

# Changes in Nutrient and Phytochemical Composition of Processed Tigernut (*Cyperus esculentus* L)

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**Abstract:** The study investigated Changes in Nutrient and Phytochemical Composition of Processed Tigernut (*Cyperus esculentus* L). Tiger nut also known as Earth-almond was purchased as dried Earth-almond tubers; carefully selected to remove dust particles and shared into four sets. The first set designated as Earth-almond air dried (EAA<sub>d</sub>) was further air-dried for four days and blended using laboratory miller. The second, third and fourth sets were soaked in water for four days to rehydrate. After which, the following processing methods were applied to sets 2, 3 and 4; blanching at 80°C for 10 minutes (Earth-almond blanch - EAB), allowed to ferment for 4 days (Earth-almond fermented - EAF) and dehydrated (Earth-almond dehydrated - EAD) by oven drying at 60°C for 3hrs after rehydration respectively. The 2nd – 4th sets were then oven dried at a temperature of 60°C for 17 hours before milling into flour. Results of proximate analysis shows that EAF had the highest protein (8.37 ±0.12), carbohydrate (49.01 ±0.17) and ash (6.20 ±0.12). The highest lipid (7.55 ±0.06) and crude fibre (19.50 ±0.23) was recorded for EAD, while the highest moisture content was recorded for EAB (19.71 ±0.35). EAF had significantly (p<0.05) improved mineral and amino acid contents; while processing generally reduced the phytochemical content when compared with the air- dried sample (EAA<sub>d</sub>).

**Keywords:** Changes, Nutrient, Phytochemical Composition, Tiger Nut

## 1. Introduction

Macronutrients, micronutrients, phytochemicals, as well as antinutritional factors present in foods, interacts with different components within food matrices. The interactions result in insoluble complexes with reduced bio-accessibility of nutrients through binding and entrapment thereby limiting their release from food matrices. The interactions of nutrients with antinutritional factors are the main factor hindering nutrients release [1]. Different processing methods are commonly used to disrupt these interactions and make nutrients and phytochemicals free and accessible to digestive enzymes [2]. Food processing can lead to improvements in, or damage to, the nutritional value of foods. Without food processing it would not be possible to sustain the needs of

modern urban populations, and the choice of foods would be limited. The seasonality of agricultural produce also necessitates processing of products so that they are available throughout the year. Processing of agricultural products is done to improve consumer acceptability while retaining its nutritional value. Processing technique such as blanching, fermentation, germination etc are means of improving the nutritional value of foods [2, 3].

Tiger nut or Earth almond (*Cyperus esculentus*) is a non-conventional and under-utilized tuber which belongs to the family *Cyperaceae* and is native to Mediterranean and tropical regions. It produces rhizomes from the base of the tuber that is somewhat spherical. It is known in Nigeria as “Aya” in Hausa, “Ofio” in Yoruba and “Akiausa” in Igbo [3]. Three varieties (black, brown and yellow) are cultivated in these region but only two varieties, yellow and brown are readily available in the

market. The yellow variety is preferred to others because of its inherent properties such as colour, size and fleshy appearance. It is widely used for human and animal consumption as a nutritious food and feed in Africa, Europe and America [4]. The food uses of Earth-almond include feeding of cattle and pigs with the chaff. It also serves as food for poultry. Tiger nut tubers are diuretic and can be used as stimulant and tonic and in the treatment of flatulence, indigestion, diarrhea, dysentery and excessive thirst [5]. In addition, tiger nut has been reported to contain higher essential amino acids than those proposed in the protein standard by FAO/WHO (1995) [6] for satisfying adult needs for protein [7]. Researchers have developed phyto milk of acceptable quality from tiger nut tubers [8, 9]. Possible industrial application of tiger nut tubers has also been investigated [10]. Although, studies have been carried out on processing methods such as germination, soaking and fermentation with tiger nut [1, 3], there is dearth of information on the effects of blanching, dehydration and air-drying processing methods on the phytochemical and nutritional composition of tiger nut. This study therefore investigated effect of these processing methods on Phytochemicals and Nutrient composition of tiger nut (Earth-almond).

## 2. Materials and Methods

The Earth-almond (tiger nut) was purchased from Bori camp market in Obio/Akpor Local Government Area of Rivers State, Nigeria. All chemicals/ reagents used in this study were of analytical grade.

