ORIGINAL ARTICLE

MICRONUTRIENTS AND HEAVY METALS CONTENT OF REFINED AND LOCAL TABLE SALTS CONSUMED IN SOME NIGERIAN CITIES

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ABSTRACT

Background: Table salt is an essential food additive needed for flavoring, pickling and curing of foods in many households. These features have made salt an important part of human diet and culture. Salt is universal consumed by human in small fairly constant amount daily. It is therefore an ideal vehicle to deliver physiological amount of micronutrients as well as heavy metals into human body. **Objectives**: Thus, this study investigates physicochemical composition, micronutrients and heavy metals content of the refined and local table salts consumed in some Nigerian cities. **Methods**: This study was conducted in four Nigerian cities with history of local salt production. Four refined table salt samples A, B, C, and D were obtained from their major distributors while the other four samples E, F, G and H were local table salts obtained from local vendors. Samples were analysed for physicochemical composition, Micronutrients and heavy metals content. **Results:** The results of physic-chemical composition indicated a moisture content range of 0.35-0.43% for a refined table salt and 0.84 – 1.62% for the local table salt samples. There was no significant differences (P>0.05) in the pH and alkalinity in both the refined and local table salts while significant differences (P<0.05) existed in the percentage water insoluble matter between the refined and local table salts. Micronutrients analysis showed that Sodium chloride content ranged from 96.89-97.80% for the refined table salt and 95.42-96.42% for the local table salts. Iodine was not detected in the local table salts while Magnesium and Calcium were present in all samples analysed. Results of heavy metals analysis indicated elevated concentrations of Copper, Lead, Arsenic and Cadmium in the local salt samples and these were far above the limit stipulated by regulatory agencies. **Conclusion:** The continuous present and consumption of these local salts samples by the inhabitant of these areas is gross violation of food safety principles.
Keywords: *Food additive, Sodium Chloride, Regulatory Agencies, Nigeria.*

1. INTRODUCTION

The sodium chloride (Table salt) is one of the most commonly used food additives with a unique place in food consumption [1]. It is an essential additive which has been used from prehistoric times for flavouring pickling preservation and curing meat and fish and for tanning [2]. Part of the overwhelming influence stems from its role as a source of Sodium and Chloride, two dominant chemical constituents of human body with important metabolic functions. Food grade or table salt must contain not less than 97% of Sodium chloride on dry matter basis and not more than 0.2% of matter insoluble in water. Anticaking agents such as Sodium aluminosilicate or Magnesium or Calcium carbonate are added to make the salt free flowing [3].

In human body, the principal function of salt is to regulate osmotic pressure and movement of fluids to and from the cells [1]. Chronic salt deprivation produces loss of weight and appetite, inertia, nausea and muscular camps leading to possible vascular collapse and death. On the other hand, excessive salt intake can contribute to hypertension and heart, liver or kidney diseases [4].

Some table salts or salt premixes contain additives such as iodine, iron, niacin, riboflavin, thiamine hydrochloride or even vitamin A. These additives are meant to address varieties of health concerns and micronutrient deficiencies especially in developing countries of the world [5]. The varieties and the amounts added vary widely from country to country. In Nigeria, the government had in 2002 lunched a National Food and Nutrition Policy underscoring its determination to improve the wellbeing of its populace. The policy had definite target for the reduction of micronutrients deficiency through fortification of salt with iodine and sugars with vitamin A [6].
Salt production is one of the most ancient and widely distributed industries in the world. Salt may be produced by mining of solid rock deposits or by evaporation of sea water, lakes, playa and underground brines. The physical and chemical composition of salt produced from various sources varies widely depending upon the manufacturing technique and the composition of the raw material [4]. Salt deposits are found in many part of Nigeria and have been exploited traditionally for over 400 years. The process though crude begins with the fetching of the brine from the salt lakes into a mound already built and tilled locally. The brine is then poured into it and the puddle is left under the sun to allow the

