



## Chemical Assessment of Different Brands of Commercial table Salts Sold in Sokoto Central Market, Sokoto

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Available online at: [www.isca.in](http://www.isca.in), [www.isca.me](http://www.isca.me)

Received 7<sup>th</sup> June 2016, revised 16<sup>th</sup> July 2016, accepted 9<sup>th</sup> August 2016

### Abstract

Table salt is the most common food additive used by a large number of people. Hence, if adulterated, it could pose a serious threat to public health. The present study was aimed at quantitatively and qualitatively assessing five different brands of commercial table salts (TS-1 – TS-5) sold in Sokoto Central Market. The qualitative analysis of each sample was conducted using standard procedures. The level of sodium (Na), potassium (K), copper (Cu), manganese (Mn) and Iron (Fe) was determined using flame photometer and atomic absorption spectroscopy. The results obtained for the salts samples showed that the density values ranges from 2.20 – 2.60 g/cm<sup>3</sup> while the moisture content was generally low having 0.50 % but TS-5 had 10.5 %. The solubility value for the salt samples fall within the range of 7.37 – 12.65 g/100g which was thrice the solubility of TS-5 (2.53 g/100g). The degree of hydrosorption for the salt samples were within the range 3.65 – 3.97 g and the conductivity values ranges from  $7.11 \times 10^{-2}$  –  $7.11 \times 10^{-2}$ . The pH value of the samples were alkaline having 7.04 – 10.21 and SO<sub>4</sub><sup>2-</sup>, Cl, I were present in all the samples except for TS-4 which do not contain SO<sub>4</sub><sup>2-</sup>. The levels of Na, K, Mn and Fe for most of the salt samples were found to fall within the permissible limit of World Health Organization (WHO) and Cu was not detected in the samples.

**Keywords:** Salt, Qualitative, Quantitative, assessment, AAS.

### Introduction

Majority of people consider salt to be that substance used to add flavor to the food. However, it is greater than that; salt plays an important role in the diet of not only human but animals and plants as well<sup>1</sup>. Salt commonly known as the common salt is a chemical compound (NaCl) formed when part of an acid is replaced by a metal and it has become a cause of many researches. Sequel to the great impacts it plays in many households and dietary contributions<sup>2</sup>. Salt is used as a flavor that blends the taste and smell sensation of food. It also hinders the growth of microorganism thereby preventing food spoilage and accord a distinct texture to processed foods. Salt is also used in controlling the fermentation rate in food processing and makes gluten in bread more effective<sup>3</sup>.

The National Agency for Food, Drug Administration and Control (NAFDAC) in order to ensure compliance based on the level of trace elements in salt adopted the specification made by Standard Organization of Nigeria (SON) that the content of Iodine should be within 40mg/kg, sodium chloride (97% min), moisture content (1.0%), calcium content (3.0g/kgmax), magnesium content (3.0 g/kg max), water insoluble matter (0.10% by weight max), sulphate content (5.0g/kg max), iron (3.0mg/kgmax), copper (2.0mg/kg max) and lead (0.11mg/kg max)<sup>4</sup>. Salts have different mineral composition which is

responsible for the unique flavor of each one. Common salt production has been long recognized. Salts in its crude form have a purity of 90-95 % NaCl. Hence, it is pulverized, packed and marketed while the industrial salt is unrefined sequel to its inability of the salt to undergo proper processes of refining<sup>5</sup>.

Essential metals such as Fe, Cu, Ni and Zn plays important role in growth and development; however, at high concentration, they can be intolerable. Some metals (Hg, Pb and Cd) are toxic even at a very low concentration<sup>6</sup>. Excessive intake of these metals accumulates in the body thereby causing toxicity. Food has been the major pathway of trace elements deposition in human body<sup>7-9</sup>. Copper and zinc are known to be essential and may enter the food materials from soil through mineralization by crops, food processing or environmental contamination. The toxicity of them is due to excessive intake. The largest amount of trace elements found in human body has been absorbed via food. Salt is a biological necessity of human life and it is added to most food. It is necessary for the body to produce digestive acids, stimulate the liver and helps get rid of gas. Besides enhancing taste, salt acts as an antimicrobial or microbiological control agent. It contributes to certain chemical reactions that create a wide variety of food characteristics<sup>10</sup>.