### 2.1. Sample Preparation of Earth-almond

Dried Earth-almond tubers were carefully selected to remove dust particles and divided into four sets. The first set was further air-dried (EAA<sub>d</sub>) for four days and blended using laboratory miller. The second, third and fourth sets were soaked in water for four days to rehydrate. After which the following processing methods were applied; blanching at 80°C for 10 minutes (EAB), soaking in water to ferment for 4 days (EAF) and dehydrated (EAD) by oven drying again after rehydration respectively. The 2nd – 4th sets were then oven dried at a temperature of 60°C for 17 hours before milling into flour. They were all sieved through 100 mesh size screen and the flour was stored in a sealed container at 4°C until further use.

## 3. Results and Discussion

### 2.2. Proximate Analysis of Processed Earth-almond

The processed Earth-almonds were analysed for moisture content, ash content, crude fibre, crude fat and crude protein as prescribed by the standard setup of AOAC (1990) [11]. Total carbohydrate was determined by simple difference method.

### 2.3. Determination of Mineral Content of the Processed Earth-almond

Minerals were analyzed by dry-ashing 1g each of each of the processed sample at 550°C in a muffle furnace. The ash obtained was dissolved in 10% HCl, filtered through an acid-washed filter paper and made up to standard volume with deionised water. Sodium, potassium, calcium, magnesium, iron, manganese and phosphorus were determined using Varian AA240 Atomic Absorption Spectrophotometer according to the method of APHA (1995) [12] Phosphorus content was determined by employing the method reported by Vanado Molybdate and read on CECIL CE 3041 colorimeter.

### 2.4. Determination of Amino acid Content of the Processed Earth-almond

Amino acids composition of processed samples was measured as hydrolysate using an amino acid analyzer (Sykam-S7130) based on high performance liquid chromatographic technique. Sample hydrolysis was prepared following the method of Spackman *et al.*, (2006) [13]

### 2.5. Determination of Phytochemical Composition of the Processed Earth-almond

The processed samples were subjected to various sample preparation stages using standard laboratory procedures for the determination of phytochemicals. Standard methods were used to determine the phytochemical contents in the processed samples: alkaloid [14], flavonoids [15] and saponin [16]

### 2.6. Statistical Analysis

Results were expressed as mean values and standard deviation of replicate determinations. The obtained data were analysed using a one way Analysis of Variance (ANOVA) using Statistical Package for Social Science (SPSS) version 20.0 Software 2011 (Soft Inc. Tulsa, USA) to test the level of significance ( $p < 0.05$ ). Duncan New Multiple range Test was used to separate the means where significant differences existed.

Table 1. Proximate Composition of processed Earth-almond (%).

Nutrients	EAA <sub>d</sub>	EAB	EAF	EAD
Carbohydrate	48.01 ± 0.05 <sup>a,b</sup>	47.40 ± 0.17 <sup>a</sup>	49.01 ± 0.17 <sup>b</sup>	46.88 ± 0.12 <sup>a</sup>
Protein	7.30 ± 0.06 <sup>a,b</sup>	6.82 ± 0.06 <sup>a</sup>	8.37 ± 0.12 <sup>b</sup>	5.90 ± 0.12 <sup>a</sup>
Lipid	6.06 ± 0.02 <sup>a</sup>	5.61 ± 0.12 <sup>a</sup>	5.90 ± 0.12 <sup>a</sup>	7.55 ± 0.06 <sup>b</sup>
Moisture	16.90 ± 0.46 <sup>a</sup>	19.71 ± 0.35 <sup>c</sup>	17.22 ± 0.12 <sup>b</sup>	15.16 ± 0.06 <sup>a</sup>
Ash	5.60 ± 0.06 <sup>a</sup>	4.97 ± 0.17 <sup>a</sup>	6.20 ± 0.12 <sup>b</sup>	5.01 ± 0.06 <sup>a</sup>
Fibre	16.13 ± 0.01 <sup>b</sup>	15.49 ± 0.12 <sup>b</sup>	13.30 ± 0.12 <sup>a</sup>	19.50 ± 0.23 <sup>c</sup>

Values are mean ± SD of replicate determination. Mean values followed by the different letters (a-d) in a row are significantly different ( $p < 0.05$ )

