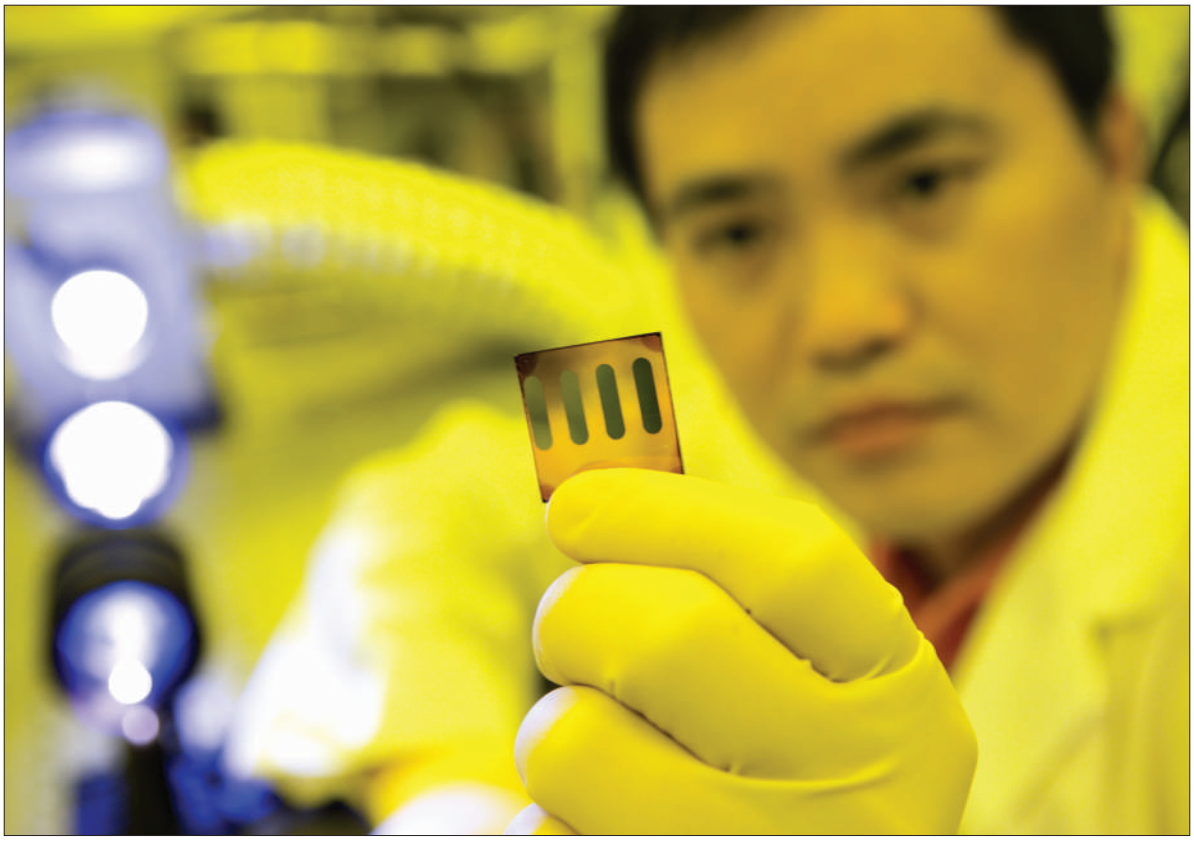

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Research Article
Interrelationship of Minerals in Non-alcoholic Beverages Marketed Within Akanu Ibiam Federal Polytechnic, Unwana, Nigeria

