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Vitamin C and Mineral Content of three Varieties of Maize at four different Water Soaking Temperatures

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Abstract
Mineral and vitamin deficiencies affect poverty-stricken people in developing countries in a disproportionate manner because poor people cannot afford a diversified diet. Food source such cereals and legumes provide nearly all the vitamins and minerals requirement of humans to maintain a healthy body but processing technique such as soaking tend to deplete the essential nutrients including vitamin C and minerals from these food sources. The effect of water soaking temperature on minerals and vitamin in maize varieties was investigated. Abotem, Abeleehi and Dorke SR varieties of maize were soaked at different water soaking temperatures of 30°C, 40°C, 50°C, and 60°C in a thermostatic water bath after which the vitamin C, and mineral (Mg, K, Na and Fe) contents were analyzed. As the soaking temperature increased, larger amount of vitamin C, Mg and K leached into the soaking water. However, for Fe, larger amount was leached into the soaking water at lower soaking temperatures. Sodium content increased as the water soaking temperature increased from 30 to 40 °C while a further increase in soaking temperature resulted in a decrease in Na content. Therefore, the retention of minerals and vitamins content in maize during soaking depended on the water soaking temperature and variety.

Keywords: Soaking; leaching; mineral content; vitamin content.

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I. Introduction

The nutritional value of maize, vegetables and fruits as major sources of energy, protein, dietary fibre, minerals and vitamins as reported by researchers have made them an indispensable component of the diet of Sub-Saharan Africans. The nutrients, especially minerals and vitamins which can be acquired relatively cheaper from maize are very important for animals and human body maintenance. In Sub-Saharan Africa (SSA), maize plays significant role in the economy and the diet of the people [1].

Different parts of the crop such as inflorescence, stalk, silk, leaves and kernels/grains are commonly used as foodstuff for humans, ingredient of homemade medicines, feedstuff for animals and source of fuel for light industries [2][3]. Research has shown that maize flour enhances the functional and nutritional quality of food when is blended with other cereal flours [4].

Maize is considered as a permanent global crop for fulfilling the nutritional requirements of humans, poultry and livestock [2]. Maize kernels contain phytochemicals, antioxidants and a good number of vitamins and minerals including vitamin C, sodium, potassium (28, 1360 mg/100 g dw, respectively), magnesium (0.1939 mg/g fw), calcium (0.1869 mg/g fw), zinc (0.0165 mg/g fw), manganese (0.0109 mg/g fw), and copper (0.0073 mg/g fw), iron (0.005 mg/g fw) [2][5][6].

Maize is demanded all year round, although it is a seasonal crop. Thus, the kernels have to be storeed so as to make them available during off-season. This requires a reduction in moisture content to prevent deterioration in storage in other to ensures prolonged shelf life. Dried kennels may be rehydrated or reconstituted by soaking it in water to facilitate processing operations, to impact characteristic flavour into the dough and to remove phytic acid. The presence of phytic acid in maize decrease the bioavailability of minerals due to its high chelating ability. Lestienne et al. [7] and Coulibaly et al. [8] in their studies found soaking to be quite effective for reducing phytic acid and thus leading to eventual increase in mineral bioavailability. It is therefore important to pay more attention to processing of maize as a means of maintaining functional and nutritional quality.

Different processing methods can have substantial effects on the amount of nutrient present in the resulting product [9]**.** Soaking as a processing technique results in alteration of nutritional quality of cereals and legumes which could manifested in either reduction in nutrients, phytochemicals and antinutrients or an improvement in digestibility or availability of nutrients [10]. Tunde-Akintunde [11] investigated the effect of soaking temperature and time on nutrient loss in dried bell pepper. He found that, at high temperatures, large amounts of vitamin C leached into the soaking water. He further indicated that, larger amounts of calcium and iron were leached into the soaking water at lower soaking temperatures.

Soaking maize kernels beyond certain temperature limit could lead to leaching of vitamins and minerals. A search in literature found soaking to be associated with significant decrease in mineral content [12]. However, reports on effects of soaking temperature on vitamins and minerals in maize varieties grown in Ghana is limited. Therefore, this research work focus on investigating the effects of soaking at different water temperatures on vitamin C and mineral content of selected varieties of maize.