**Table 2.** Mineral Composition of Processed Earth-almond (mg/100g).

Minerals	EAA <sub>d</sub>	EAB	EAF	EAD
Manganese	1.35 ± 0.06 <sup>b</sup>	0.33 ± 0.06 <sup>c</sup>	1.46 ± 0.03 <sup>a</sup>	0.27 ± 0.06 <sup>c</sup>
Iron	14.28 ± 0.06 <sup>b</sup>	7.29 ± 0.06 <sup>c</sup>	16.00 ± 0.06 <sup>a</sup>	3.55 ± 0.06 <sup>d</sup>
Magnesium	60.26 ± 0.06 <sup>b</sup>	56.12 ± 0.58 <sup>c</sup>	63.00 ± 0.58 <sup>a</sup>	51.08 ± 0.58 <sup>d</sup>
Calcium	125.33 ± 1.15 <sup>b</sup>	120.29 ± 2.89 <sup>c</sup>	130.42 ± 1.15 <sup>a</sup>	110.25 ± 1.15 <sup>d</sup>
Sodium	7.90 ± 0.06 <sup>ab</sup>	5.28 ± 0.06 <sup>bc</sup>	8.10 ± 0.09 <sup>a</sup>	3.00 ± 0.06 <sup>c</sup>
Potassium	5.37 ± 0.06 <sup>a</sup>	3.99 ± 0.06 <sup>a</sup>	5.91 ± 0.04 <sup>a</sup>	3.12 ± 0.06 <sup>a</sup>
Phosphorus	131.90 ± 0.58 <sup>b</sup>	128.28 ± 1.15 <sup>b</sup>	135.08 ± 2.89 <sup>a</sup>	121.18 ± 0.58 <sup>c</sup>

Values are mean ±SD of replicate determination. Mean values followed by the different letters (a-d) in a row are significantly different (p<0.05)

**Table 3.** Amino Acid Composition of Tiger Nuts Processed (mg/100g).

Amino acids	EAA <sub>d</sub>	EAB	EAF	EAD
Glycine	4.74	3.64	5.65	2.74
Alanine	4.78	3.27	5.84	3.18
Serine	5.38	4.89	6.67	3.68
Proline	4.28	3.68	5.84	1.97
Valine	5.67	4.75	6.88	2.97
Threonine	6.93	6.54	7.68	5.78
Isoleucine	4.14	3.64	5.98	2.95
Leucine	6.64	5.65	7.99	3.76
Aspartate	4.57	2.78	6.78	2.69
Lysine	3.65	2.29	5.89	1.79
Methionine	6.68	4.50	7.08	1.08
Glutamate	7.57	5.25	9.19	4.74
Phenylalanine	6.57	5.75	7.57	4.90
Histidine	2.32	1.76	3.01	1.52
Arginine	4.66	3.55	6.79	2.35
Tyrosine	3.39	2.90	5.65	2.04
Tryptophan	1.15	1.09	2.06	0.86
Cysteine	3.65	1.96	4.67	1.84

**Table 4.** Phytochemical content of Processed earth-almond.

Phytochemicals	EAA <sub>d</sub>	EAB	EAF	EAD
Alkaloids	16.50 ± 0.03 <sup>a</sup>	15.90 ± 0.05 <sup>b</sup>	15.20 ± 0.12 <sup>b</sup>	15.20 ± 0.01 <sup>b</sup>
Saponin	11.90 ± 0.12 <sup>a</sup>	11.20 ± 0.10 <sup>a</sup>	10.50 ± 0.06 <sup>b</sup>	9.90 ± 0.12 <sup>b</sup>
Flavonoid	31.80 ± 0.17 <sup>a</sup>	30.60 ± 0.12 <sup>b</sup>	29.40 ± 0.17 <sup>c</sup>	30.20 ± 0.06 <sup>b</sup>

Values are mean ±SD of replicate determination. Mean values followed by the different letters (a-d) in a row are significantly different (p<0.05)