Edible salts can be contaminated by heavy metals because it is one of the most ubiquitous food ingredients around. Some

studies of heavy metals in salt had previously been conducted in Iran<sup>11</sup>. Scientific studies since the 1970s have determined varying amounts of trace metals in different spices<sup>6</sup>. The average amount of metal found in a spice can vary from spice to spice or location of where the spices are produced. Natural food spices such as pepper and mustard reported to contain significant quantities of some trace metals<sup>12</sup>. There is often little information available about the safety of those plants and their products in respect to heavy metal. These trace metals in spices and medicinal plants play vital role as structural and functional components of metalloproteins and enzymes in living cells<sup>13</sup>. It is with this in mind that this study tends to undertake a qualitative and quantitative assessment of five (5) different brands of commercial and table salts sold in Sokoto Central Market.

## Methodology

**Materials:** Five brands of commercial table salts were used for the study as indicated in Table (1)

Table-1  
List of samples

Samples	% purity	Brands
TS-1	99.97%	Dangote edible salt
TS-2	70%	Cassava salt
TS-3	99%	Royal salt
TS-4	98%	Mr.Chef salt
TS-5	60%	Block salt (Gishirin shanu)

**Chemicals and Reagents:** All chemicals used for the study were of analytical grades and purity (98 – 99 %). Flame spectrophotometer and Atomic Absorption spectrophotometer (AAS) were the major equipment's used.

**Sample Treatment:** Each sample was oven dried at 105° C to constant weight for 6 hours. The oven dried materials were crushed and sieved through 2.00 mm mesh to obtain a representative sample.

**Methods: Determination of Density:** Principle of Archimedes was used. 5 g of each previously dried sample was carefully placed into a 10 cm<sup>3</sup> measuring cylinder containing 5 cm<sup>3</sup> of kerosene and the differences in volume was recorded<sup>14</sup>.

**Determination of Moisture Content:** Moisture analysis was carried out according to the method of AOAC (2000) by weighing 4 g quality of each salt sample into a petri dish. It was dried in an oven at 105°C for 4 hours. The dried salt was transferred into a desiccator and allowed to cool. The weight of the sample was taken. The weight loss expressed as a

percentage was taken as percent moisture. The result was obtained as the average of two independent determinations.

$$\text{Moisture Content (\%)} = 100 \times \frac{W_1 - W_2}{W_1}$$

W<sub>1</sub> = Weight of sample + Petri dish before drying, W<sub>2</sub> = Weight of sample + Petri dish after drying, W<sub>1</sub> = Weight of sample.

**Determination of Solubility:** Fifty gram (50 g) of each sample was separately added to 100 cm<sup>3</sup> of boiling water and stirred for some time till no more salt can dissolve. The solutions were allowed to cool at room temperature and filtered. 20 cm<sup>3</sup> of the saturated solution of each sample was evaporated to find the amount of salt that dissolved in it<sup>14</sup>.

**Determination of Degree of Hydrosorption:** Four grams (4 g) of each sample was placed in small dried and weighed porcelain crucibles of identical sizes. The crucibles containing the samples were kept above water in a desiccator (to provide saturated atmosphere). The increase in weight (due to absorption of water) was recorded each day until constant weight<sup>14</sup>.

**Determination of pH:** The pH of samples was determined by weighing (1 g) of each sample into a plastic cylinder and dissolved in 10 ml of distilled water. The solutions were properly mixed for 30 minutes and allowed to stand for 1 hour, and a pH meter was used to determine the pH of the solutions, after proper calibration of the electrode. The pH values recorded were the average of duplicate determination<sup>15</sup>.

**Determination of Conductivity:** For each sample, 50 cm<sup>3</sup> of distilled water was taken in a beaker at room temperature. The sample was added to the water step-wise; 1 g in each step from 0 -10 g and 2 g in the subsequent steps from 10 g – 20 g with continuous stirring after each addition to ensure complete dissolution. The electrodes were kept 4.5 cm apart the resistance (R), and conductance (C), of the solutions were recorded after every addition<sup>14</sup>.

