UPTAKE OF IRON, COPPER AND ZINC BY SOME SELECTED NIGERIAN FOOD MATERIAL USING DIFFERENT GRINDING METHODS

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ABSTRACT

The uptake of iron, copper and zinc by cowpea, onion, pepper, tomato and maize from grinding stone, blender and disc attrition mill was studied. With grinding stone, the mineral uptake ranged between 0.00-1.1 mg/kg dry wt. With the blender, the range of uptake of iron, copper and zinc are 3.10-6.00, 0.00-0.09 and 0.00-0.35 mg/kg dry wt respectively. Similarly, with disc attrition mill, the range of uptake of iron is 11.10-28.00 mg/kg dry wt., copper is 0.10-4.03 mg/kg dry wt while zinc is 0.10 -1.35 mg/kg dry wt.

The result shows that generally, the uptake of metals was lowest using grinding stone, followed by blender and highest with disc attrition mill for the samples used in this study. Iron was significantly taken up from the three grinding devices; grinding stone ($p<0.05$), blender ($p <0.01$) and disc attrition mill ($p<0.01$) respectively. Copper and zinc were significantly taken up only from the disc attrition mil ($p<0.05$).

Keywords: Uptake, Nigerian food, iron, copper, zinc and grinding.

INTRUDOCTION

Pepper, tomato, onion, cowpea, maize and vegetables are usually subjected to one form of grinding before they are finally cooked for human consumption. In Nigeria, it is currently being done using grinding stone, blender and disc attrition mill. These grinding devices are made up of different materials of construction. Grinding stone, which is an igneous rock contains felspar, magnetite etc. These ores contain sodium, potassium, iron and some other metals. The blade of the blender made of stainless steel which is an alloy of iron, carbon, chromium, nickel and other metals. The disc attrition mill is made from scraps of metals, mostly iron. These grinding instruments which are either made up of metal or contain metals may readily release some of their metals as contaminants into food during grinding.

Many studies have shown that food processing, packaging and other technological processes, can significantly increase the total concentration of metals in food above acceptable limits (Concon, 1988; Creaser *et al.,* 1999; Jieun and Brittin 1995; Flint *et al.,* 1997). The accumulation of these metals can cause middle and long term health risks. Iron, an essential element in the manufacture of haemoglobin becomes toxic at high concentrations. Iron overload in the body leads to cirrhosis and deposition of iron in lungs, pancrease and heart (Corinne and Lawcer, 1977). Furthermore, it can cause disturbances in the liver function, as well as endocrine and cardiovascular effects (Robert, 1978). Copper is also an essential element, being part of number of copper proteins. The toxicity of copper has been linked to Wilson's disease which is characterized by excessive accumulation of copper in liver, brain and kidney (Lyon, 1980). Clinical abnormalities of the nervous system, kidney and liver are related to copper accumulation. Zinc, like copper as an essential element plays an important role in the metabolism of proteins and nucleic acids. It is essential for synthesis of DNA and RNA. Also, RNA polymerase is a zinc metalloenzyme (Fernandez - Madrid *et al.,* 1973; Fiabane and Williams, 1977). Zinc toxicity from usual intakes of dietary zinc has not been reported but pharacological amounts are not innocuous (Klevay, 1980). When patients with Sickle cell anaemia were given about 150 mg of zinc daily, some of them developed signs of copper deficiency (Prasad *et al.,* 1978). Also, young men treated with 150 mg of zinc daily displayed a substantial fall in plasma high-density lipoprotein cholesterol (Hooper *et al.,* 1980). The likehood of the toxic effects of these metals at high level of intake warrants our knowledge and study of the amounts of metals that could incidentally leach into common Nigerian foods during grinding. The objective of the present study was to determine the possible uptake of iron, copper and zinc by foods on adoption of different grinding methods.

MATERIAL AND METHODS

The onion, tomato, pepper, maize and cowpea in this study were purchased at Kuto market, Abeokuta, Ogun State of Nigeria. Moisture content of the market samples were determined using an air oven method of the Association of Official Analytical Chemist (AOAC, 1970). The stalks of the pepper and tomato were removed as well as the skin of the onion. The cowpea was soaked in distilled deionised water in a previously clean glass beaker for 30 minutes and manually dehulled. Maize was soaked in distilled deionised water for four days. The procedure was carried out in duplicate. The samples were than separately ground with grinding stone, blender and disc attrition mill. Each sample was also ground with pestle and mortar to determine the natural levels of the metals present. The pH of the paste of each sample was determined using a carefully calibrated pH meter (Pye Unicam Model PW 9418).