Results of proximate composition (Table 1) of the processed Earth-almond showed EAF to have the highest protein content (8.37 ± 0.12), carbohydrate (49.01 ± 0.17) and ash (6.20 ± 0.12). The highest lipid (7.55 ± 0.06) and crude fibre (19.50 ± 0.23) were recorded for EAD, while the highest moisture content was recorded for EAB (19.71 ± 0.35). Although there were little or no significance differences among the processed groups as shown in Table 1. The values obtained in this study fall within the range reported in literature [3, 17]. Fermentation decreased the fibre content and increased the protein, carbohydrate and ash contents. Increase in carbohydrate level is an indication of good source of energy because carbohydrate hydrolysis in the body, yields glucose, which can be utilized as energy or stored as glycogen in the muscle and liver for future use [18]. The effect of fermentation on proteins has yielded inconsistent results likely due to different experimental designs, study durations, and variation in the initial protein or amino acid profile of foods. Several studies had reported increase [19], while others observed decrease [20, 21] in protein and/or some amino acids upon fermentation. It appears that most of these effects may not reflect actual changes but

relative changes; due to loss of dry matter resulting from microbial hydrolysis of carbohydrates as source of energy. Increase in the ash content of EAF may be attributed to the fact that fermentation is one of the processing methods that are applied to free the complexed minerals present in the ash and make them readily bioavailable [20, 22]. The decrease in the ash content of the blanched Earth-almond could be due to leaching of some mineral elements into water [4]. Dehydrated Earth-almond (EAD) had the least moisture content due to the high fibre content because the higher the fibre content, the lower the water retaining capacity of the flour, which is an indication of a longer shelf life.

Mean values for mineral content of nutritional importance are presented in Table 2. Phosphorus (135.08 ± 2.89 mg/100g) was the predominant micronutrient element, followed by calcium (130.42 ± 1.15 mg/100g), magnesium (63.00 ± 0.58 mg/100g), iron (16.00 ± 0.06 mg/100g), sodium (8.10 ± 0.09 mg/100g), potassium (5.91 ± 0.04 mg/100g) and manganese (1.46 ± 0.03 mg/100g). A significant increase (p<0.05) of these minerals was observed in fermented sample when compared to EAA<sub>d</sub> sample. These values were lower

than those reported for raw tiger nut by Suleiman *et al.*, (2018) [23] and this could be attributed to different soil condition, climatic condition, season, water source and cultural practices adopted during planting cultivation [24]. The increase in mineral content during fermentation might be due to loss of dry matter, as microbes degrade carbohydrates and protein [25]. Fermentation also increases bioavailability of calcium, phosphorous, and iron likely due to degradation of oxalates and phytates that complex with minerals thereby reducing their bioavailability [26]. There are different mechanisms by which fermentation increases the mineral bioavailability. Firstly, fermentation reduces phytic acid that binds minerals making them free and more available [22]. Secondly, fermentation loosens the complex matrix that embeds minerals. Both phytase and  $\alpha$ -amylase make the matrix loose by degrading phytate and starch, respectively. The mineral levels obtained from these processed samples imply that it could be useful as supplements in human and animal nutrition. Mineral elements are needed in small proportions for the proper functioning of cells and tissues in the human system for healthy growth, and development [27].

The amino acid composition observed in the processed Earth-almond sample is shown in Table 3. Eighteen different amino acids were present. The most abundant essential and non-essential amino acids were found in EAF. These amino acids includes: leucine (7.99mg/100g), threonine (7.68mg/100g), phenylalanine (7.57mg/100g) and methionine (7.08mg/100g) for essential; while the most abundant non-essential amino acid was glutamate (9.19mg/100g). The least amino acid was tryptophan (0.86 mg/100g) as recorded for EAD. The results corroborates the findings of Effiong and Umoren (2011) [28] for alanine (2.70-4.37mg/100g), phenylalanine (4.28- 5.14mg/100g), tyrosine (2.37-3.32mg/100g), histidine (1.70- 2.37mg/100g) and arginine (4.32-6.21mg/100g) in processed horse eye bean. However, there were variations in the amino acid values recorded in this study when compared with values (10.22- 19.70g/100g) for raw and cooked black variety of tiger nut as reported by Aremu *et al.*, (2015) [29]. Among the different processing methods, fermentation recorded the highest value in all the observed amino acids. Erbas *et al.*, (2005) [30] reported that the amount of free amino acids (FAAs) increased significantly ( $p < 0.05$ ) during fermentation. Blanching and dehydration showed a significant reduction ( $p < 0.05$ ) in all amino acid composition when compared with EAF an EAA<sub>d</sub>. Erbas *et al.*, (2005) [30] also reported that dehydration decreased free amino acids and attributed it to Millard reaction and partial degradation of FAAs during dehydration. Some of the essential amino acids were found to compare favourably with Food and Agriculture Organization Standard (1998) [31]. Oyetayo and Agbaje (2012) [32] have earlier reported that amino acids of fermented Acha were higher than the raw sample. Also Oyetayo *et al.*, (2007) [33] reported that food rich in total essential amino acid will contribute to the supply of essential amino acid in diet.