II. Material And Methods

Materials Collection

Three varieties of matured and dried maize used for the study were obtained from Crops Research Institute's (CRI) farm at Fumesua, Kumasi, where cereals and legumes are breed. The kernels were authenticated by the Agronomy Section of the Council for Scientific and Industrial Research (CSIR), Fumesua, Kumasi. All the reagents used were of analytical grade. The chemical analysis was performed at the Chemistry and Food Science Department Laboratory of the Kwame Nkrumah University of Science and Technology, Kumasi-Ghana.

Preparation of Samples

Weighed samples of the varieties were soaked in a thermostatic water bath at four different temperatures of 30^{o}C, 40^{o}C, 50^{o}C, and 60^{o}C. Samples were separately placed in a bag made from nylon mosquito net, labelled and placed into the portable water bath. The samples were removed at a time interval of 60 min, quickly blotted the residual surface water on the kernels with tissue paper [13] and then reweighed [14][15]. The weight gain was monitored with electronic Compact Scale, SF-400C until subsequent increase in weight of soaked kernel was less than 0.01 g. The soaked samples were ground to form paste using electric blender. The paste obtained was placed in a zip-lock bag and stored in the refrigerator at 4°C for the quantitative analysis.

Determination of Mineral Content

The Method described by Obasi and Wogu [16] was used in the mineral determination. The samples were digested by wet-digestion procedure using combination of the following acids; Percholic, nitric and sulphuric acids. The digest obtained thereafter was used for the various analyses. De-ionized water was employed to avoid any interferences of minerals that may be present in the water. The, potassium and sodium were determined on the Jenway Digital Flame Photometer (PFP7 Model) adopting the filter corresponding to each mineral element. The other mineral elements were read at their respective wavelengths with their respective hollow cathode lamps using appropriate fuel and oxidant combination on a Perkin-Elmer Model 403 Atomic Absorption Spectrophotometer (AAS).

Determination of Vitamin Content

Vitamins C content was calculated using the titration method described by AOAC [17]. Ethanol was used to extract the vitamin c and was titrated against 2,6 -dichlorophenolindophenol. The vitamin C content was then computed using the formular:

$$\text{Vitamin C (mg/100 g)} = \frac{\text{Titre value} \times 0.606}{\text{Weight of sample}} \times 100$$

III. Results And Discussion

Processing of cereals may affect the nutritional quality and functionality of the resulting food products. The effects of soaking temperature on vitamin and mineral content (mg/100g) of selected varieties of maize is provided in **Table 1**. Temperature and variety variations influenced the amount of minerals and vitamin C content of the sample.

		Vitamin and Mineral Concentrations in mg/100g				
Sample	**T/°C**	**Vitamin C**	**Magnesium Mg**	**Potassium (K)**	**Sodium (Na)**	**Iron (Fe)**
ABOTEM	**30**	25.19	**40.51**	**454.25**	**1.514**	**10.64**
	40	21.67	**39.96**	**433.80**	**1.268**	**10.65**
	50	19.69	**39.63**	**379.55**	**2.270**	**11.79**
	60	15.93	**39.06**	**330.95**	**1.233**	**12.09**
ABELEEHI	**30**	21.80	**40.85**	**433.00**	**2.028**	**10.37**
	40	22.09	**40.25**	**411.85**	**2.622**	**10.60**
	50	17.99	**39.89**	**351.80**	**3.132**	**11.39**
	60	13.75	**39.50**	**286.80**	**2.417**	**12.59**
DORKE SR	**30**	18.14	**39.32**	**411.60**	**3.034**	**7.585**
	40	14.42	**38.915**	**344.75**	**3.872**	**9.385**
	50	12.58	**38.315**	**300.90**	**2.158**	**10.67**
	60	14.48	**37.745**	**281.40**	**2.281**	**10.67**

Table 1: Vitamin C and Mineral Content of Soaked Samples of Abotem, Abeleehi, and Dorke SR