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Abstract

Background and Objective: Soymilk, kunnu and zobo are among the most appreciated and locally consumed non-alcoholic beverages in Nigeria. They contain minerals which are essential for a healthy life but at higher levels, may pose a health risk to humans. Thus, in order to guarantee food safety, the mineral composition, ratio and safety index of these beverages were investigation. These were done with a view to making sound nutritional considerations with respect to mineral safety and bioavailability. **Materials and Methods:** Samples were collected, digested and analyzed for essential and toxic elements using emission and absorption techniques. The concentration levels of elements determined were used to compute mineral ratios and safety indexes. **Results:** The results of the mineral compositions revealed no significant differences among most of the elements in the samples and the concentration levels of the non-essential elements were found below the recommended permissible limits except for cadmium. When the mineral ratios were computed, it was observed that the ratio of calcium relative to potassium in the entire drinks was below the ideal range, signifying available calcium for absorption might be impaired. Conversely, the ratio of iron to copper was above the standard range, indicating copper overloading. Overall, there were synergisms in the levels of essential elements in the drinks while antagonistic effect was observed with zinc in the entire samples, copper in soymilk and sodium in zobo. **Conclusion:** The interrelationships of minerals and their bioavailability in the beverages bared credence that the drinks are safe for human consumption.

Key words: Non-alcoholic beverages, mineral composition, dietary pattern, mineral safety index, mineral bioavailability

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Non-alcoholic beverages play a very important role in the dietary pattern of people in the developing countries like Nigeria. Most of these beverages are made up of about 90% water, sugar, flavouring agents and sometimes preservative in their production[1]. Soybeans (*Glycine max*) are used for the production of soymilk, millet grains (*Pennisetunglaucum*) for the production of kunnu and the calyces of roselle plant (*Hibiscus sabdariffa*), for the extract called zobo drink. All these plants are commonly grown in Nigeria especially in the Northern part of the country.

The non-alcoholic nature of these beverages makes them to be readily consumed by all and sundry as substitutes to alcoholic ones[2]. They are also very nutritious and of medicinal value. Many people depend on drinking these locally made beverages because they are of lower price compare to other processed fruit and soft drinks.

Minerals are known to be necessary for life and their deficiencies or overloading may result into one illness or the other[3,4]. Watts[5] noted that evaluating mineral profiles and knowing the concentration levels of these minerals alone is not enough to predict their absorptions and bio-availabilities, their interrelationships should be intricately considered. Several mineral ratios may collectively play a role in contributing to mineral imbalances, the interrelationships among mineral elements are of paramount important. This helps to determine the absorption of a certain mineral element relative to others in order to ensure it adequacy in the body[6]. This means that any potentially available part of a nutrient after gastrointestinal digestion should be attributed to its bioavailability. However, measuring the release and solubilisation of elements *in vitro* does not necessarily represent the efficiency with which they will be absorbed by the intestinal mucosa and used for metabolic functions. These are also partly dependent on factors such as disease states, physiological and developmental factors, the effects of other nutrients present and drug interaction[5,7]. Therefore, *in vitro* techniques are particularly useful to predict the release of minerals from meals and to identify underlying food factors that affect bioavailability without considering host-related influences. In the line of the above, this study was carried out not only to determine the mineral contents of these common disregarded drinks of health benefits but also to determine mineral interrelationships and their bioavailability.

MATERIALS AND METHODS

Sample collection: Samples of soymilk, kunnu and zobo drinks prepared for hawking within Akanu Ibiam Federal Polytechnic, Unwana were collected immediately after production from a seller in Unwana, Afikpo North, Nigeria. They were taken to the laboratory for analysis. This research project was conducted from May-October, 2018.

Mineral analysis: A portion, 2.0 g of each sample was incinerated in a furnace (Carbolite, Derbyshire, UK) at 600 for 3 h to constant weight. The ashed samples obtained were allowed to cool and each was transferred into a separate 50 cm^3 beaker, with the crucible washed with 25 cm^3 of 6 N HCl into the corresponding beaker. The beaker was then heated to boiling to break the ash. The solution was carefully filtered and transferred into a 50 cm^3 standard flask and made up to the mark with double distilled deionized water.