water to evaporate leaving behind a crust that is rich in crystals. The crust is further broken and process locally into table salt.
The direct use of this unpurified or unrefined table salts for culinary and eating purposes have been discouraged by the regulatory agencies of government. This is because of the expected adverse health effect that may occur due to heavy metals contamination which is widespread in the environment [7]. Heavy metals such as lead, cadmium arsenic, mercury when consumed into the human body can result in serious health challenges such as kidney dysfunction, liver toxicity, impairment of periphery and central nervous system, increase risk of some cancers etc. [8, 9]. In view of the aforementioned risk the presence of these local salts in the market indicates that this type of salt is still being used by the consumers. In this study, physicochemical properties, micronutrients and heavy metals content of refined package salts and the local table salts consumed in some Nigerian cities are assessed and compared with the standards outlined by regulatory species.

2. MATERIALS AND METHODS

2-1 Study Area: This study was conducted in four Nigerian cities with long history of traditional or local salt production. Table salts are produced locally from salt lakes, seawater and Mines by women from these areas. Inspite of the availability of refined salts in the markets, some residents of these areas still prefer the use of local unrefined salt for cultural and economic reasons.

2-2 Sample Collection: Four samples of refined and packaged table salts were purchased directly from their major distributors with NAFDAC registration, number, production and expiry date clearly stated. They were labeled A, B, C, and D. Four samples of locally processed or unrefined salts were obtained from vendors in Port Harcourt, Abakaliki, Makurdi and Jos. They were also labeled E, F, G and H respectively. The samples collected and labeled were packaged in polyethylene bags and transported to the laboratory for analysis.

2-3 Research Methodology: The percentage moisture content, alkalinity and water insoluble matter were determined according to standard methods as described by BIS (2006). The pH of the salt samples was determined by dissolving 2g of salt samples into 200ml of distilled water. It was stirred continuously until it was completely dissolved. The pH meter was then inserted into the solution and allowed until a stable figure was gotten before the reading was taken [11].
Sodium chloride content of salt samples was determined as total chloride. 20g of the dried samples were dissolved in 200ml of water and heat to boiling then allowed cooling. 10ml of the solution was taken into conical flask and 1ml of potassium chromate indicator was added. This was titrated against Silver nitrate till the reddish brown tinge persists after brisk shaking [10].

Micronutrients content of salt samples, which included iodine, magnesium, calcium sulphate, were determined using titrimetric method of analysis [12]. Heavy metals such as copper, lead, iron arsenic and cadmium present in each sample were determined using Atomic Absorption spectrophotometer. The metals were analysed by dissolving 2g of salt samples into 3ml nitric acid and 1ml concentrated hydrochloric acid was also added. The solution was diluted with distilled water to 100ml. specific cathod hallow lamp for each metal was used to determine their concentration at specific wavelengths [12].

2-4 Statistical Analysis: All analysis was carried out in triplicate. The mean and standard devotion of the data was determined. Significant difference between mean were analysed using Duncan multiple range test (DMRT). All analysis was done using Statistical Package for Social Science (SPSS) version 2.0 for windows. Statistical test was performed at 5% significant level.

3. RESULTS

The results obtained from the study are show in Table 1-4.

Table 1: The table presents the physicochemical composition of refined and local table salts consumed in some Nigerian cities.

	Refined Table Salts				Local Table Salts			
	A	B	C	D	E	F	G	H
Moisture content (%)	0.43 ± 0.01^{C}	0.38 ± 0.02^{c}	0.36 ± 0.01^{c}	0.35 ± 0.01^{c}	1.62 ± 0.02^{a}	1.02 ± 0.02^{b}	0.84 ± 0.01^{b}	0.89 ± 0.0^{b}
pH	7.60 ± 0.02^{a}	7.64 ± 0.01^{a}	7.70 ± 0.03^{a}	7.69 ± 0.02^{a}	7.66 ± 0.01^{a}	7.69 ± 0.03^{a}	7.68 ± 0.01^{a}	7.65 ± 0.01^{a}
Alkalinity (%Na_2CO_3)	0.20 ± 0.01^{a}	0.25 ± 0.01^{a}	0.28 ± 0.02^{a}	0.027 ± 0.02^{a}	0.22 ± 0.01^{a}	0.20 ± 0.01^{a}	0.32 ± 0.03^{a}	0.30 ± 0.02^{a}
Water insoluble matter (%)	0.12 ± 0.01^{c}	0.09 ± 0.01^{c}	0.09 ± 0.01^{c}	0.08 ± 0.02^{c}	1.20 ± 0.01^{b}	2.01 ± 0.02^{a}	1.82 ± 0.02^{ab}	2.02 ± 0.02^{a}