Maize contains minerals which play a significant role in the maintenance of both animals and human health. The iron content of maize soaked at different temperatures of 30°C, 40 °C, 50 °C and 60°C ranges from 10.64 - 12.09 mg/100g for Abotem, 10.37 - 12.59 mg/100g for Abeleehi and 7.585 - 10.67 mg/100g for Dorke SR. **Figure 1** shows the influence of water temperature on the concentration of Fe in Abotem, Abeleehi and Dorke SR maize varieties. It was observed that soaking temperature had significant influence on the iron content of the sample studied. In all the samples, the iron content increased with increase in soaking temperature. This observation is in line with the results obtained by Tunde-Akintunde [11] which reported that larger amounts of calcium and iron were leached into the soaking water at lower soaking temperatures. The results showed that Abotem and Abeleehi retained highest amounts of 12.09 and 12.59 mg/100g respectively at 60°C while Dorke SR had its maximum of 10.67 at 50 °C and 60 °C. Maize is important source of iron which is a major constituent of blood and enzymes associated with transfer of electron. Its deficiency results in fatigue, headache and sore tongue in addition to anaemia [18]. Therefore, processing of cereals should result in minimum loss of iron as possible. Hence, soaking temperature of Abotem and Abeleehi should be <50°C

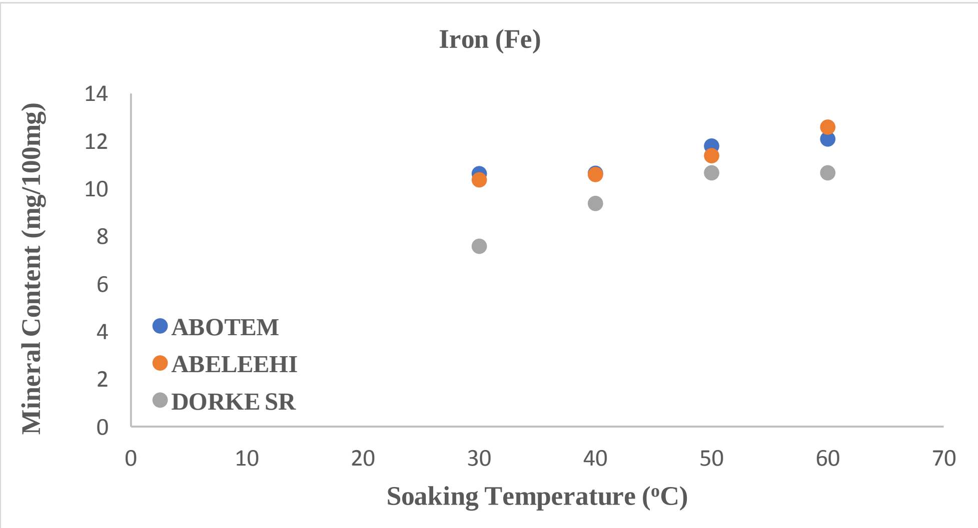

Figure 1: Iron content of soaked Abotem, Abeleehi and Dorke SR samples

Maximum amount of sodium was recorded at different soaking temperature. Abotem and Abeleehi retained highest amount of 2.270 and 3.132 mg/100g respectively at 50 °C while Dorke SR recorded the maximum of 3.872 mg/100g at 40°C as indicated in **Table 1**. The results of the study suggest that there was nonlinear relationship between the soaking temperature and the amount of Na retained after soaking. Therefore, for processing of Abotem and Abeleehi, soaking temperature of 50°C could be used to maximize Na retention during soaking. The amount of Na retained in Dorke SR increased as the soaking temperature increased from 30 °C to 40°C and decreased beyond this temperature as shown in **figure 2**.

