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Effects of Dehulling On the Mineral Elements Content of Some Cereals (Maize, Millet, And Guinea Corn)

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ABSTRACT: *Cereals are grasses cultivated for the edible components of its grains which are composed of the endosperm, germ, and bran. However, to improve palatability and organoleptic qualities, most grains undergo further processing to yield better product, this processing includes dehulling, winnowing which may alter the nutritional composition of the resultant products to varying degree. The present study investigated the effect of dehulling on mineral content of cereals. Mineral elements composition in the undehulled and dehulled millet were: potassium (18.89 and 18.91) mg/kg, magnesium (14.13 and 14.26 mg/kg), calcium (44.12 and 48.15 mg/kg), zinc (5.28 and 5.33 mg/kg), iron (5.64 and 5.82 mg/kg) and copper (18.00 and 18.00 mg/kg) respectively. Undehulled and dehulled guinea corn were: potassium (17.45 and 15.29 mg/kg), magnesium (15.22 and 14.32 mg/kg), calcium (40.14 and 34.14 mg/kg), zinc (4.45 and 4.04 mg/kg), iron (4.49 and 5.37 mg/kg) and copper (17.02 and 18.48 mg/kg) respectively. Undehulled and dehulled maize were: potassium (64.24 and 48.17 mg/kg), magnesium (13.28 and 12.14 mg/kg), calcium (24.17 and 42.62 mg/kg), zinc (4.27 and 4.17 mg/kg), iron (6.09 and 5.41 mg/kg) and copper (16.00 and 15.27 mg/kg) respectively. Dehulling is inevitably and negatively affects the levels of desirable nutrients which are mostly located on the outer parts of some grains.*

KEYWORD: dehulling, mineral element, cereals, Nigeria

INTRODUCTION

Nearly two-thirds of the world's food production is made up of cereals, and along with pulses and oilseeds, form a major part of dietary proteins, calories, vitamins and minerals to the world population in general and to the developing world in particular (Betschart, 1982). Diet in developing countries is based mainly on cereals and legumes (FAO, 2009), and 68 to 98% of the cereals produced in these climes are directly used for human consumption. Globally, among plant-based foods, cereals are grown in over 73.5% of the world's arable lands (FAO, 2009). Agriculture is the main stay of Nigerian economy. A cereal is any grass cultivated for the edible components of its grain (botanically, a type of fruit called a caryopsis), composed of the endosperm, germ, and bran. Cereal grains are grown in greater quantities and provide more food energy worldwide than any other type of crop; they are therefore staple crop. Cereals are those members of the grass family, the Poeceace grown for their characteristic fruit, the caryopsis, which have been the most important sources of world's food for the last 10,000 years (Onwueme, 1991). Wheat and barley are the oldest cultivated cereals.

The role of cereals to modern society is related to its importance as food crop throughout the world. In most parts of Asia and Africa, cereals products comprise 80% or more of the average diet, in central and western Europe, as much as 50% and in the United State, between 20 - 25% (Onwueme, 1991).Cereals are the major dietary energy suppliers and provide significant amount of protein, minerals (potassium and calcium) and vitamins (vitamin A and C) (Idem and Showemimo, 2004). Cereals are consumed in a variety of forms, including pastes, noodles, cakes, breads, drinks etc. depending on the ethnic or religious affiliation. The bran, husk, plant parts and other residues (after processing) are useful as animal feeds and in the culture of micro-organism. The vast majority of these farmers have limited access to modern input and other productive resources are unlikely to have access to pesticides, fertilizers, hybrid seeds and irrigation without some form of public sector intervention (Ogunwole *et al.*, 2004). Some of major problems militating cereals production in Nigeria are climatic factors (rainfall, temperature and solar radiation), soil factors, migration, socioeconomic considerations and government policies, pests and diseases among others. The rate of growth of Nigeria's food production is 2.5% per annum in recent years, while food demand has been growing at the rate of more than 3.5% per annum due to high rate of population growth of 2.83% (Kolawole and Ojo, 2007).