Values are mean ± standard deviation of triplicate determination. Values with different superscripts in the same column are significantly different. ($P<0.05$).

Table 2: The table presents the micronutrients content of refined and local table salts consumed in some Nigerian cities.

	Refined Table Salts				Local Table Salts			
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
NaCl (%)	97.80±0.01^{a}	97.00±0.02^{a}	96.89±0.12^{a}	97.05±0.01^{a}	96.30±0.14^{b}	96.42±0.01^{b}	95.58±0.12^{c}	95.42±0.02^{c}
I_2 (ppm)	ND	37.10±0.03^{b}	48.90±0.01^{a}	38.21±0.40^{b}	ND	ND	ND	ND
Mg (g/kg)	0.26±0.02^{d}	0.25±0.01^{d}	0.92±0.04^{c}	4.09±0.08^{a}	3.00±0.18^{b}	0.21±0.02^{d}	3.82±0.05^{a}	0.62±0.01^{cd}
Ca(g/kg)	0.83±0.18^{a}	0.43±0.05^{b}	0.46±0.01^{b}	0.26±0.04^{c}	0.72±0.23a^{b}	0.22±0.01^{c}	0.81±0.03^{a}	0.28±0.02^{c}
SO_4 g/kg	ND	ND	0.30±0.14^{a}	0.40±0.01^{a}	ND	ND	ND	ND

Values are mean ± standard deviation of triplicate determination; Values with different superscripts in the same column are significantly different ($P<0.05$); Nacl = Sodium chloride; I_2 = Iodine, Mg = Magnesium; Ca = Calcium; SO_4 = Sulphate

Table 3: The table presents the heavy metals content of refined and local table salts consumed in some Nigerian cities.

	Refined Table Salts (mg/kg)				**Local Table Salts**			
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Cu	1.30±0.02^{c}	1.14±0.01^{c}	1.32±0.02^{c}	1.12±0.01^{c}	2.24±0.03^{b}	2.28±0.01^{b}	3.21±0.02^{a}	3.14±0.03^{a}
Pb	0.11±0.01^{e}	0.24±0.01	0.23±0.01^{c}	0.26±0.02^{d}	2.43±0.02^{b}	1.36±0.02^{c}	4.21±0.02^{a}	3.82±0.01^{a}
Fe	0.08±0.02^{e}	3.20±0.02^{c}	3.08±0.05^{c}	2.80±0.02^{d}	6.30±0.02^{a}	6.30±0.01^{a}	4.56±0.03^{b}	5.36±0.02^{ab}
As	0.35±0.06^{c}	0.26±0.24^{d}	0.49±0.123^{c}	0.45±0.23^{c}	1.33±0.08^{a}	0.68±0.01^{bc}	1.08±0.23^{b}	1.10±0.02^{b}
Cd	ND	0.02±0.01^{d}	0.08±0.02^{c}	ND	0.52±0.01^{a}	0.48±0.01^{a}	0.34±0.02^{b}	0.50±0.01^{a}

Values are mean ± standard deviation of triplicate determination; Values with different superscripts in the same column are significantly different ($P<0.05$); Cu = Copper; Pb = Lead; Fe = Iron; As = Arsenic Cd = Cadmium.

Table 4: Mean concentration of toxic metals in refined and unrefined salt and standards.