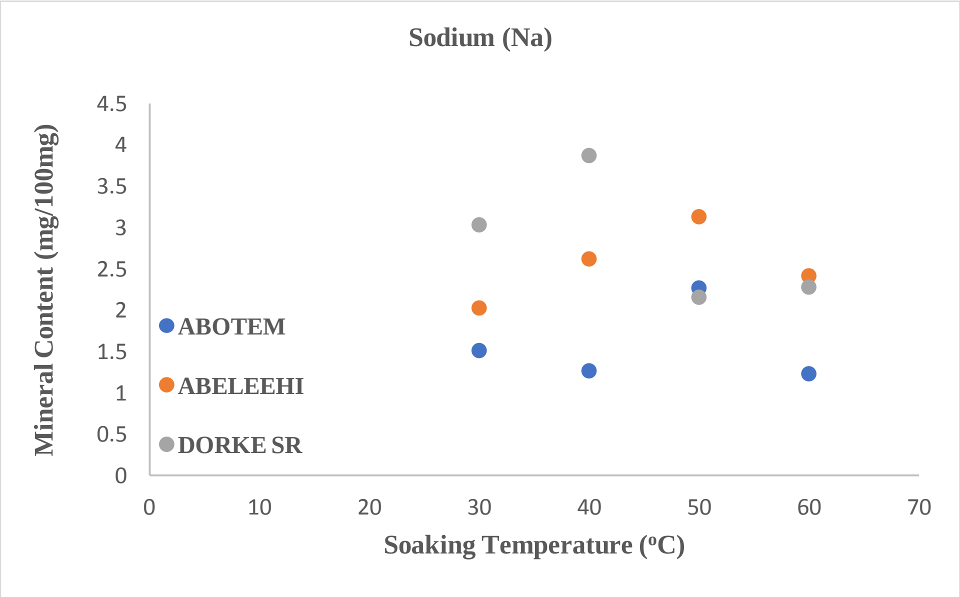

Figure 2: Sodium content of soaked Abotem, Abeleehi and Dorke SR samples

Sodium is needed by the body for the maintenance of osmotic pressure, acid-base balance, absorption of glucose and transmission of impulse [19].

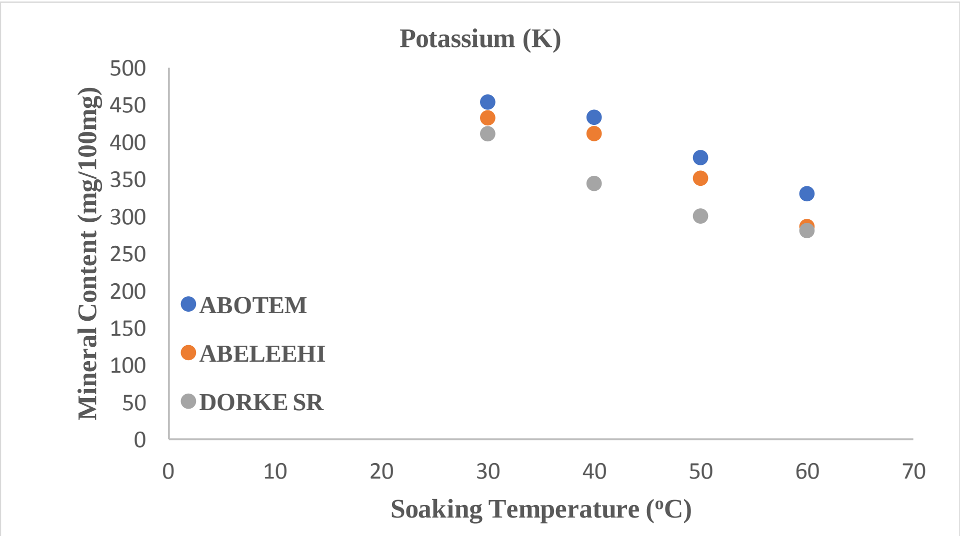

Fig. 3: Potassium content of soaked Abotem, Abeleehi and Dorke SR samples

The effect of soaking temperature on potassium content of selected maize varieties is shown in **Figure 3**. Potassium content of the samples varied as the soaking temperature increased. Strong influence of soaking temperature was observed during the study. The K content at different soaking temperatures ranges from 330.95 - 454.25 mg/100g for Abotem, 286.80 - 433.00 mg/100g for Abeleehi and 281.40 – 411.60 mg/100g for Dorke SR The results showed that higher contents of K was recorded at low soaking temperatures. Thus, increasing the soaking temperature of the kernels resulted in greater loss of K as shown in **figure 3**. The decrease could be attributed to the leaching of the mineral into the soaking medium as a result of increased temperature. Elmaki et al. [20] made similar observation when they investigated the influence of soaking and ⁄ or cooking on minerals in cultivars of white beans. They found that increasing the soaking temperature of beans and discarding the soaking water resulted in greater loss of minerals.