Effect of dehulling of cereals
Dehulling simply means the removal of the covering or the stem and leaves from some grains, fruits, vegetables and seeds. However, to improve palatability and organoleptic qualities, most times, these grains undergo further processing to yield "better products". These processes include dehulling, dehusking, milling, etc. in Nigeria, this is mostly done traditionally by pounding using stone or wooden mortar and pestle. The first objective of this processing is usually to remove some of the fibrous outer layers of the grain called the hull or bran. Women and children labour hard and long to decorticate these grains to remove the outer layers of fibre which adversely affect the cooking quality and taste mouth-feel of the final product (Schmidt, 1992). The grain may first be moistened with about 10 percent water or soaked overnight helping the endosperm to break into small particles during pounding and the pericarp separated by winnowing, screening and sieving (FAO, 1995).

However, this may alter the nutritional composition of the resultant products to varying degrees (Oghbaei and Prakash, 2016). The outer parts of the kernels, especially the aleurone layer and the germ, tend to be richer in minerals when compared to the starch endosperm. Most vitamins and minerals (44.45%) are found in the germ and bran portions of grains, and these types of pre-processing techniques result in major losses (in descending order) of thiamine, biotin, vitamin B6, folic acid, riboflavin, niacin, and pantothenic acid; there are also substantial losses of calcium, iron, and magnesium (Fardet, 2010; Truswell, 2002).

MATERIALS

Chemicals/reagents: Nitric acid, hydrochloric acid and deionized water.
Apparatus/Materials: Atomic Absorption Spectrophotometer (AAS) (SavantAA), Weighing Balance (Model No.: BP12002).

Sample collection

The selected cereals; Maize, Sorghum (Guinea Corn) and Millet were obtained from Keffi main market, Keffi Local Government Area, Nasarawa State.

Sample preparation

The grains were cleaned and divided into two groups. One group was dehulled, winnowed and dried under mild sunlight, and then pulverized into flour using agate mortar and pestle, it was sieved using 2.0mm wire mesh sieve. The flour samples were then stored in an air tight polythene bags awaiting analyses. The second group was also given the same treatment as the first but without dehulling, and were used as control samples.

MINERAL ELEMENT DETERMINATION

Sample digestion

Samples were digested according to the method described by the Association of Official Analytical Chemists (AOAC, 2006). Samples 1 g each was weighed into 250 cm^3 conical flask, 20 cm^3 *aqua regia* (nitric acid and HCl in a ratio of 1:3) was added which was then evaporated on a hot plate in a fume cupboard until the brown fumes disappeared leaving the white fumes. The digest was brought down, allowed to cool and filtered (using Whatman No. 1 filter paper) into 50 cm^3 volumetric flask and was made up to mark with deionized water and was transferred into a clean sample bottle. It was properly labelled and kept awaiting atomic absorption spectrometric (AAS) analysis.

Mineral analysis

The digested samples were aspirated into an Atomic Absorption Spectrometer for mineral (Ca, Mg, K, Zn, Fe and Cu) analyses. Standard addition technique (SAT) was used to calibrate the instrument. Standards were prepared by serial dilution techniques within the concentration range of each metal determined using Analar grade reagents. The instrument was first calibrated with solutions of metal standards before the analyses. The same process was carried out to determine each of the metals in the samples using different lamps and appropriate blanks.

RESULT AND DISCUSSION

Results of mineral analysis

The result of the mineral elements composition in the undehulled and dehulled millet is shown in Table 3.1. The mineral composition of undehulled and dehulled were: potassium (18.89 and 18.91) mg/kg, magnesium (14.13 and 14.26 mg/kg), calcium (44.12 and 48.15 mg/kg), zinc (5.28 and 5.33 mg/kg), iron (5.64 and 5.82 mg/kg) and copper (18.00 and 18.00 mg/kg) respectively.

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The result of the mineral elements composition in the undehulled and dehulled guinea corn is shown in Table 3.2. The mineral composition of undehulled and dehulled were: potassium (17.45 and 15.29 mg/kg), magnesium (15.22 and 14.32 mg/kg), calcium (40.14 and 34.14 mg/kg), zinc (4.45 and 4.04 mg/kg), iron (4.49 and 5.37 mg/kg) and copper (17.02 and 18.48 mg/kg) respectively.

The result of the mineral elements composition in the undehulled and dehulled maize is shown in Table 3.3. The mineral composition of undehulled and dehulled were: potassium (64.24 and 48.17 mg/kg), magnesium (13.28 and 12.14 mg/kg), calcium (24.17 and 42.62 mg/kg), zinc (4.27 and 4.17 mg/kg), iron (6.09 and 5.41 mg/kg) and copper (16.00 and 15.27 mg/kg) respectively.

