

COMPARATIVE ANALYSIS OF THE MINERAL COMPOSITION OF BOILED, ROASTED AND RAW PEANUTS (*ARACHIS HYPOGAEAE*)

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ABSTRACT

A comparative analyses of mineral composition of boiled, roasted and raw peanuts sourced from the locality was carried out using flame photometry and Atomic Absorption Spectroscopy (AAS). K and Ca were analyzed using flame photometer while the other metals were analyzed using Atomic Absorption Spectroscopy. The results obtained showed that the concentration of the standard error of mean of Cu in boiled peanut was 2.11 ± 0.01 , roasted 3.06 ± 0.01 and raw 2.12 ± 0.01 mg/100g; Zn in boiled peanut was 0.71 ± 0.01 , roasted 1.11 ± 0.01 and raw 0.9 ± 0.00 mg/100g; Pb, in peanut was 0.01 ± 0.00 , roasted 0.01 ± 0.01 and raw 0.05 ± 0.03 mg/100g; Mg showed that boiled peanut was 2.15 ± 0.01 , roasted 1.2 ± 0.00 and raw 3.02 ± 0.01 mg/100g, Mn in boiled peanut was 3.01 ± 0.01 , roasted 1.03 ± 0.00 and raw 2.53 ± 0.01 mg/100g, Fe was 1.02 ± 0.00 in boiled peanuts, 1.71 ± 0.00 in roasted and 2.00 ± 0.00 mg/100g in raw, Se in boiled peanut was 0.49 ± 0.01 , roasted 0.34 ± 0.01 and raw 0.62 ± 0.01 mg/100g; Cr in boiled peanut was 0.01 ± 0.00 , roasted 0.01 ± 0.00 , and raw 0.00 ± 0.00 mg/100g; Ca in boiled peanut was 1.08 ± 0.03 , roasted 0.75 ± 0.03 and raw peanuts was 1.52 ± 0.00 mg/100g; K in boiled peanut was 2.55 ± 0.001 , roasted was 3.32 ± 0.01 and raw 2.35 ± 0.00 mg/100g;. The results showed that roasted peanuts contained higher mineral compositions of Cu, Mg, Ca and K which are essentially important for human growth and development. Eating of groundnut is highly recommended because of the availability of these essential minerals.

INTRODUCTION

Peanut is an edible seed of the leguminous plant, *Arachis hypogaea*. It grows annually and is a good source of protein (Asibuo *et al.*, 2008). It belongs to the family Fabaceae, genus-*Arachi*, species – *A. hypogaea*. It is a herbaceous plant of which there are different varieties such as Boro light, Boro red, Mokwa, Campala, Auta and Ela (Anyasor *et al.*, 2009).

The crop is native to India, Africa and it is cultivated mostly in the Northern and Eastern part of Nigeria. Although a legume, it is generally included amongst the oilseed due to its high oil content. Peanuts are rich in protein, oil and fibers (Suchoszek *et al.*, 2011). It is widely used as an economic food enhancement to counter malnutrition owing to its high nutritional value (Sarvamangala *et al.*, 2011). It is a globally important oil seed valued as a source of high quality cooking oil, crude fat, crude protein, crude fiber, water, ash, total sugar, amino acids, fatty acids, vitamins, minerals and other anti-nutritional factors (Wang, 2017) and appreciated worldwide as an affordable, flavourful, serving as a primary ingredient for peanut butter, confections, and nutritional bars, among other finished products. Peanuts can be eaten raw, cooked, roasted or fried to serve as snack. The paste is used as margarine or butter (Atasie *et al.*, 2009) and also used as thickener in soups and stews.

Peanut production is a main stay of the economy in countries such as Ghana, India, Asian continent and Nigeria in the

70s (Atasie *et al.*, 2009). Arya, Chauhan and Salve in 2015 reported that peanut contains bioactive compounds such as arginine - an amino acid that is needed to keep the liver, skin, joints and muscles healthy. Resveratrol which inhibits the development of cancer, improved blood flow to the brain; phytosterols help to block the absorption of cholesterol in the body and helps to reduce the level of cholesterol in the body are contained in the peanut. Phenolic acids have great anti-oxidant capacity, flavonoids which help to protect against heart disease were also reported in the peanut (Francisco and Resurrection, 2008).