**Test for Sulphate:** To the portion of each sample extract, acetic acid was added, and boiled to expel CO<sub>2</sub> gas. Barium chloride solution was added. Appearance of a white precipitate insoluble in nitric acid was taken as positive test for sulphate ions<sup>15</sup>.

**Test for Chloride:** A portion of each sample extract in a test tubes was acidified with dilute nitric acid and boiled to expel CO<sub>2</sub> gas; Silver nitrate solution was added, appearance of white precipitates was taken as an indication for the presence of chloride ions<sup>15</sup>.

**Test for Iodide:** Equal portion of the sample extracts each in test tubes was acidified with dilute nitric acid and boiled to expel CO<sub>2</sub> gas, silver nitrate solution was added, yellow precipitates was produced insoluble in dilute nitric acid and ammonium hydroxide solution indicates the presence of iodide ions<sup>15</sup>.

**Determination of iodine content:** Ten gram (10 g) of each sample was dissolved in approximately 100 ml of distilled water. The pH was adjusted to 2.8 using 0.6% HCl. 30 mg of potassium iodide powder was added to convert all the iodate present to elemental iodine. The liberated iodine was titrated with freshly prepared 0.004 M sodium thiosulphate solution in the presence of starch as an indicator. Iodine content was calculated using standard conversion table for iodine determination<sup>15</sup>.

**Determination of Sulphate:** Fifty (50) cm<sup>3</sup> of each sample was taken into a measuring cylinder and 2 cm<sup>3</sup> of 50 % HCl and 2 cm<sup>3</sup> of barium chloride solution was added, mixed thoroughly and allowed to stand for 10 minutes. The precipitate formed for each sample was washed and filtered off thoroughly on ash less filter paper with distilled water, it was oven dried and weighed. The weight of SO<sub>4</sub><sup>2-</sup> was calculated from the weight of precipitates<sup>15</sup>.

**Determination of Chloride:** Fifty (50) cm<sup>3</sup> of each sample was measured, 1.0cm<sup>3</sup> of potassium chromate indicator solution was added and titrated against 0.014 M standard silver nitrate titrate solution to a pinkish-yellow endpoint; also reagent blank was established by the titration method outlined above<sup>15</sup>.

**Mineral and Heavy Metal Analysis:** One (1.00 g) of each sample was digested using 5 ml conc. HNO<sub>3</sub> and 2ml of conc. HClO<sub>4</sub>. After digestion, the samples were filtered and the filtrates were diluted to 100 ml with deionized water. The solutions were digested in a fume cupboard by heating to a final volume of 3 - 5 ml. 10 - 15 ml of water was added and filtered through an acid washed filter paper into a 50ml volumetric

flask. The filter paper was washed with water and diluted to volume with deionized water.

Flame photometer was set up according to the instructions in the instrument manual. The instrument was calibrated for each determination using appropriate standard solutions. Distilled water was aspirated in order to set the meter at zero. The highest concentration of the standard solutions was aspirated in order to set the meter to 100% deflection. % deflection reading of all the intermediate standard solutions was recorded. The sample solution was aspirated and the reading (%) was recorded. (O and 100% reading with O and top standard after every 10-20 sample determination were checked). The concentration of the element in sample solution was noted and K and Na contents in salt samples were measured<sup>16</sup>.

**Determination of Cu, Fe and Mn using Atomic Absorption Spectroscopy:** Atomic absorption spectrophotometer was set up according to the instructions in the manual. The wet digest sample solution was placed in a 100ml volumetric flask and make up to 100 ml. Three concentrations of standard solution of a particular metal to be analyzed were selected; blank solution was aspirated and adjusted to zero. Each standard solution was aspirated into flame, calibration curve for absorbance versus concentration of each standard solution was prepared and the reading of the prepared samples solution was obtained directly from the instrument<sup>16</sup>.

## Results and Discussion

**Results:** The results of determination of physical parameters, qualitative test and quantitative analysis are shown in Tables 2-4.