Thereafter, the pastes were oven-dried at 60°C for 48 hours. On cooling, the dried pastes were ground with pestle and mortar and stored in plastic bottles, 2g weight of each sample was ashed at 450°C in a muffle furnace. The ash was dissolved in 1:1 nitric acid, filtered and made up to 100cm³ in a standard flask with distilled deionised water (Osibanjo and Ajayi, 1980). The metal concentrations were determined by atomic absorption spectrophotometer (Perkin Elmer Instrument Model 403). The data generated were analysed statistically (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

The natural metal contents of the samples are shown in Table -1 while Table - 2 presents the levels of these minerals resulting from the use of different grinding methods. The values of minerals uptake are presented in Table - 3. The result generally shows that the uptake of the metals was lowest for grinding stone and highest for the disc attrition mill. The ranges of the total uptake of iron, copper and zinc from grinding stone, blender and attrition mill are 0.00-1.10, 0.00-6.00 and 0.10-28.00 mg/kg dry wt respectively. The uptake of iron compared to other metals was highest in the three grinding devices, with grinding stone having a range of 0.04 - 1.10 mg/kg dry wt, blender a range of 1.20-6.00 mg/kg wt and disc attrition mill with a range of 11.10-28.00 mg/kg wt. The uptake of iron is significant in all the three grinding devices ($p > 0.05$ for grinding stone, $p < 0.01$ for blender and $p < 0.01$ for disc attrition mill). The uptake of iron and copper from the disc attrition mill agrees with previous work (Akinpelu, 1992).

The blades of the blender and the disc attrition mill are composed mostly of iron, hence it is not surprising that the metal is picked up more by these equipments. Also, there is the possibility that the blades of the blender and disc attrition mill may have undergone rusting to some extent due to frequent use under wet conditions. This may probably contribute to more iron being leached into the food during grinding.

The disc attrition mill from which significant quantities of iron, copper and zinc were picked up is the popular choice for grinding by the urban dwellers. Contamination of food by metals during grinding could constitute a health risk since high levels of these metals have been shown to be toxic (Corinne and Lawcer, 1977; Robert, 1978; Lyon,

Table - 1 : Mean values of Iron, Copper and Zinc in the food samples: Mortar and Pestle Grinding (Natural levels)

Samples	pH	Moisture %	Iron mg/kg dry wt.	Copper mg/kg dry wt.	Zinc mg/kg dry wt.
Cowpea	6.6	33.1 ± 1.9	14.30 ± 0.16	2.13 ± 0.01	3.00 ± 0.10
Onion	5.7	90.1 ± 2.9	7.80 ± 0.10	4.75 ± 0.02	6.10 ± 0.20
Pepper	5.5	80.2 ± 1.8	15.10 ± 0.18	1.90 ± 0.01	3.15 ± 0.12
Tomato	4.3	91.2 ± 2.5	20.10 ± 0.14	1.55 ± 0.00	1.75 ± 0.03
Maize	3.0	47.9 ± 1.6	12.10 ± 0.12	4.43 ± 0.02	6.30 ± 0.20

Values are mean ± SD of duplicate determinations.

Table - 2 : Mean level of Iron, Copper and Zinc after grinding with grinding stone, blender and attrition mill

Food sample	pH	Iron (mg/kg dry wt) Grinding stone	Blender	Attrition mill	Copper (mg/kg dry wt) Grinding stone	Blender	Attrition mill	Zinc (mg/kg dry wt) Grinding stone	Blender	Attrition mill
Cowpea	6.6	15.10 ± 0.16	20.30 ± 0.16	30.00 ± 0.32	2.00 ± 0.04	2.13 ± 0.05	2.63 ± 0.05	3.00 ± 0.10	3.00 ± 0.10	3.80 ± 0.12
Onion	5.7	7.90 ± 0.10	9.00 ± 0.14	20.10 ± 0.18	4.80 ± 0.06	4.84 ± 0.12	4.85 ± 0.10	6.10 ± 0.22	6.20 ± 0.20	6.20 ± 0.20
Pepper	5.5	15.50 ± 0.18	18.20 ± 0.14	27.10 ± 0.28	1.90 ± 0.12	1.95 ± 0.10	4.80 ± 0.20	3.15 ± 0.12	3.50 ± 0.11	4.00 ± 0.15
Tomato	4.3	21.10 ± 0.20	24.20 ± 0.24	31.20 ± 0.29	1.58 ± 0.16	1.58 ± 0.06	5.58 ± 0.20	1.75 ± 0.04	1.80 ± 0.03	3.10 ± 0.10
Maize	3.0	13.20 ± 0.16	18.10 ± 0.20	40.10 ± 0.36	4.43 ± 0.20	4.43 ± 0.20	6.82 ± 0.24	6.20 ± 0.22	6.30 ± 0.20	6.50 ± 0.22

Values are mean ± SD of duplicate determination.