The present study, revealed high level of flavonoids (29.40 $\pm$ 0.17- 31.80 $\pm$ 0.17 mg/100g), followed by moderate

amount of alkaloids (15.20 $\pm$ 0.12-16.50  $\pm$ 0.03mg/100g) and saponin (9.90  $\pm$  0.12-11.90  $\pm$  0.12 mg/100g). Processing generally reduced the level of phytonutrients present in the samples (Table 4). EAF recorded more reduction when compared with EAB and EAA<sub>d</sub>. Percentage reduction range for flavonoids, alkaloids and saponins include: 3.77-7.55%, 3.64- 7.88% and 5.88- 16.81% respectively when compared with EAA<sub>d</sub>. Adekanmi *et al.*, (2009) [34] also reported a reduction in phytonutrients of processed tiger nut. They observed that the alkaloid content of raw, soaked and toasted tiger nut were 2.63%, 2.29- 2.55% and 1.93- 2.30% respectively. The percentage reduction observed for soaking (13-48%) and toasting (25-65%) were higher compared to the percentage reduction observed with blanching, dehydration and fermentation in the present study. A similar trend was observed by Katarie *et al.*, (1998) [35] and Vjayakumari *et al.*, (1996) [36]. This variation could be attributed to the processing methods, time, temperature and seasons of planting. Phytochemicals are important plant secondary metabolic products produced in phenylpropanoid biosynthesis and shikimate pathways during the growth of plants [37]. Advances in research have revealed importance of these phytonutrients to human health by virtue of their antioxidant properties, cholesterol-lowering effect [38] and reduction in the production of pro-inflammatory cytokines and immunosuppressive cells [39]. The effect of fermentation on phytonutrients is not specific. Fermentation has significant effect on phytochemicals that are both beneficial and adverse. Fermentation of high-carotenoid biofortified maize resulted in significant loss of carotenoids [40] depending on the duration of fermentation process. Moreover, the microorganisms fermenting the foods can utilize these phytochemicals thus leading to their reduction [41]. Contrary to the above, Wang *et al.*, (2014) [42] investigated the effect of fermentation on antioxidant profiles of four cereals using *Bacillus subtilis* and *L. plantarum*. There was a significant increase in the total phenolic acid and total flavonoid contents with greatest increase in samples with starter culture.

## 4. Conclusion

The results obtained in this study, revealed that processing via fermentation (EAF) resulted to changes that improved the protein, carbohydrate, ash, mineral and amino acid contents of the tiger nut. High levels of lipid and crude fibre were recorded for dehydrated sample (EAD); while Phytochemical constituents were generally reduced by the various processing methods.

## References

- [1] Nkhata, S. G, Emmanuel A, Kamau, E. H. and Shingiro, J. (2018). Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. *Food Science and Nutrition*, 6 (8), 2446-2458.