Table 3.1: Mineral element (mg/kg) composition of dehulled and undehulled millet

Parameter	**Dehulled**	**Undehulled**	**FAO/WHO (2001) RDA (mg/d)**
K	18.91±0.09	18.89±0.09	3,400
Mg	14.26±0.07	14.13±0.014	400
Ca	48.15±0.05	44.12±0.08	1,000
Zn	5.33±0.002	5.28±0.04	11
Fe	5.82±0.22	5.64±0.24	8
Cu	18.00±1.01	18.00±6.21	900

FAO -Food and Agricultural Organization
WHO -World Health Organization
RDA -Recommended Dietary Allowance

Table 3.2: Mineral element (mg/kg) composition of dehulled and undehulled guinea corn

Parameter	**Dehulled**	**Undehulled**	**FAO/WHO (2001) RDA (mg/d)**
K	15.29±0.051	17.45±0.41	3,400
Mg	14.32±0.11	15.22±0.05	400
Ca	34.14±0.036	40.14±0.014	1,000
Zn	4.04±0.05	4.45±0.41	11
Fe	5.37±0.16	4.49±0.18	8
Cu	18.48±0.09	17.02±0.04	900

FAO -Food and Agricultural Organization
WHO -World Health Organization
RDA -Recommended Dietary Allowance

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Table 3.3: Mineral element (mg/kg) composition of dehulled and undehulled maize

Parameter	Dehulled	Undehulled	FAO/WHO (2001) RDA (mg/d)
K	48.17±0.018	64.24±0.024	
Mg	12.14±0.018	13.28±0.127	40
Ca	42.62±0.042	24.17±0.29	400
Zn	4.17±0.0174	4.27±0.012	5.00
Fe	5.41±0.014	6.09±0.07	6.00
Cu	15.27±0.09	16.00±0.014	73.30

FAO -Food and Agricultural Organization
WHO -World Health Organization
RDA -Recommended Dietary Allowance

DISCUSSION OF RESULTS

The present study investigated the effect of dehulling on the levels of some minerals (K, Mg, Ca, Fe, Zn and Cu) of grains (guinea corn, millet and maize). The results revealed a positive effect of dehulling on the concentrations of K, Mg, Ca, Zn, Fe and Cu. This study shows that dehulling increases the K (18.91 mg/kg) content of millet, though it is in a close range with the undehulled millet (18.89 mg/kg). The concentration of Mg in both dehulled and undehulled millet is lower as compared to that of K in millet, the Mg content in dehulled millet (14.26 mg/kg) was slightly higher as compared to the concentration of Mg in undehulled millet (14.13 mg/kg). From the current study the concentration of Ca in undehulled millet (44.12 mg/kg) was lower than dehulled (48.15 mg/kg), Zn and Fe for undehulled millet (5.28, 5.64 mg/kg) was slightly higher than that of the dehulled (5.33, 5.82 mg/kg) respectively. The concentration of Cu for both dehulled and undehulled millet was found to be the same (18.00 mg/kg). This might be due to the fact that total separation of the millet was not possible because of the size, although, dehulling of grains is carried out to also reduce the levels of anti-nutrients.
The study by Joseph *et al.* (2020), shows high concentration of Fe, Zn and Mg (40.30, 38.53 and 311.06 mg/kg respectively) in undehulled millet which is different from the results obtained in the current study.
It has been found that the in vitro extractability and bioaccessibility of minerals such as calcium, iron, and zinc were increased in millet by germination; however, the antinutritional factors such as

phytic acid were decreased (Suma and Urooj 2011; Krishnan and others 2012). Furthermore, the relative in vitro solubility of iron was doubled by the germination of millet grains.

The results obtained in the present study for sorghum revealed a clear negative effect of dehulling on the concentration of K, Mg, Ca, Zn and Cu, the concentration of undehulled Fe (4.49 mg/kg) in guinea corn is lesser than that of the dehulled Fe (5.37 mg/kg). Concentration of K (400.00 mg/kg) in undehulled sorghum in a related study by Abdulrahman *et al.* (2016), was found to be higher as compared to that (15.22 mg/kg) obtained from undehulled guinea corn in the present study. Concentration of Mg for undehulled guinea corn (15.22 mg/kg) was found to be higher as compared to the dehulled guinea corn (14.32 mg/kg). The concentration of Ca for undehulled guinea corn (40.14 mg/kg) was also found to be higher as compared to that obtained for dehulled guinea corn (34.14 mg/kg). From the result of the current study for dehulled sorghum Zn, Fe and Cu (4.04, 5.37 and 18.48 mg/kg) was found to be higher as compared to the result obtained by Kiri *et al.* (2016) for concentration of Zn, Fe and Cu (0.3690, 0.1710 and 0.0044) in undehulled guinea corn.