It was reported by Johnston *et al.*, 2009 that peanut helps to control weight gain by children. Oil extracted from peanuts are used for the production of important domestic commodities worldwide. It is used in industrial production of soaps, margarine, paints, cosmetics and pharmaceutical preparations (Kabiru *et al.*, 2019). Nutritionally, peanut oil was reported to be the best compared to other plant seed-oils like protecting the body from free radical damage and reducing the risk of heart disease (Johnston *et al.*, 2009).

Works on the phytochemical properties of peanut had been carried out (Kabiru *et al.*, 2019). The aim of this study is to compare the minerals composition of boiled and roasted and raw peanuts

Materials and methods

Materials

Sample, collection and sorting - Fresh

peanut seeds were obtained from Afor Market in Unwana, Afikpo North Local Government Area of Ebonyi State. The peanut seeds were thoroughly sorted in order to remove foreign materials, broken and immature seeds. The seeds were divided into three (3) parts, one part was boiled, the second part was roasted and the third portion was kept raw.

Methods

Processing techniques

Roasting - The seeds were shade-dried to a constant weight at room temperature of about 25-30°C. A portion (weight) of the seeds was placed on a frying pan and was roasted for too long using a heat source after which it was allowed to cool. The peanut seeds were pulverized to fine powder (or paste) using the electric blender. It was stored in an air tight container.

Boiling - The second portion of the peanut seeds was boiled in distilled water at a temperature of 100°C in a seed/water ratio of 1:10 (w/v) for 45 minutes. After boiling, the water was drained off and the boiled seeds were allowed to cool and later mashed into paste using a ceramic mortar and subsequently stored in an air-tight container (AOAC, 1948).

Raw - The third portion of the peanut seeds was kept raw.

Preparation of stock solutions (AOAC, 1948).

Copper - A stock solution that contained 100mg/ml of Cu^{2+} was prepared by dissolving 2.682g of $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ in deionized water and diluted to 1000ml.

The standard solutions of concentration 0.0, 0.5, 1.0 and 2.0ppm were prepared from this stock solution

Zinc - A stock solution that contained 100g/ml of zinc ion was prepared by dissolving 1.0g zinc ribbon in 10ml of concentrated HCl. The solution was evaporated almost to dryness and the salt was re-dissolved in 1000ml of de-ionized water. Standard solutions of concentration 0.0, 0.5, 1.0 and 1.5ppm were prepared from the stock solution.

Magnesium - Exactly 1.0g of magnesium ribbon was accurately weighted and dissolved in 10ml concentrated HCl. The solution was then boiled and evaporated almost to dryness on a water bath. Deionized water was added and the solution was transferred into a 100ml volumetric flask. The solution was made to mark with deionized water. From this stock solution which contained 100g/ml of Mg^{2+} ions, four standard solutions of concentrations 0.0, 0.5, 1.0 and 1.5ppm were prepared. To each of the calcium and magnesium solutions, strontium chloride solution was added such that there was 1500mg of strontium ions in the final solution.

Iron - A stock solution containing 100 mg/ml of Fe^{3+} ions was prepared from 1.0g of pure iron wire. The wire was dissolved in 100 ml concentrated HNO_3 , boiled in water bath and diluted to 100ml with distilled water. From this stock solution, standard solutions of concentration 0.0, 0.05, 1.0, 2.0 and 4.0 ppm were prepared.

Calcium - Exactly 2.497g of oven dried CaCO_3 was accurately weighed and dissolved with HCl and diluted to 100ml

with deionized water. The solution contained 100mg Ca^{2+} ions. From this stock solution, calcium standard solution with concentrations 0.0, 3.0, 6.0 and 9.0 ppm were prepared.

Potassium - A stock solution containing 100mg/ml of K^+ ions was prepared by dissolving 1.90 of KCl in water. The solution was made to 100ml mark with distilled water. Then from the stock solution, standard solutions concentration of 0.0, 2.0, 4.0 and 6.0 ppm were prepared.