- [2] Iyayi, E. A., Kluth H. and Rodehutsord, M. (2008) Effect of heat treatment on antinutrients and pre faecal crude protein digestibility in broilers of four tropical seeds. *International Journal of Food Science and Technology*. 43, 610-616.
- [3] Adejuyitan, J. A. (2011). Tiger nut processing: Its food uses and Health benefits. *American Journal of Food Technology*. 6 (3), 197-201.
- [4] Oladele, A. K. and Aina, J. O. (2007). Chemical Composition and Functional Properties of Flour Produced from Two Varieties of Tiger nut (*Cyperus esculentus*). *African Journal of Biotechnology*. 6 (21), 2473-2476
- [5] Chopral, R. N, Naya, S. I and Chopra, I. C. (1986). Glossary of Indian medicinal plants (including the supplement). *Canal of Scientific and Industrial Research*, New Delhi, 18-30.
- [6] FAO/WHO (1995). Energy and Protein requirement General Report of a Joint FAO/WHO/UWU expert consultation. *WHO Technical Report Series No 724*.
- [7] Bosch, L. and Alegna, A. (2005). Reverse-phase High Pressure Liquid Chromatography (RP-HPLC) determination of tiger nut and orgeal amino acid contents. *Food Science and Technology International*, 10, 30 – 40.
- [8] Abaejoh, R., Djomdi, I. and Ndojouenkeu, R. (2006). Characteristics of tiger nut (*Cyperus esculentus*) tubers and their performance in the production of a milky drink. *J. Food Processing and Preservation*, 30, 145-163.
- [9] Ukwuru, M. U., Omachona, L. J. and Onokah, N. (2008). Production and quality assessment of tiger nut (*Cyperus esculentus*) imitation milk during storage. *Journal of Food Science and Technology*, 45, 180 – 182.
- [10] Oderinde, R. A. and Tahir, O. A. (1988). Chemical investigation of Nigerian *Cyperus esculentus* (L) tuber for possible industrial applications. *Nigerian Journal of Science*, 22, 70 – 73.
- [11] AOAC (1990). Official Methods of Analysis. 15th Edition. Association of Official Analytical Chemists, Washington, D. C. U.S.A.
- [12] APHA- (1995). American Public Health Association. Standard methods. Washington.
- [13] Spackman, D. H., Stein, W. H. and Moore, S. (2006). Automatic recording apparatus for use in chromatography of amino acids. *Analytical Chemistry* 30, 1190-1206.
- [14] Harbone, Z. B. (1973). Phytochemical Methods: A guide to modern techniques of plant analysis, Chapman and Hall, London 113-185.
- [15] Bohn, B. A. and Kocipai-Abyazan, R. (1994). Flavonoids and condensed tannins from the leaves of Hawaiian *vaccinium valticulatum* and *V. calycinum*. *Pacific Science*, 48, 458-463.
- [16] Obadoni, B. O. and Ochuko, P. O. (2001). Phytochemical studies and comparative efficiency of the extract of some homeostatic plants in Edo and Delta states of Nigeria. *Global Journal of Pure and Applied Science*, 8, 203-208.
- [17] Aremu, M O, Olaofe, O. and Akintayo, E. T. (2006). Compositional evaluation of Cowpea (*Vigna unguiculata*) varieties and Scarlet runner bean (*Phaseolus cocineus*) varieties flour. *Journal of Food, Agriculture and Environment*, 4 (2), 39 – 43.
- [18] Esenowo, G. J. (2004). Developmental Biology and Plant Physiology. Abeam Publishing Co. Nigeria 23-168.
- [19] Doudu, K. G., Taylor, J. R. N., Belton, P. S. and Hamaker, B. R. (2003). Factors affecting sorghum protein digestibility. *Journal of Cereal Science*, 38, 117–131.
- [20] Pranoto, Y., Anggrahini, S. and Efendi, Z. (2013). Effect of natural and Lactobacillus plantarum fermentation on *in vitro* protein and starch digestibilities of sorghum flours. *Food Bioscience* 2, 46–52.
- [21] Osman, M. A. (2011). Effect of traditional fermentation process on the nutrient and antinutrient contents of pearl millet during preparation of Lohoh. *Journal of the Saudi Society of Agricultural Science*, 10, 1–6.
- [22] Lopez, Y., Gordon, D. T. and Fields, M. L. (1983). Release of phosphorous from phytate by natural lactic fermentation. *Journal of Food Science*, 48, 935–954.
- [23] Suleiman, M. S, Olajide, J. E, Omale, J. A., Abbah, O. C. and Ejembi, D. O. (2018). Proximate composition, mineral and some vitamin contents of tiger nut (*Cyperus esculentus*). *Clinical Investigation (London)* 8 (4), 161-165.
- [24] Steven, R. T., Vermon, R. Y. and Michael, C. A. (1985). Vitamins and Minerals. In: Fennema, O (Ed). *Food Chemistry*, (2nd Ed) Marcel Dekker, New York. 523.
- [25] Day, C. N. and Morawicki, R. O. (2018). Effects of fermentation by yeast and amylolytic lactic acid bacteria on grain sorghum protein content and digestibility. *Hindawi Journal of Food Quality*, 1–8.
- [26] Sriprya, G., Antony, U. and Chandra, T. S. (1997). Changes in carbohydrate, free amino acids, phytate and HCl extractability of minerals during germination and fermentation of finger millet (*Eleusine coracana*). *Food Chemistry* 58, 345–350.
- [27] Kalita, O., Mukhopadhyay, P. K. and Mukherjee, A. K. (2007). Evaluation of the nutritional quality of four unexplored aquatic weeds from North –East India for the formulation of cost effective fish feeds. *Food Chemistry*, 103, 204-209.
- [28] Effiong, O. O and Umoren, U. E. (2011). Effect of Multi pressing Techniques on the Chemical Composition of Horse Eye Bean (*Mucuna urens*). *Asian Journal of Animal Sciences*, 5 (5), 340-348.
- [29] Aremu, M. O., Bamidele, T. O., Agere, H., Ibrahim, H. and Aremu, S. O. (2015). Proximate Composition and Amino Acid Profile of Raw and Cooked Black Variety of Tiger nut (*Cyperus esculentus* L.) Grown in Northeast Nigeria. *Journal of Biology, Agriculture and Healthcare* 5 (7), 213-221.
- [30] Erbas, M., Ertugay, M. F. and Certel, M. (2005). The Effect of Fermentation and storage on free amino acids of tarhanna. *International Journal of Food Sciences and Nutrition*, 56 (5), 349-358.
- [31] Food and Agriculture Organisation (1998). Carbohydrates in human Nutrition. FAO, Food and Nutrition Papers No. 66, Rome, Italy.
- [32] Oyetayo, V. O. and Agbaje, R. B. (2012). Effect of different processing methods on the micronutrient and amino acid composition of *Digitaria exilis* (Kippist) Stapf. *Journal of Life Science*, 6, 365-369