The resulting extract was used for the determination of sodium and potassium concentrations using a flame photometer (Model 405, Corning, Halstead Essex, UK), with NaCl and KCl respectively as standards. Phosphorous was determined as phosphate by the Vanadomolybdate colorimetric method[8] using a Spectronic 20 (Gallenkamp, London, UK) instrument, with KH_2PO_4 as a standard. Other elements (calcium, magnesium, iron and zinc, copper, manganese, selenium, cadmium, lead, chromium and nickel) were determined by the use of an atomic absorption spectrophotometer (Alpha 4, Chem. Tech. Analytical, England). Prior to the mineral analyses, the limits of detection and quantification of the respective metals were determined according to Harris[9]. All chemicals used were of analytical grade and were obtained from British Drug House (BDH), London, UK. Double distilled deionized water was used throughout during the analysis.

Calculations and statistical analysis: Samples were analysed in triplicates and the data presented as mean of determinations $\pm$ standard deviation. One-way analysis of variance (ANOVA) was performed using SPSS version 24.0 (IBM® Corporation) to assess the significant variability of metal concentrations in different non-alcoholic drinks analysed. Means were compared by the Duncan' multiple range test and significance was established at 5% confidence level. Mineral ratios, mineral safety indexes (MSI) and the differences between the standard MSI and the samples MSI were calculated[5,7].

RESULTS

Mineral constituents: The result of concentration levels of elements investigated in the 3 non-alcoholic drinks is presented in Table 1. With exception of calcium, the mineral

Table 1: Concentration levels (mg kg^{-1}) of macro-elements, micro-elements and toxic elements determined in the non-alcoholic beverages

Elements	Soymilk	Kunnu	Zobo	Standard
Macro-elements				
K	112.070±8.36[b]	107.66±10.22[b]	105.11±9.99[a]	4000-4700
Na	275.990±8.32[b]	169.04±7.04[c]	585.78±6.76[a]	1000-1500
Ca	158.650±1.55[a]	165.31±10.41[a]	171.25±11.07[a]	800-1100
Mg	53.420±2.61[a]	28.03±4.25[b]	34.63±4.67[b]	110-300
Micro-elements				
P	89.950±2.78[a]	78.25±7.45[b]	36.70±3.70[c]	380-1055
Fe	9.980±0.86[a]	9.90±2.31[a]	14.34±5.43[b]	15.0*
Cu	3.500±0.62[a]	2.87±0.31[a]	2.95±0.09[a]	1.3†, 2.0‡, 5.0*
Zn	25.520±2.95[a,b]	22.83±1.03[b]	29.09±1.71[a]	5.0†, 5.0*
Mn	0.086±0.01[a]	0.44±0.01[b]	0.11±0.01[a]	0.05†, 0.4‡
Se	1.500±0.06[a]	0.91±0.11[b]	0.98±0.05[b]	
Toxic elements				
Cd	0.030±0.01[a]	0.03±0.002[a]	0.020±0.00a	0.005†, 0.003‡
Pb	DL[b]	0.02±0.007[b]	0.1730±0.016[a]	0.015†, 0.01‡, 0.3*
Ni	DL[a]	0.49±0.074[a]	0.14±0.025[a]	0.1†, 0.07‡
Cr	0.070±0.016[a]	0.03±0.009[a,b]	DL[b]	0.1†, 0.05‡
As	DL	DL	DL	*0.2

Mean±standard deviation within each row followed by a different letter is significantly different at $p \leq 0.05$ and vice versa, DL: Below limits of detection, recommended dietary allowance was used for macro-elements, †USEPA[10] maximum permissible limit, ‡WHO[6] maximum permissible limit, *FAO[11] maximum permissible limit of metals in beverages

Table 2: Computed mineral ratios of essential elements in the 3 non-alcoholic beverages