Selenium - The standard solution of selenium was prepared by dissolving 100mg of selenium metal in hot concentrated nitric acid and diluted to 100 ml with water. From this solution serial dilution were made to obtain different concentration levels of 5, 15, 30, 40, 55, 70, 80 and 100 mg ml^{-1} .

Chromium - Exactly 7.690 g of chromium nitrate ($\text{Cr}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$) and dissolved in 250ml of deionized water. It was diluted with more deionized water in 1litre in a volumetric flask with deionized water. From this stock solution, chromium standard solutions of 0.0, 0.3, 1.0 and 2.0 ppm were made from.

Lead - To prepare a stock solution of 100mg/l Pb, 1.5980g of lead nitrate ($\text{Pb}(\text{NO}_3)_2$) was dissolved in 100ml of deionized water. This was diluted to 1litre in a volumetric flask with deionized water. From this stock solution, lead standard solutions of 0.0, 0.5, 1.0 and 1.5 ppm were prepared.

Determination of iron, copper, manganese, magnesium, zinc, lead, selenium, chromium by atomic

absorption spectrophotometer (AOAC, 1948)

Exactly 1.0g of the sample was first digested with 20ml of acid mixture 650ml concentrated HNO_3 ; 80ml of perchloric acid (PCA); 20ml Concentrated H_2SO_4 and aliquots of the diluted clear digest used for atomic absorption spectrophotometry using filters that match the different elements.

Sample preparation

Exactly 1g of the dried sample was weighed into a digestion flask and 20ml of the acid mixture (650ml concentrated HNO_3 ; 80ml of perchloric acid (PCA); 20ml Concentrated H_2SO_4) was added. The flask was heated until a clear digest was obtained. Then the digest was diluted with distilled water to the 500ml mark. Appropriate dilutions were then made for each element. For the determination of magnesium, enough SrCl_2 solution containing 10,000mg/ml was added to yield a 1, 500mg/ml of Sr^{2+} in the final solution. Calibration curves were prepared for each element using standard solution.

Determination of calcium and potassium by flame photometry

About 1.0g of the sample was digested with 20ml of acid mixture (650ml of concentrated HNO_3 ; 80ml PCA; concentrated H_2SO_4) and aliquots of the dilute clear digest was taken for photometry using flame analyzer.

Sample preparation

The sample was prepared as earlier described for atomic absorption spectrophotometry and suitable dilutions were made from the acid digest and ran in the instrument. Absorbance for Ca was

read at 624nm while that of K was read at 589nm. Calcium and potassium concentrations were obtained from the calibration curves obtained from the standards.

Results and discussion**Results**

The results of the analyses are presented in the table below:

Table 1: Statistical analysis of the mineral content of boiled peanuts

Parameters (ppm)	1st	2nd	3rd	Mean	StDv	SEM
Cu	2.1	2.13	2.09	2.106667	0.016996732	0.01
Zn	0.72	0.71	0.7	0.71	0.008164966	0.005
Pb	0.01	0.01	0.02	0.013333	0.004714045	0.003
Mg	2.18	2.12	2.16	2.153333	0.024944383	0.014
Mn	3.01	3	3.02	3.01	0.008164966	0.005
Fe	1.02	1.03	1.02	1.023333	0.004714045	0.003
Se	0.49	0.48	0.5	0.49	0.008164966	0.005
Cr	0	0.01	0.01	0.006667	0.004714045	0.003
Ca	1	1.14	1.1	1.08	0.058878406	0.034
K	2.56	2.52	2.56	2.546667	0.018856181	0.011