Table - 3 : Uptake of Iron, Copper and Zinc after grinding with grinding stone, blender and attrition mill

Food sample	pH	Iron (mg/kg dry wt) Grinding stone	Blender	Attrition mill	Copper (mg/kg dry wt) Grinding stone	Blender	Attrition mill	Zinc (mg/kg dry wt) Grinding stone	Blender	Attrition mill
Cowpea	6.6	0.80	6.00	15.70	0.00	0.00	0.58	0.00	0.00	0.80
Onion	5.7	1.10	1.20	12.30	0.05	0.09	0.10	0.10	0.10	0.10
Pepper	5.5	0.40	3.10	12.0	0.00	0.05	2.90	0.00	0.35	0.85
Tomato	4.3	1.00	4.10	11.10	0.03	0.03	4.03	0.00	0.05	1.35
Maize	3.0	1.10	6.00	28.00	0.00	0.00	2.39	0.00	0.00	0.20

Mean values are for duplicate determination.

1980). However, processing of pepper, tomatoes and onions into stew and of maize into fine paste (Ogi) or eko (porridge) involves substantial slurrying with water. This dilution effect stands to reduce the amount of the minerals as contaminants in these ground items.

Conclusion

Trace elements contaminants in food via processing should be strictly controlled so as to ensure that their metal concentrations do not exceed tolerance levels. The use of grinding stone, inspite of its time and energy constraints stands to be the most attractive of the three grinding techniques. The grinding stone is also the most acceptance in terms of its low cost, easy availability, durability and tolerable mineral uptake hence a negligible source of mineral toxicity. However, continuous surveillance of all processes during which contaminants can appear is the most effective approach to the prevention of contamination in food and foodstuffs.

REFERENCES

1. Akinpelu, O.A. Iron and Copper uptakes during the wet milling of some Nigerian Foods. *J. Food Sci. Tech.,* **29,** 10 (1992)
2. Association of Official Analytical Chemist (AOAC). Official methods of analysis, 11th edition Washington, DC (1970)
3. Concon, J.M. Food Toxicology, Dekker, New York (1998)
4. Corinne, H.R. and Lawcer, M.R., Normal and Therapeutic nutrition. Macmillan Publishers, New York, 5th ed. 112-115 (1977)
5. Creaser, C. and Purchase, R. Food contaminants: Sources and Surveillance; Royal Society of Chemistry, Cambridge, UK (1991)
6. Fernandez - Madrid, Prasad, F.A.S. and Oberleas, D. Effects of zinc deficiency on nucleic acids, collagen and non-collagenous protein of the connective tissue. *J. Lab. Clin. Med.,* **82:** 95 (1973)
7. Fiabane, A.M. and Williams, D.R. Principles of Bio-inorganic chemistry. The Chemical Society, Burlington House, London (1977)
8. Flint, G.N., Packirisamy, S. Purity of food cooked in stainless steel utensils. Foods Additives and Contaminants **14(2):** 115 (1977)
9. Hooper, P.L., Visconil, L., Garry, P.J. and Johnson, G.E. Zinc lowers High Density Lipoprotein Cholesterol levels, *J. Am. Med. Assoc.,* **244,** 1960 (1980)
10. Jieun, P., Brittin, H.C. Increased iron content of food due to stainless steel cookware. *Journal of the Americal Dietetic Association*, **97(6),** 659 (1995)
11. Klevay, L.M. Interactions of Copper and Zinc in cardiovascular Disease. *Ann. N.Y. Acad. Sc.,* **365:** 140-151 (1980)
12. Lyon, A. Monograph, an evaluation of carcinogenic risk of chemicals on humans; some metals and metallic compounds, Further Agency for Research on Cancer (IARC) **23,** (1980)
13. Osibanjo, O. and Ajayi, S.O. Trace heavy metals in the tree barks as indicators of atmospheric pollution, *Env. Int.,* **4,** 239 (1980)
14. Prasad, A.S., Brewer, G.J., Schoomaker, E.B. and Rabbani, P. Hypocupremia induced by zinc therapy in Adults., *J. Am. Med. Assoc.,* **240,** 2166 (1978)
15. Robert, A.G. "Toxic effects of metals" in toxicology. The Basic Science of Poison. Casarette and Doull's ed. Macmillan Publishers. New York, 284-20 (1978)
16. Steel, R.G.D. and Torrie, J.H. Principles and procedures of statistics, London, McGraw Hill (1960)