K increased could be attributed to the leaching of the minerals into the processing water as well as high cooking temperature which could have caused loss of some of these minerals. However, the rate at which K was lost during the soaking process was not the same. This could be as a result of differences in variety.

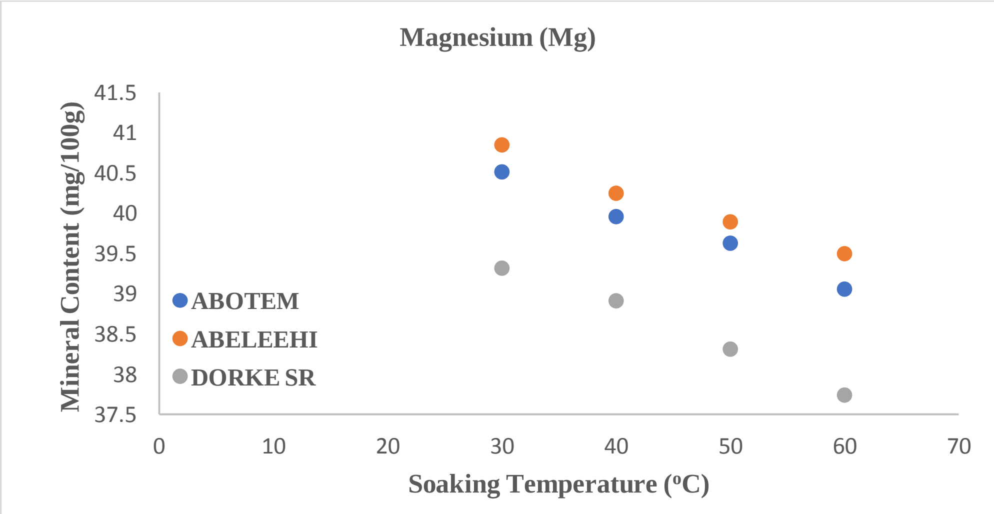

Figure 4: Magnesium content of soaked Abotem, Abeleehi and Dorke SR samples

The magnesium content of all the samples reduced with increase in soaking temperature. Within the temperature range of 30 to 60 °C, the Mg content decreased from 40.52 to 39.06 mg/100g, 40.85 to 39.50mg/100g and 39.32 to 37.74 mg/100g for Abotem, Abeleehi and Dorke SR respectively. **Figure 4** shows the influence of soaking temperature on Mg concentrations in the samples. The results suggest that, probably, the temperature acted as catalyst that helped the breakdown of the cell wall of the kernels thereby created large surface area that led to leaching of Mg during the soaking process. Since there was no published report on effect of soaking temperature on mineral retention of maize variety, direct comparison of the results of this study cannot be provided. However, the trend observed in this study is similar to observation made by Omafuvbe and Oyedapo [21] and Omafuvbe et al. [22] that large surface area contributed to the loss of mineral content during boiling of African oil bean and soybean kernels

From **Table 1**, the amount of vitamin C present in the varieties decreased with increase in water soaking temperature. This implies that larger amount of the vitamin leached into the soaking water at higher temperatures. The observed trend as shown in Figure 5 may be due to water-soluble nature of the vitamin and thus dissolves in the soaking water. Also, the ability of heat to destroy vitamin C [23] may have accounted for low levels of vitamin C at higher soaking temperatures. The results confirm earlier report by Abiodun and Uchenna [24] that some water-soluble vitamins are readily destroyed by boiling and cooking process.

