0.963	-0.980	-0.295	0.629	0.882	1

* Correlation is significant at the 0.05 level (2- tailed)

Pearson correlation for minerals in raw groundnut samples from Fedis woreda

The results of correlation coefficients for raw groundnut samples from Fedis woreda of East Harargihe were calculated and the data is presented in Table 8. From the result the presence of significant positive correlation of Zn with Ca, K and P; Ca with K and P; Mg with Na, Na with K and K with P can be witnessed. This indicates that the coexistence of these minerals together in the soil on which the groundnut has been cultivated. The presence of strong negative correlation of Fe with (Zn, Ca, K and P) were also evidenced. Likewise, a strong positive correlation between Fe with K, Zn with (Na and P), Ca with Mg were observed for roasted groundnut samples collected from Fedis woreda (Table 9).

Table 8. Pearson correlation data for minerals in raw groundnut samples from Fedis woreda

Minerals	Fe	Zn	Ca	Mg	Na	K	P
Fe	1						
Zn	-0.997*	1					
Ca	-0.870	0.905	1				
Mg	0.272	-0.344	-0.711	1			
Na	-0.477	0.409	-0.019	0.716	1		
K	-0.852	0.810	0.484	0.272	0.866	1	
P	-1.000*	0.998*	0.880	-0.291	0.459	0.842	1

* Correlation is significant at the 0.05 level (2- tailed)

Table 9. Pearson correlation coefficients for minerals in roasted groundnut samples Fedis woreda.

Minerals	Fe	Zn	Ca	Mg	Na	K	P
Fe	1						
Zn	-0.595	1					
Ca	-0.272	-0.612	1				
Mg	0.294	-0.943	0.840	1			
Na	-0.999*	0.556	0.317	-0.249	1		
K	0.998*	-0.643	-0.213	0.351	-0.994	1	
P	-0.117	0.868	-0.924	-0.984	0.070	-0.177	1

* Correlation is significant at the 0.05 level (2- tailed)

Conclusion

The levels of proximate compositions and minerals compositions in raw and roasted groundnut seed samples collected from Babile and Fedis, Oromia region, Ethiopia were determined for proximate parameters by physical means while minerals levels in raw and roasted groundnut seed samples were analyzed for their contents of Mg, Ca, Fe and Zn using flame atomic absorption spectrometer (FAAS), Na and K using Flame photometer and P using UV-Visible spectroscopy after wet digestion. The proximate compositions of the analyzed groundnut samples have been found to be in the normal range of recommended values. Similarly, the levels of minerals analyzed were also found to be in the safe region compared with the recommended values.

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Conflict of interest

The authors have declared that there is no conflict of interest

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