Table 2: Statistical Analysis of the mineral content of roasted peanuts

Parameters (PPM)	1st	2nd	3rd	Mean	StDv	SEM
Cu	3.07	3.05	3.05	3.056667	0.00942809	0.005
Zn	1.1	1.14	1.1	1.113333	0.018856181	0.011
Pb	0	0.01	0.02	0.01	0.008164966	0.005
Mg	1.21	1.2	1.2	1.203333	0.004714045	0.003
Mn	1.01	1.06	1.03	1.033333	0.020548047	0.012
Fe	1.71	1.7	1.71	1.706667	0.004714045	0.003
Se	0.35	0.33	0.35	0.343333	0.00942809	0.005
Cr	0	0.01	0.01	0.006667	0.004714045	0.003
Ca	0.76	0.72	0.76	0.746667	0.018856181	0.034
K	3.34	3.3	3.32	3.32	0.016329932	0.011

Table 3: Statistical Analysis of the mineral content of raw peanuts

Parameters (ppm)	1st	2nd	3rd	Mean	StDv	SEM
Cu	2.11	2.1	2.14	2.116667	0.016996732	0.01
Zn	0.9	0.91	0.91	0.906667	0.004714045	0.002
Pb	0.01	0.12	0.01	0.046667	0.051854497	0.03
Mg	3.01	3	3.02	3.023333	0.012472191	0.007
Mn	2.52	2.52	2.54	2.526667	0.00942809	0.005
Fe	2	2	2	2	0	0
Se	0.62	0.63	0.61	0.62	0.008164966	0.005
Cr	0	0	0	0	0	0
Ca	1.53	1.52	1.52	1.523333	0.004714045	0.002
K	2.35	2.35	2.36	2.353333	0.004714045	0.002

Table 4: Comparative analyses of the results from boiled, roasted and raw peanuts

Parameters (ppm)	Boiled	Roasted	Raw	WHO (2012) STD
Cu	–	3.06±0.01	2.12±0.01	2.0
Zn	0.71±0.01	1.11±0.01	0.91±0.00	3.0
Pb	0.01±0.01	0.01±0.01	0.05±0.03	0.01
Mg	2.15±0.01	1.2±0.03	3.02±0.01	150
Mn	3.01±0.01	1.03±0.01	2.53±0.01	0.05
Fe	1.02±0.00	1.71±0.00	1±0.00	0.3
Se	0.49±0.01	0.34±0.01	0.62±0.01	
Cr	0.01±0.00	0.01±0.00	0±0.00	1.0
Ca	1.08±0.03	0.75±0.03	1.52±0.01	200
K	2.55±0.01	3.32±0.01	2.35±0.00	Not available

Discussion

The result of the mineral analysis of the boiled, roasted and raw peanut samples were presented in Tables 1, 2, and 3. The results showed that boiled peanuts had a Cu concentration of 2.11 ± 0.001 mg/100g, roasted 3.06 ± 0.01 mg/100g and raw 2.12 ± 0.01 mg/100g. The comparative analyses in Figure 1 showed that the roasted peanuts has the highest level of Cu in the samples. The results for the

analyses of Cu obtained are in tandem with the submission of Uche *et al.*, (2014); while it was less with the submission Settaluri *et al.* (2012) of 0.671mg/100g for Cu. According to literature, the high concentration of Cu above the permissible limit of (WHO, 2012) of 2mg/g is toxic to the body. High concentration of Cu can lead to diarrhea, headaches and in severe cases kidney failure (Alana, 2020).