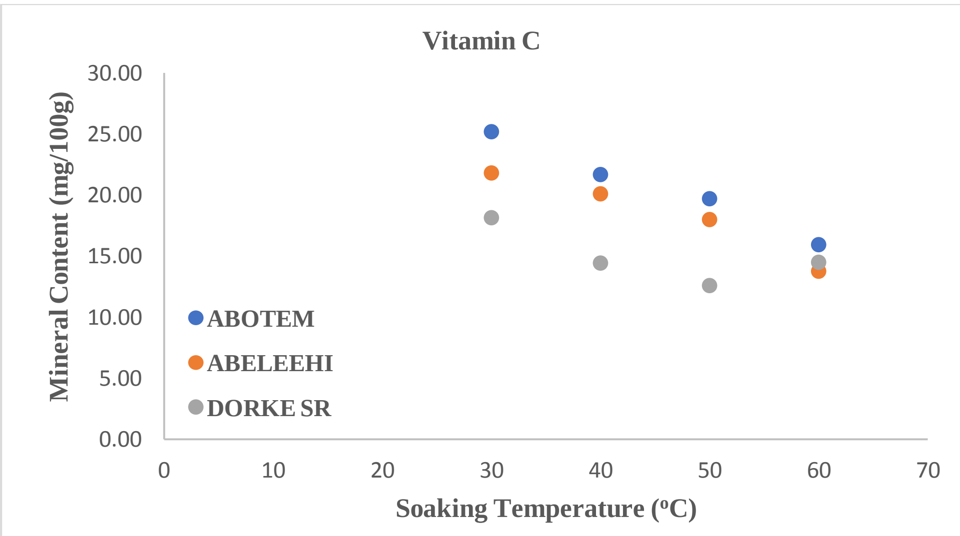

Figure 5: Vitamin C content of soaked Abotem, Abeleehi and Dorke SR samples

Vitamins are required to regulate growth and maintenance of the human body and also control the metabolic process in the cell. Because the body is unable to produce enough vitamin C by itself, the food must supply all the vitamin C required by the body. Thus, any processing technique that will results in high depletion of vitamin C from the food material before consumptions is undesirable.

IV. Conclusion

This study has shown that soaking of maize at different water temperatures had effects on the mineral and vitamin C contents. Although, the Fe content of the maize varieties increased at higher soaking water temperatures, the amount of vitamin C and the other minerals leached into the soaking water were higher at these temperatures, therefore, soaking at higher temperatures could cause a reduction in food quality and functionality. These vitamins and minerals are highly indispensable because they are needed for the proper functioning of body muscles, nerves and cells and as much as possible every effort should be made to minimize the loss of these nutrients during processing. This implies that soaking needs to be optimised so as to obtain re-hydrated maize of good quality.

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Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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Conflicts of Interest

The authors declare that there was no conflict of interest in respect to the publication of this article.

References

[1]. Badu-Apraku, B. and Fakorede, M.A.B (2017). Maize in Sub-Saharan Africa: importance and production constraints," *Advances in Genetic Enhancement of Early and Extra-early Maize for Sub-Saharan Africa*, Cham, Switzerland: Springer International Publishing

[2]. Nuss E. T, Tanumihardjo S. A. Maize: A paramount staple crop in the context of global nutrition. Comprehensive Reviews in Food Science and Food Safety. 2010; **9**:417-436.

[3]. Naqvi S, Ramessar K, Farré G, Sabalza M, Miralpeix B, Twyman RM, et al. High-value products from transgenic maize. Biotechnology Advances. 2011; 29:40-53

[4]. Nawaz H, Shad MA, Mehmood R, Rehman T, Munir H. Comparative evaluation of functional properties of some commonly used cereal and legume flours and their blends. International Journal of Food and Allied Sciences. 2015; **1**:67-73

[5]. Emmanuel SA, Olajide O, Abubakar S, Akiode SO, Etuk-Udo G. Chemical evaluation, free radical scavenging activities and antimicrobial evaluation of the methanolic extracts of corn silk (*Zea mays*). Journal of Advances in Medical and Pharmaceutical Sciences. 2016; **9**:1-8

[6]. Jana ŽS, Janković M, Basić Z, Vančetović J, Maksimović V. Antioxidant activity, phenolic profile, chlorophyll and mineral matter content of corn silk (*Zea mays* L): Comparison with medicinal herbs. Journal of Cereal Science. 2016; **69**:363-370

[7]. Lestienne I., Icard-Vernière C., Mouquet C., Picq C., & Trèche S. Effects of soaking whole cereal and legume seeds on iron, zinc and phytate contents. Food Chemistry. 2005; 89: 421–425

[8]. Abdoulaye Coulibaly, Brou Kouakou and Jie Chen. Phytic Acid in Cereal Grains: Structure, Healthy or Harmful Ways to Reduce Phytic Acid in Cereal Grains and Their Effects on Nutritional Quality. American Journal of Plant Nutrition and Fertilization Technology**.** 2011; 1: 1-22.