Heavy metals	Refined table salts	Local table salts	Son maximum limit	Codex maximum limit
Cu (mg/kg)	1.22±0.02	2.74±0.02	2.0	2.0
Pb (mg/kg)	0.21±0.01	2.96±0.01	2.0	2.0
Fe (mg/kg)	2.29±0.02	5.71±0.02	30	50
As (mg/kg)	0.39±0.02	1.05±0.02	0.5	0.05
Cd (mg/kg)	0.05±0.01	0.46±0.01	0.1	0.05

Cu = Copper; Pb = Lead; Fe = Iron; As = Arsenic Cd = Cadmium .

4. DISCUSSION

The moisture content of the refined table salts ranged from 0.35-0.43% while that of the local salts samples ranged from 0.84-1.62%. (Table 1) The moisture content of the refined salts were within the limit specified by regulatory agencies while that of the local table salts were above specified limit of 1.0% moisture content. There was no significant difference ($P>0.05$) in the moisture content of the refined table salt samples while it existed among the local table salt samples. The result for moisture content was similar to that reported by Usman and Filli (2011) who also noted that lower moisture content of table salt is very crucial to its keeping quality since it makes the salt free flowing, retain it crystal form as well as minimizing formation of lumps. The high moisture content of the local table salt could be attributed to inadequate drying procedures and poor packaging. The pH and alkalinity of table salt ranged from 7.60-7.70 and 0.25-0.30% Na_2CO_3 respectively. There was no significant differences ($P>0.05$) among samples. The results were also within the limit stipulated by regulatory agency [11]. The percentage water insoluble matter in the table salts samples indicated significant differences ($P<0.05$) among samples. There was a higher percentage of water insoluble matter in local salt samples. From our result, percentage water insoluble matter ranged from 0.08-0.12% for the refined salt and 1.20-2.02% for the local table salt. The result for the refined table salt was within the limit stipulated by regulating agencies [11]. Usman and Filli (2011) reported similar values for percentage water insoluble matter which ranged from 0.079-1.299% for packaged salt in Nigeria. Unrefined or natural salts are rich in natural impurities such as dust, sand particles and other contaminants. He suggested that proper purification processes and packaging will help in reducing the level of water insoluble matter present in table salt.

Micronutrients content of refined and local table salts (Table II) indicated that Sodium chloride content ranged from 96.89-97.80% with the average of 97.19% for the refined table salt while that of local table salts ranged from 95.42-96.42% with the average of 95.93%. The local table salts with the average of 95.93% Sodium chloride content did not meet the requirement as recommended by SON (1992) and Codex (2006) which specified 97% as a minimum content of sodium chloride in food grade salt. According to Usman and Filli (2011) the concentration of sodium chloride in table salt determines its saltiness and salinity. The lower concentration of Sodium chloride in the local table salt could be as a result of impurities and lack of purification and concentration processes. This underscores the use for proper refining processes through recrystallization or hydromilling, which is essential for clarification, concentration and quality upgrading. Iodine was not detected in all the local table salts as well as one sample of the refined table salt. This is against the government regulation that all table salt in Nigerian market must be iodised. However, samples with iodine were within the limit of 30-50ppm as specified by the government [11]. Iodine is an important nutrients for humans of which its deficiency has resulted in cretinism mental recordation in children, increased child mortality, goiter, and reproductive failure in adult [4-16]. This is why the WHO in its 39th meeting at Geneva resolved and urged all member countries to give priority to the prevention and control of iodine deficiency disorder through fortification of iodine in table salt. Magnesium was present in all the table salt samples analysed. The values for magnesium were within the limit of 3.0g/kg as prescribed by regulatory agencies [11-15] but lower values were reported by Usman and Filli (2011). According to Warren *et al.,* (1968) Magnesium is an important mineral needed for a wide range of activities such as a co-factor in phosphate transfer in cells during energy production, enzymatic activities and mineral balance in human body. Calcium is one of the micronutrients present in table salt. All the table salt samples analysed indicated the present of calcium ions. Values obtained were below the limit of 3.0g/kg specified by regulatory agencies. Bergner (1977) reported calcium content of 0.35g/kg which is similar to our findings. Calcium is required by human body for proper bone and teeth formation, blood clotting and contraction of muscles [20]. The result obtained for sulphate indicated that only two samples C and D contain sulphate ions. The values obtained did not exceed the recommended limit of 1.00g/kg. According to Markovich (2001) sulphate is required by human body for the proper cell growth and development. It is also involved in a variety of biological processes such as biosynthesis of amino acids, hormones, enzymes and antibodies.