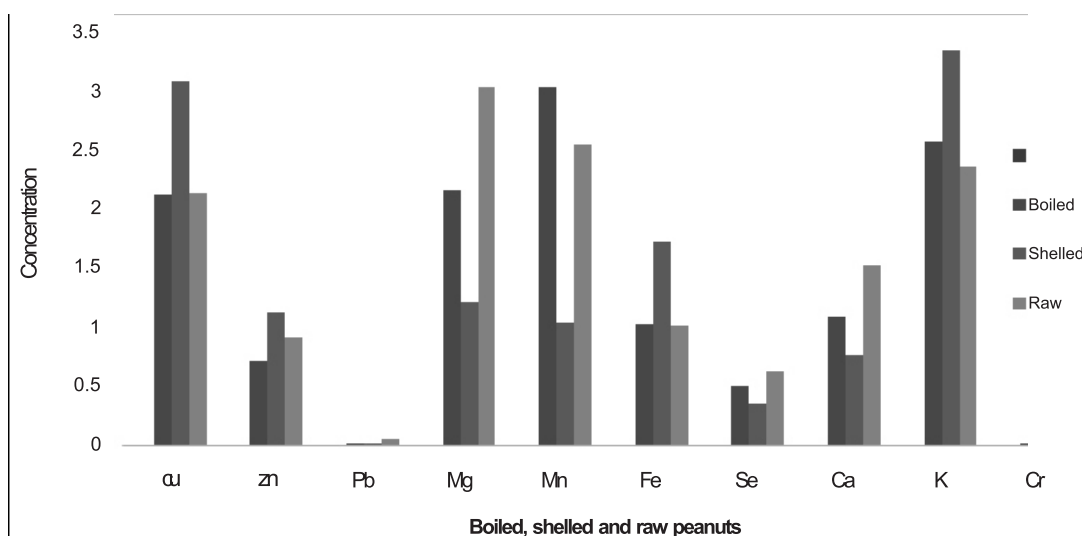


Fig. 1: Levels of metals in the boiled, roasted and raw peanuts samples

Results also showed that boiled peanuts has a Zn concentration of $0.71 \pm 0.01 \text{ mg/100g}$, roasted $1.11 \pm 0.01 \text{ mg/100g}$ and raw peanuts $0.91 \pm 0.01 \text{ mg/100g}$. The comparative analyses of Zn in Figure 1 showed that roasted shelled peanut recorded the highest level of Zn while the boiled peanut recorded the lowest. The result is in tandem with the submission of Uche *et al.* (2014) while it was less with the submission of 3.30 mg/100g Settaluri *et al.* (2012 a). According to the Institute of Medicine, Food and Nutrition Board (2001), too much intake of zinc can cause zinc toxicity which can occur in both acute and chronic forms. Acute adverse effects of high zinc intake includes nausea, vomiting, loss of appetite, abdominal cramps, diarrhea and headaches Uche *et al.* (2014).

In the results obtained as shown in Tables 1, 2, 3, the boiled peanut had Pb concentration of $0.01 \pm 0.00 \text{ mg/100g}$, roasted $0.01 \pm 0.01 \text{ mg/100g}$ and raw $0.05 \pm 0.03 \text{ mg/100g}$. The comparative analyses results in Figure 4 showed that the peanuts contained negligible amount of Pb. Lead is said to have no health benefit in the body, while intake of Pb leads to hypertension, anemia, renal impairment and strokes (WHO, 2021).

The results in Tables 1, 2, 3 showed that Mg concentration in the boiled peanuts was $2.15 \pm 0.01 \text{ mg/100g}$, roasted $1.2 \pm 0.00 \text{ mg/100g}$ and raw $3.02 \pm 0.01 \text{ mg/100g}$. The comparative analysis in Figure 4 showed that the raw peanuts has the highest level of Mg in the samples. The result is in tandem with the submission of Uche *et al.* 2014 while it was less with the submission of Settaluri *et al.* (2012 b), which recorded 2.083 mg/100g .

Manganese helps in blood clotting and sex hormones. Its deficiency can lead to bone demineralization, increased premenstrual pain in women and decreased serum cholesterol (Institute of Medicine, Food and Nutrition Board, 2001).

Results of Mn also showed that boiled peanuts had 3.01 ± 0.01 mg/100g for boiled peanut, roasted 1.03 ± 0.01 mg/100g and raw 2.53 ± 0.01 mg/100g. The comparative analysis in Figure 1 showed that the boiled peanuts had the highest level of Mn in the samples. The result agreed with the result submitted by Uche *et al.* (2014), which was 3.01 ± 0.61 mg/100g for boiled peanut. Manganese intake promotes normal blood pressure and function and keeps bone strong while its deficiency can lead to hypocalcemia, loss of appetite, retention of sodium, neurological and muscular symptoms, (Rude *et al.*, 2016).