Mineral ratios	Soymilk	Kunnu	Zobo	Ideal range
Ca/Mg	2.97	5.90	4.95	3.0-11.0
Ca/K	1.42	1.54	1.63	2.2-6.2
Ca/P	1.76	2.11	4.67	1.8-3.6
Na/K	2.46	1.57	5.57	1.4-3.4
Na/mg	5.17	6.04	16.92	2.0-6.0
Zn/Cu	7.29	8.30	9.86	4.0-12.0
Zn/Fe	2.56	2.41	2.03	0.8-3.5
Fe/Cu	2.85	3.45	4.86	0.2-1.6

elements were found to be present in appreciable and adequate quantities and the toxic metals were found below the recommended standards except for cadmium. The concentration levels of zinc were higher compared to other micro-nutrients analysed. Arsenic was not detected in the entire samples while lead and nickel were not detected in soymilk. There were no significant differences in the concentration levels of calcium and copper in the entire samples at $p \leq 0.05$, while there were noticeable differences in the concentration levels of the other macro-nutrients and micro-elements.

Mineral ratios: The results of mineral ratios were calculated and presented in Table 2. Ratios of Ca/Mg, Ca/K and Ca/P of soymilk were below the ideal range. While Fe/Cu ratios of the entire beverages were above the recommended range, ratios of Ca/K were below. Zn/Cu and Zn/Fe ratios of the entire drinks were within the ideal values.

Mineral safety indexes: The safety indexes of the minerals investigated in the drinks were computed and the differences between the standard MSI and the calculated MSI are presented in Fig. 1. Zinc had a negative index in the entire samples, so also zinc and copper had negative indexes in zobo and soymilk, respectively. Other minerals had positive indexes in the 3 beverages.

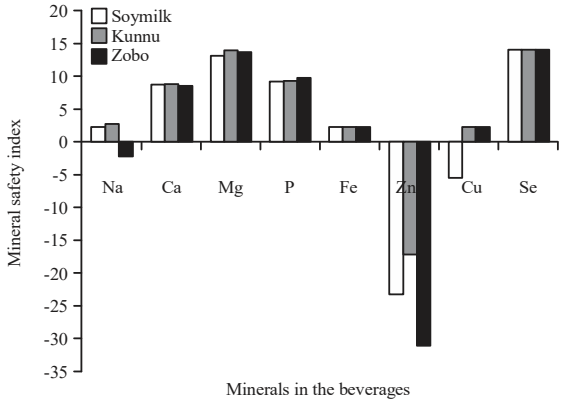

Fig. 1: Mineral safety indexes of sodium, calcium, magnesium, phosphorus, iron, zinc, copper and selenium calculated in the three non-alcoholic beverages analyzed

DISCUSSION

The results of the mineral compositions (Table 1) revealed no significant differences among most of the elements in the 3 samples and the concentration levels of the non-essential elements were found below the recommended permissible limits except for cadmium. The results also reflected the variability among the samples analysed with respect to mineral contents, which could be attributable to diverse recipes used in the production of individual products. Cereals are rich in phytic acids and this was reflected in the concentration levels of phosphorus in both soymilk (89.95 ± 2.78 mg kg^{-1}) and kunnu (78.25 ± 7.45 mg kg^{-1}) (Table 1), which were produced from soybeans and millets, respectively. Phosphorus is stored in plants inform of phytates, which has the tendency to bind other minerals thereby leading to their unavailability to the body[12,13].

Among the micro-elements, zinc had the highest concentration. It has been established that if the concentration level of zinc is high in a food sample, it has an antagonistic effect on the bioavailabilities of copper and iron[12], which were very low. The absence of arsenic in the entire samples lead and nickel in soymilk is desirable as these metals are not needed in the body for any biochemical process. Other toxic metals were detected below the standards except cadmium. There inclusion in the drinks might be as a result of the water used for the production and soil to plant pollution. Evaluating mineral profiles and recommended daily intakes are not enough to predict their bioavailability, their interrelationships should be intricately considered. Several mineral ratios may collectively play a role in contributing to mineral imbalances[14]. In Table 2, relationships between some important elements were deduced. This helps to determine the absorption of a certain mineral element relative to others in order to ensure it adequate supply in the body is met[6]. Watts[5] noted that interrelationship of mineral elements is much more important than knowing the mineral levels alone. Hence, the ratios of some elements relative to others are of paramount importance.