- [33] Oyetayo, F. L., Akindahunsi, A. A. and Oyetayo, V. O. (2007). Chemical profile and amino acids composition of *Pleurotus sajor-caju*. *Nutrition Health*, 18, 383-389.
- [34] Adekanmi O. K, Oluwatooyin O. F, and Yemisi A. A (2009). Influence of processing techniques on the nutrients and antinutrients of tiger nut (*Cyperus esculentus*). *World Journal of Dairy Food Science*, 4, 88-93
- [35] Kataria, A., Chanhan, B. M. and Ghandi, S. (1988). Effect of domestic processing and cooking on the antinutrients of black gram. *Food Chemistry*, 30, 149-156.
- [36] Vijayakumari K., Siddhuraju P. and Janardhanan. K. (1996). Effect of different post-harvest treatments on antinutritional factors in seeds of the tribal pulse *Mucuna pruriens* (L.) DC. *International Journal Food Science and Nutrition*, 47, 263-272.
- [37] Zhang, G., Xu, Z., Gao, Y., Huang, X. and Yang, T. (2015). Effects of germination on the nutritional properties, phenolic profiles, and antioxidant activities of buckwheat. *Journal of Food Science* 80, 1111-1119
- [38] Golzarand, M., Mirmiran, P. and Bahadoran, Z. (2014). Dietary phytochemical index and subsequent changes of lipid profile: A 3-year follow-up in Tehran Lipid and Glucose Study in Iran. *ARYA Atherosclerosis*, 10, 203-210.
- [39] Lesinski, G. B., Reville, P. K., Mace, T. A., Young, G. S. and Ahn-Jarvis, J. (2015). Consumption of soy isoflavone enriched bread in men with prostate cancer is associated with reduced proinflammatory cytokines and immunosuppressive cells. *Cancer Prevention Research*, 8, 1036-1044.
- [40] Ortiz D, Nkhata, S., Buechler, A., Rocheford, T. and Ferruzzi, M. G. (2017). Nutritional changes during bio fortified maize fermentation (steeping) for ogi production. *The FASEB Journal* 31: 1.
- [41] Hubert, J., Berger, M., Nepveu, F., Paul, F. and Dayde, J. (2008). Effects of fermentation on the phytochemical composition and antioxidant properties of soy germ. *Food Chemistry* 109, 709-721.
- [42] Wang, C., Wu, S. and Shyu, Y. (2014). Antioxidant properties of certain cereals as affected by food grade bacteria fermentation. *Journal of Bioscience and Bioengineering* 117: 449-456.