The present study shows the concentration of Fe, Zn and Mg for dehulled guinea corn as 5.37, 4.04 and 14.32 mg/kg which is lower as compared to that obtained by Joseph *et al.* (2021) for Fe, Zn and Mg (37.16, 25.76, 155.93 mg/kg) respectively. This is opposite with a study by Pranoto *et al.* (2013), who reported that fermentation increases the magnesium, iron, calcium, and zinc content in some fermented foods that are commonly consumed in India. The iron content in dehulled sorghum (5.37 mg/kg) was in accordance to the work of Pranoto *et al.* (2013). Although phytin phosphorus has previously been reported to affect the bioavailability of many minerals, including of Fe and Zn in sorghum (Radhakrishnan and Sivaprasad, 1980), and that dehulling can remove 40 to 50 percent of both phytate and total phosphorus (FAO, 1995), this observed significant increase was demonstrated only during pearling of sorghum grains and relates specifically to ionisable iron and soluble zinc (SankaraRao and Deosthale, 1980).

From the results high concentration of K, Mg, Zn, Fe and Cu in undehulled maize was observed and lower concentration of Ca (24.17 mg/kg) as compared to the concentration of Ca (42.62 mg/kg) in dehulled maize. Undehulled maize was found to have the highest concentration of K (64.24 mg/kg), in a related study by Bello and Udo (2018) the concentration of K in undehulled maize was 42.24 mg/kg which is slightly lower than that obtain in the current study, while the concentration of K in the farmented maize was 50.28 mg/kg which is higher than that obtained from the current study (48.17 mg/kg) for dehulled maize.

The concentration of Ca in dehulled maize (42.62 mg/kg) was higher as compared to that which was obtained by Oluchukwu and Peter (2019) 0.059mg/100g for malted maize. Ca content for undehulled maize (24.17 mg/kg) was lower as compared to the concentration obtained for the dehulled maize (42.62 mg/kg).

The results obtained by Joseph *et al.* (2021) for Fe, Zn and Mg (31.46, 16.86 and 117.49 respectively) is higher as compared to that obtained in the current study for dehulled maize.

The result obtained for concentration of Zn from the present study (4.27-4.17 mg/kg) is in line with the recommended dietary allowance for zinc in children between the ages of 1 to 3years which is 3 mg/day, those between the ages of 9 to 13years is 8 mg/day. The RDA for zinc in male adult in male adult is 11 mg/day and for female adult is 8 mg/day (NIH, 2013).

It inevitably and negatively affects the levels of desirable nutrients which are mostly located on the outer parts of the grains. This further adds credence to the observations that most minerals and other micronutrients are located on the outer parts of grain kernels. The observations in the present study throw more light on the effects of dehulling and other processing practices on the levels of micronutrients in grains.

CONCLUSION

The practice of dehulling cereals to improve palatability and organoleptic qualities, most times, unwittingly leads to severe reduction or total loss of valuable nutrients. The findings in this investigation indicate that K, Mg, Zn and Cu are substantially lost when guinea corn and maize are decorticated Fe and Ca concentration varies when it is dehulled in guinea corn and maize respectively - a practice aimed at producing “better products” but unfortunately does more harm than good. From the present study it was observed that there was a positive effect on dehulling of millet as the dehulled millet has higher mineral concentration as compared to the undehulled millet. This might be due to the present of bran in the undehulled millet.

Recommendation

Insufficient consumption of minerals which are usually observed in some dehulled cereals are known to affect the performance and health of humans. Thus, mineral contents of food items are important and to estimate their daily dietary intake.

Due to lack of innovative cereals processing technologies to provide easy-to-handle, ready-to-cook or ready-to-eat, and safe products and meals at a commercial scale that can be used to feed large populations in urban areas, it is therefore recommended that dehulling should be encouraged in some cereals.

Evaluation of nutritive value and potential health benefits of cereals and their fractions in animal and human models should be performed in future research studies to support efforts for promoting their utilization as food.

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