The results in Tables 1, 2, 3 showed that the Fe concentration of boiled peanuts was 1.02 ± 0.00 mg/100g, roasted 1.71 ± 0.00 mg/100g and raw 2.00 ± 0.00 mg/100g. And the comparative analysis in Figure 4 showed that roasted peanuts had the highest level of Fe in the sample. The result obtained is in line with the submission of Uche *et al.* (2014), which was 1.60 ± 0.32 mg/100g roasted peanut. From the literature, it was stated that Fe helps to regulate cell growth and differentiation and its deficiency leads to anemia (Miret, Simpson & McKie, 2003).

In the results obtained for Se, in Tables 1,

2, and 3 it was shown that the boiled peanuts had 0.49 ± 0.01 mg/100g, roasted 0.34 ± 0.01 mg/100g and raw 0.62 ± 0.01 mg/100g. The comparative analysis in Figure 1 showed that the raw peanuts have the highest level of Se in the samples. Results obtained for the three samples were lower compared to the submission by USDA (2011), which was 7.5mg/100g. From literature, high intake of selenium above the recommended dose can cause bad breath, fever, as well as liver, kidney and heart problems. In extreme cases, it can cause death (Institution of Medicine, Food and Nutrition Board, 2000), while its deficiency can cause male infertility, Sunde *et al.*, (2012).

Results of the analysis obtained for Ca showed that boiled peanuts had 1.08 ± 0.03 mg/100g, roasted 0.75 ± 0.03 mg/100g and raw 1.52 ± 0.00 mg/100g. From the comparative analysis in Figure 1, it was shown that raw peanuts have the highest level of Ca in the samples. The results obtained were low compared to the submission of USDA (2011) which was 54 mg/100g. From studies, high intake of Ca can weaken the bones, create kidney stones. Its deficiency can lead to dental changes, cataracts, alterations in the brain and osteoporosis (Alana, 2020).

Result obtained from the analysis for K showed that boiled peanuts has 2.55 ± 0.01 mg/100g, roasted 3.32 ± 0.01 mg/100g and raw 2.35 ± 0.00 mg/100g. The comparative analysis in Table 4

showed that the roasted peanuts had the highest level of K in the samples. The result obtained showed variation with the result submitted by Uche *et al*, (2014) which was 187.07 ± 0.09 mg/100g and the submission by Settaluri *et al* (2012 b) which is less with 658 mg/100g. From studies, K helps increase bone density, preserve muscle mass. While its deficiency or high intake can cause weakness and muscle pain and constipation (Schwalfenberg, 2011).

Finally, in the result obtained for Cr, it was shown that boiled peanuts had 0.01 ± 0.00 mg/100g, roasted 0.01 ± 0.00 mg/100g and the raw 0.00 ± 0.00 mg/100g. The comparative analysis in Figure 4 showed no significant or trace of Cr in any of the samples. Result obtained is in tandem with the submission of USDA (2011) which was 0.01 mg/100g for boiled peanut, while it was less in the submission

of 7.5mg/100g. Chromium helps in stimulating fatty acid and cholesterol synthesis and also in brain function, its high intake can lead to renal failure, thrombocytopenia, dermatitis and hypoglycemia (Vincent, 2003).

Recommendations

From the findings, roasted peanuts should be taken since it contains more of the mineral elements among others. It is also recommended that organizational initiatives and grater commercialization of peanuts should be taken as a dual approach to build a healthy population.

Conclusion

This study has shown that roasted peanuts contained higher mineral compositions such as Cu, Mg, and Ca and K, which are essential for human growth and development. Its consumption is advised.