The ratio of sodium relative to potassium is of great importance because it is a maker of blood pressure[7]. When sodium is dominant relative to potassium, an inflammatory response may set in and conversely, a low Na/K ratio can also indicate a disturbance in neurological and renal function[5]. In the entire studied drinks, the dietary Na:K ratios of soymilk and kunnu were within the acceptable ideal range (Table 2), signifying low concentration of potassium relative to sodium in zobo. The implication is that the 2 minerals showed synergistic interaction, therefore the absorption of potassium would not hamper that of sodium and vice versa, when these drinks are consumed.

Calcium metabolism is significantly depends on Ca/P ratio and the higher the ratio (>0.5), the better the absorption of calcium in the small intestine[15]. Diet with Ca/P ratio above two helps to increase the uptake of calcium and it is inferred that, a diet of ratio less than a half is considered poor[5]. Only kunnu was within the recommended range. This implies that kunnu was rich in dietary calcium and for others, the absorption of calcium might be impaired.

The ratio of zinc relative to copper is also of great importance in diets. Interestingly in this study, the entire samples passed the recommendations. The implication is that there would be synergistic interaction between the 2 elements when these products are consumed. It is an established fact that if the concentration level of zinc is high in a food sample, it has an antagonistic effect on the bioavailability of copper and iron[3,12].

The ratio of iron to copper is also an important one to be considered because they are involved in cellular respiration and electron transport[5]. If this ratio is elevated, it is indicative of excessive amount of tissue iron being present relative to copper which may lead to free radical production and a corresponding reduction of Fe/Cu ratio is associated with iron deficiency, that is, decreasing the available iron to be incorporated into haemoglobin[5]. The computed values (Fe/Cu) in the entire drinks were below the acceptable ideal range, suggesting iron overloading.

A markedly elevated Ca/Mg ratio is associated with increased insulin levels[5]. Only soymilk did not meet up with the recommended range. A low Ca/K ratio would indicate an elevation of thyroid expression which could be related to adrenal activity[5]. Surprisingly, none of these products measured up to the standards. A low Na/Mg ratio would indicate a reduced adrenal expression. Of the drinks assayed, only soymilk had its Na/Mg ratio within the ideal range. It was observed that the ratio of zinc relative to iron in the entire drinks were within the recommended ideal range. This implied that the entire drinks were considered as good diets with respect to Zn/Fe ratio[5].

Figure 1 presented the safety indexes of respective metals analysed in the beverages. The entire drinks were overloaded with zinc, hence this might lead to reduction of iron and copper to be available for absorption[7,12]. Overload of zinc was also reported in five insects commonly eaten in South West, Nigeria by Adeyeye and Olaleye[14] and in ten organs of African giant pouch rat studied by Adeyeye and Adesina[16]. However, copper was equally overloaded in soymilk, this might cancel

this effect. In another form, the very high level of copper as was observed in this study might impair the metabolism of iron, zinc and manganese. Similar observation of copper overloading was reported[7]. Roselle extract could cause sodium overload the consumers to the tune of 12%, this might cause reduction in the amount of available potassium for absorption and lead to secondary hypertension[16]. Other elements had their MSI as positive, indicating that their levels were safe in the drinks.

Generally, the drinks contained minimum nutritive mineral elements required for proper body growth. However, calcium fortification is required to raise its level to the acceptable reference daily intake due to its importance in man's nutrition. The regulatory authorities such as Standards Organization of Nigeria (SON), National Agency for Food, Drugs Administration and Control (NAFDAC) and Consumers Protection Agency (CPA) should ensure that locally produced beverages are safe and wholesome, by periodically inspecting production facilities and occasionally sampling and testing products to ensure conformity to the specified standards.

CONCLUSION

This investigation has revealed the concentration levels of essential macro-minerals, essential trace elements and non-nutritional metals present in three non-alcoholic drinks marketed within Akanu Ibiam Federal Polytechnic, Unwana, Nigeria. These locally produced non-alcoholic beverages were found to contain minimum nutritive mineral elements, required for body maintenance, proper development and growth.