[9]. Suri D.J. and Tanumihardjo S.A. Effects of Different Processing Methods on the Micronutrient and Phytochemical Contents of Maize: From A to Z. Comprehensive Reviews in Food Science and Food Safety. 2016; 15: 912-926. https://doi.org/10.1111/1541-4337.12216

[10]. Morteza Oghbaei & Jamuna Prakash. Effect of primary processing of cereals and legumes on its nutritional quality: A comprehensive review, Cogent Food & Agriculture. 2016; 2:1, 1136015, DOI: 10.1080/23311932.2015.1136015

[11]. Tunde-Akintunde TY. (2010). Water Absorption Characteristics of Nigerian Acha (Digitaria exilis). International J. of Food Engineering. 2004; 6(5):1556-3758.1650. Available at: http://www.bepress.com/ijfe/vol6/iss5/art11

[12]. Bressani R, Turcios, JC, Colmenares de Ruiz AS. and Palacios de Palomo, P. (2004). Effect of processing conditions on phytic acid, calcium, iron and zinc contents in lime-cooked maize. J. Agric. 2004; pp. 1157-1162

[13]. Seyhan-Gurtas F, Ak MM and Evranuz EO. Water diffusion coefficients of selected legumes grown in Turkey as affected by temperature and variety. Turkish Journal of Agriculture. 2001; 25: 297-304

[14]. Fan LT, Chu PS. and Shellenberger, J. A. Diffusion of water in kernels of corn and sorghum. Cereal Chemistry. 1963; 40:303-313.

[15]. Lu, R.; Siebenmorgen, T. J. and Archer, T. R. (1994). Absorption of water in long-grain rough rice during soaking. Journal of Food Process Engineering. 1994; 17:141-154. https://doi.org/10.1111/j.1745-4530.1994.tb00332.x

[16]. Obasi NE and Wogu CO. Effect of soaking time on proximate and mineral compositions and anti-nutritional factors of yellow maize (zea mays). Nigerian Food Journal. 2008;26(2): 69 – 77.

[17]. AOAC. Official method of analysis, 14th edition, Association of Official Analytical Chemists Washington DC, USA, 2005

[18]. Onigbinde AO. Food and Human nutrition: Biochemical integration. In: biochemical interactions in food processing. Revised edn. Alva Corporate Organisation. Benin city. 2005; Pp 302-320.
[19]. Onimawo AI and Egbekun KM. Comprehensive food science and nutrition, revised edition, ambik press limited, Benin city, Edo State Nigeria. 1998; 87: 32 – 51.
[20]. Elmaki HB, Abdelrahaman SM, Idris WH, Hassan AB, Babiker EE & El Tinay AH. Content of antinutritional factors and HCl-extractability of minerals from white bean (Phaseolus vulgaris) cultivars: influence of soaking and ⁄ or cooking. Food Chemistry. 2007; 100: 362–368
[21]. Omafuvbe and BO Ayedapo OO. Biochemical changes during natural fermentation of African oil bean (Pentaclethra macrophylla) seeds. Nig. Journal of Nutrition Sci. 2000; 21:19 – 23.
[22]. Omafuvbe BO, Shonukan OO and Abiose SH. Microbiological changes in fermentation of soybean for "soy-daddawa"- a Nigerian food condiment. Food Microbiology. 2000; 17: 469 – 474.
[23]. Tull A. Food & nutrition (3rd). Oxford: Oxford University Press.
[24]. Abiodun AO and Uchenna CU. Mineral, vitamin and Antinutritional content of African Breadfruit (Treculia Africana) seeds lum Processed with Aum and Trona. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402, p- ISSN: 2319-2399. 2013;(5)5: 71-78. www.Iosrjournals.Org

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