The result of heavy metals content of table salt samples are shown in Table III. The mean concentration of heavy metals in refined and local table salt compared to SON and Codex standards are shown in Table IV. Copper is essential for good health but at higher intake it can lead to hepatic cirrhosis, kidney and brain damage [22]. Copper content of samples analysed ranged from 1.14-3.21mg/kg. This result indicated on elevated copper concentration in the local salt samples for above the maximum permitted level of 2mg/kg which violates SON and Codex standards for copper in food grade salt. The result of our study for copper was lower compared to 3.95mg/kg reported by Usman and Filli (2011) during their determination of heavy metals in some selected table salt sample in Nigerian metropolis.

Lead is a toxic metal occurring naturally in the earth's crust. When it enters the body, it accumulate, in teeth and bones with series of negative consequences on different organs and system such as central and peripheral nervous systems, gastrointestinal tract, kidney and brain damage [23]. Lead has a series of consequences on the health of children. At high exposure, it affects the brain and central nervous system to cause coma, convulsion and death. From the result of our investigation, all table salt samples analysed showed the presence of lead with the ranged of 0.11-4.21mg/kg. There was a significant differences ($P<0.05$) in the concentration of lead among salt samples analysed. The results showed low concentration of lead in the refined table salts. The local table salts indicated an elevated lead concentration for above the maximum level of 2.0mg/kg permitted by Codex and SON standards. The results for lead obtained for samples G and H (4.21mg/kg and 3.82mg/kg) were similar to that reported by Dim *et al*, (1991) on lead content of local cooking salts in middle Benue trough in Nigeria. It is important to note that Nigeria had experienced cases of lead poisoning in Zamfara State where over 200 people died and most recently in Niger State [25].

Iron is an essential element that is needed by the body at lower concentration. From the result of our study iron concentration ranged from 0.08 – 6.30mg/kg. This is far below the concentration of 30mg/kg recommended [11]. The result of our study was similar to the report of Usman and Filli (2011). Therefore to achieved the recommended concentration of iron in table salts fortification is required.

Arsenic was present in all salt samples analyzed with the concentration ranging from of 0.26 – 1.33mg/kg. Arsenic in human is related to heart disease, cancer, vitamin A deficiency and night blindness. [27, 28, 29]. From the result of our work, arsenic concentration in the salt samples were far above the maximum level permitted by regulatory agencies. Cadmium was present in some table salt samples with the concentration range of 0.02 – 0.52mg/kg. Cadmium exposure induces bone damage, osteoporosis, and renal tubular dysfunction which can leads to renal failure in long term [30].

From the results obtained for the local table salt samples, cadmium concentrations were higher (0.34 – 0.52mg/kg) compared to the permitted level of 0.1mg/kg by the standard organization of Nigeria. The result of this study on cadmium in the refined salts was similar to the value of 0.02mg/kg reported by Nwachoko et al (2012) on the cadmium content of some refined table salts in south-eastern Nigeria.

This study was limited to these four regions of Nigerian because traditional salt production from mines and sea water is a predominant venture of women from these regions.

5. CONCLUSION

The results of physic-chemical composition of the local table salt analysed showed that moisture content and water insoluble matter in local table salts were higher than the limit stipulated by regulatory agencies. Micronutrients indicated that sodium chloride content of the local salt were also lower compared to the standard of 97% stipulated by regulatory agencies while iodine was not present in local table salt as well sample A which was a foreign salts used in this study. All values obtained for toxic metals in the local table salts were higher than the maximum permitted limit for human consumption as prescribed by SON and Codex regulation. Therefore the continuous present and consumption of these local salts samples by the inhabitant of these areas is gross violation of food safety principles.

6. REFERENCES

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