**Table-2**  
**Determination of physical parameters**

Parameter	TS-1	TS-2	TS-3	TS-4	TS-5
Density(g/cm <sup>3</sup> )	2.60 ±0.1	2.40 ±0.14	2.20 ±0.11	2.30 ±0.33	2.60 ±0.1
Moisture content (%)	0.5 ±0.02	0.50 ±0.01	0.50 ±0.01	0.50 ±0.01	10.5 ±0.01
Solubility (g/100g)	9.79 ±0.03	7.37 ±0.05	12.65 ±0.01	12.07 ±0.02	2.53 ±0.01
Degree of hydrosorption (g)	3.84 ±0.02	3.87 ±0.06	3.92 ±0.01	3.65 ±0.03	3.97 ±0.03
pH	8.42 ±0.03	7.48 ±0.02	7.04 ±0.01	7.04 ±0.01	10.21 ±0.04

Key: Data are expressed as the mean ± S.D (n = 3)

**Table-3**  
**Qualitative analysis**

Parameter	TS-1	TS-2	TS-3	TS-4	TS-5
Conductivity (ohm)	7.32x10 <sup>-2</sup> ±7x10 <sup>-4</sup>	7.11x10 <sup>-2</sup> ±2 x10 <sup>-4</sup>	7.38 x10 <sup>-2</sup> ±4x10 <sup>-4</sup>	7.52x10 <sup>-2</sup> ±6x10 <sup>-4</sup>	7.49x10 <sup>-2</sup> ±9x10 <sup>-4</sup>
Sulphate	+++	++	++	-	+++
Iodide	+++	+++	+++	+++	+++
Chloride	+++	+++	+++	+++	+++

Key: +++ = present, ++ = moderately present, - = absent

**Table-4**  
**Quantitative analysis**

Samples	TS-1	TS-2	TS-3	TS-4	TS-5
Sodium (mg/kg)	17000	17400	19000	19000	4800
Potassium (mg/kg)	85	70	110	105	1100
Manganese ( $\mu\text{g/kg}$ )	20.25 $\pm$ 0.1	0.097 $\pm$ 0.001	2.53 $\pm$ 0.001	19.39 $\pm$ 0.01	0.055 $\pm$ 0.001
Iron ( $\mu\text{g/kg}$ )	30.95 $\pm$ 0.01	7.75 $\pm$ 0.001	ND	3.89 $\pm$ 0.001	8.38 $\pm$ 0.001
Copper( $\mu\text{g/g}$ )	ND	ND	ND	ND	ND
Iodide (mg/kg)	42.24 $\pm$ 0.02	27.44 $\pm$ 0.02	38.4 $\pm$ 0.01	53.20 $\pm$ 0.04	20.02 $\pm$ 0.01
Sulphate (mg/kg)	1.14 $\pm$ 0.02	1.06 $\pm$ 0.01	1.13 $\pm$ 0.04	ND	1.04 $\pm$ 0.01
Chloride (mg/kg)	98.55 $\pm$ 0.03	99.86 $\pm$ 0.06	96.58 $\pm$ 0.02	98.58 $\pm$ 0.02	98.98 $\pm$ 0.04

Key: Data are expressed as the mean  $\pm$  S.D (n = 3), ND; not detected

**Discussion: Density:** The density of a material is defined as its mass per unit volume. Different materials have different densities, so density is an important concept regarding buoyancy, purity and packaging<sup>17</sup>. Densities of the samples were analyzed to verify the compactness of the free flowing nature of the salts. The results obtained indicated the density of the samples to be; 2.6gcm<sup>3</sup>, 2.4gcm<sup>3</sup>, 2.2gcm<sup>3</sup>, 2.3gcm<sup>3</sup> and 2.6gcm<sup>3</sup> for TS-1 - TS-5 respectively. TS-1 and TS-5 had the highest density which could be due to the presence of heavier particles which are of lesser amount in other samples<sup>18</sup> TS-3 had the lowest density which may be due to the presence of least heavy particles than the other four samples<sup>18</sup>.