REFERENCES

- Alana, B. (2020). Copper toxicity symptoms and treatment. *Medical News Today*. Retrieved on November 30, 2020.
- Anyasor, G. N., Ogunwenmo, K. O., Oyelana, O. A., Ajayi, D. & Dangana, J. (2009). Chemical analysis of peanuts (*Arachis hypogaea*) oil. *Pak. Journal Nutri.*, 8(3), 269-272.
- AOAC (1948). Official methods of analysis, association of official analytical chemists, Washington DC USA.
- Arya, S. S., Chauhan, S. & Salve, A. (2015). Food engineering and technology department. Institute of chemical technology. Nig Pariklin Marg. Matunga Mumbai - 400010, India, p.59.
- Asibuo, J. Y., Arkromah, R., Safo-Kantanka, O. & Adu-Dapaah, K. (2008). Evaluation and nutritional quality of peanuts (*Arachis hypogaea* L.) from Ghana. *Afr. Journal Food Agric. Nutri. Dev.*, 8(2): 134 – 141.
- Atasie, V. N., Akinhanmi, T. F. & Ojiodu, C. C. (2009). Proximate analysis and physicochemical properties of peanuts (*Arachis hypogaea* L.). *Pak. Journal Nutr.*, 8(2): 194 – 197.
- Francisco, M. L. Resurrection, A. V. (2008). Functional components in peanuts. *Critical Reviews in Food Science and Nutrition*, 48(8): 715 – 746.
- Institute of Medicine, Food and Nutrition Board (2000). *Dietary reference intake for vitamin C, vitamin E, selenium and carotenoid*. Washington DC: National Academy press, pp. 10. 13.
- Institute of Medicine, Food and Nutrition Board (2001). *Dietary reference intake for vitamin A, vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, silicon, vanadium and zinc*. Washington, DC: National Academy press, pp. 3-8.
- Johnston, C. A., Tyler, C., McFarlin, B. K., Poston, W. S., Haddock, C. K., Reeves, R. S., & Foreyt, J. P. (2009). Effects of a school-based weight maintenance program for Mexican-American children: Result at 2 years. *Obesity* (Silver Spring).
- Kabiru, H. D., Yinusa, I., Adam, D. S. & Abdulmalik, M. F. (2019). Physicochemical characterization and antimicrobial properties of *Nauclea latifolia* (Smith) seed oil. *FUDMA Journal of Science (FJS)*, 3(4): 372 – 379.
- Miret, S., Simpson, R. J., & Mckie, A. T. (2003). Physiology and molecular biology of dietary iron absorption. *Annual Review of Nutrition*, 23: 283-301. Doi:10.1146/annurev.nutr.23.011702.073139.
- Rude, R. K., Shils, M. E. (2006). Magnesium. In: Shils, M. E., Shike, M., Ross, A. C., Caballero, B., Cousins, R. J. eds. *Modern nutrition in health and disease*. 10th ed. Baltimore: Lippincott Williams and Wilkins, 223 – 247.

- Sarvamangala, G., Gowda, M. C., Varshney, R. (2011). Identification of quantitative trait loci for protein content, oil content and oil quality for peanuts (*Arachis hypogaea* L.). *Field Crops Research*. 122:49-59.
- Schwalfenberg, G. K. (2011). Alkaline diet: Is violence that an alkaline pH diet benefits health. *Journal of Environment Public Health*, 727630. Retrieved on July 6, 2021 from <http://www.Ncbi.nlm.nih.gov/pmc/articles/PMC3195546>.
- Settaluri, V. S., Kandala, C. V. K., Puppala, N., & Sundaram, J. (2012 a). Peanuts and their nutritional aspects - A review. *Food and Nutrition Science*, 3: 1644-1650. <http://dx.doi.org/10.4236/fns2012.312215>.
- Settaluri, V. S., Kandala, C. V. K., Puppala, N. & Sundaran, J. (2012 b). Food and nutrition sciences. *Peanuts and their Nutritional aspect*. A review 3rd ed., 1644 – 1650.
- Suchoszek-Lukaniuk, K., Jaromin, A., Korycinska, M., & Kozubek, A. (2011). Nuts and seeds in health and disease prevention.
- Uche, S. N., Charity, U. N., Idowu P. (2014). Groundnut as a source of protein seeds. *Journal of Food Processing*, 4(2): 22-32.
- USDA: <http://www.nal.usda.gov/fnic/foodcomp/search>
- Vicent, J. B. (2003). The potential value and toxicity of chromium picolinate as a nutritional supplement, weight loss agent and muscle development agent. *Sports Med.*, 33: 213 – 230.
- Wang, Q. (2017). Peanut processing characteristics and quality evaluation springer.
- World Health Organization. (2021). Global health observatory regulations and controls on lead paint.