SIGNIFICANCE STATEMENT

This study has revealed that these notable non-alcoholic beverages on sales within Akanu Ibiam Federal Polytechnic, Unwana, Nigeria contained appreciable mineral elements required for the proper growth and development in human. There existed mutual synergism in some mineral relationships while some elements showed antagonistic interrelationships, indicative of probable imbalances during absorption in the body. This has formed a basis for other researchers and has created a standard for future studies on mineral interrelationships and bioavailability.

REFERENCES

1. Osuntogun, B. and O.O. Aboaba, 2004. Microbiological and physico-chemical evaluation of some non-alcoholic beverages. Pak. J. Nutr., 3: 188-192.
2. Ndidi, U.S., C.U. Odoh and A.O. Saleeman, 2012. Effects of storage conditions on the physicochemical properties and microbial load of kunu, soymilk, yoghurt and zobo drinks. Int. J. Food Nutr. Saf., 2: 16-26.
3. Soetan, K.O., C.O. Olaiya and O.E. Oyewole, 2010. The importance of mineral elements for humans, domestic animals and plants: A review. Afr. J. Food Sci., 4: 200-222.
4. Ajala, L.O., G.O. Oyeleke and E.O. Olagunju, 2013. Nutritional assessment of juice extract from *Hibiscus sabdariffa*. Int. J. Biol. Pharm. Applied Sci., 2: 10-17.
5. Watts, D.L., 2010. HMTA mineral ratios -A brief discussion of their clinical importance. Trace Elem. Newsletter, Vol. 21.
6. WHO., 2012. Technical Note: Supplementary Foods for the Management of Moderate Acute Malnutrition in Infants and Children 6–59 Months of Age. World Health Organization, Geneva, ISBN: 9789241504423, Pages: 12.
7. Adeyeye, E.I. and T. Jegede, 2017. Chemical composition (Proximate, minerals, vitamins), mineral ratios and mineral safety index of the innards of male and female *Neopetrolisthe smaculatus*. J. Bio. Innov., 6: 479-498.
8. Pearson, D., 1976. The Chemical Analysis of Foods. Churchill Livingstone, Edinburgh.
9. Harris, D.C., 2016. Quantitative Chemical Analysis. 9th Edn., W.H. Freeman and Company, New York, USA, ISBN: 9781319117313.
10. USEPA., 2015. Dietary guidelines for Americans 2015-2020. 8th Edn., U.S. Department of Healthand Human Services and U.S. Department of Agriculture. December 2015. https:// health. gov/dietaryguidelines/2015/guidelines/
11. FAO., 1997. Manuals of Food Quality Control. Food and Nutrition Paper of Food and Agriculture Organisation of the United Nations, Rome, Italy.
12. Khamoni, J.A., T. Hamshaw and P.H. Gardiner, 2017. Impact of ingredients on the elemental content of baby foods. Food Chem., 231: 309-315.
13. Schwartz, M.B., L.R. Vartanian, C.M. Wharton and K.D. Brownell, 2008. Examining the nutritional quality of breakfast cereals marketed to children. J. Am. Diet. Assoc., 108: 702-705.
14. Adeyeye, E.I. and A.A. Olaleye, 2016. Chemical composition and mineral safety index of five insects commonly eaten in South West Nigeria. FUW Trends Sci. Technol. J., 1: 139-144.
15. Loughrill, E., D. Wray, T. Christides and N. Zand, 2017. Calcium to phosphorus ratio, essential elements and vitamin D content of infant foods in the UK: Possible implications for bone health. Matern. Child Nutr., 13: 123-128.
16. Adeyeye, E.I. and A.J. Adesina, 2018. Proximate and mineral compositions, Mineral Safety Index (MSI) of ten organs of African giant pouch rat. Int. J. Pharmacol. Phytochem. Ethnomed., 9: 1-9.