**Moisture Content:** The moisture content of sample TS-1, TS-2 and TS-4 was found out to be 0.5% while TS-3 and TS-5 had the highest moisture content of 36% and 10.5% respectively. The results showed that, the moisture content for TS-1, TS-2 and TS-4 fall within the level specified by the Standards Organization of Nigeria (SON) and Nigeria Institute of standards (NIS).SON recommended moisture content of 1.0 % max<sup>19</sup>. Higher moisture content tends not to allow free flowing of salts, crystals and increases lump formation.

**Solubility:** The solubility of TS-1 was found to be 9.79g in 100cm<sup>3</sup> of distilled water, while the solubility of TS-2 was 7.37g in 100cm<sup>3</sup> of distilled water and 12.65g, 12.07g and 2.53n in 100cm<sup>3</sup> of distilled water for TS-3, TS-4 and TS-5 respectively. Considering the effect of temperature on solubilities<sup>20</sup> and possible experimental errors, the solubility of TS-3 was found to be more soluble than all the four samples tested. This could be due to weak intermolecular bond between the particles of TS-3 which can easily be broken by water molecule and this an indication that TS-3 has the least amount of precipitate followed by TS-4, TS-1, TS-2 and TS-5<sup>20</sup>.

**pH and Conductivity:** The pH of a sample is an important parameter that directly influences mineral mobility<sup>21</sup>. The result of the pH determination indicated that the samples are alkaline compared to the codex standard. TS-1 had the pH of 8.42 while TS-2 had 7.48 and TS-3, TS-4 and TS-5 had the pH of 7.04, 8.03, and 10.21 respectively. This showed that TS-5 had the highest degree of alkalinity 10.21, followed by TS-1, TS-4, TS-2 and TS-3 having almost a neutral pH. The pH value of most salt samples collected from the market tends to decrease from the point of production with time and this may be primarily due to contamination during handling<sup>22</sup> at retail end and also, different keeping conditions in different markets. The pH of the salt is very much influenced by the type and quantity of impurities present, and this may in turn affect the stability of the iodine compounds<sup>23</sup>. The result of conductivities showed that TS-4 (7.523X10<sup>-2</sup>) had the highest electrical conductivity followed by TS-5 (7.489x10<sup>-2</sup>), TS-3 (7.380x10<sup>-2</sup>), TS-1 (7.321x10<sup>-2</sup>) and TS-2(7.108x10<sup>-2</sup>).

**Degree of Hydrosorption:** The result of degree of hydrosorption showed that TS-5 (3.97g) has the highest weight due to increase in absorption of water, followed by TS-3 with (3.92g) while TS-2 had (3.87g). TS-1 and TS-4 had (3.84g) and (3.65g) respectively. The high weight due to increase in absorption of water may be attributable to high particles in the samples.

**Macronutrient's Determination: Sodium:** The result obtained revealed that sodium was present at high concentration in all the test samples. TS-3 and TS-4 had the concentration of 19000mg/kg each while TS-2 was having 17400mg/kg. The concentration of sodium in TS-1 and TS-5 was 17000mg/kg and 4800 mg/kg respectively. The maximum tolerable limit for sodium as prescribed by WHO is 6065ppm. Sodium is a

critically important macronutrient in the human body. A common dietary source of sodium is table salt (NaCl). In humans, it is essential for the maintenance of normal physiology<sup>24</sup>. An adequate intake of sodium is required for optimal growth, and it is the predominant cation in the extracellular fluid; either a deficiency or excess of sodium will alter overall fluid balance and distribution<sup>24</sup>. Na deficit is exemplified by mood changes, muscle cramps, fatigue, hair loss, hypotension and dehydration. The recommended daily intake of Na is 1–3.8 mg/day<sup>24</sup>. The adverse effect of the high concentration of Na is hypertension.

**Potassium:** The concentration levels of potassium in the selected salt samples were 1100, 110, 105, 85 and 70mg/kg for TS-5, TS-3, TS-4, TS-1 and TS-2 respectively. Potassium plays a key role in vast majority of physiological processes<sup>25</sup>. Hence the maximum allowable limit for potassium as per WHO is 100ppm. Potassium is a useful macronutrient in humans. K<sup>+</sup> plays a vital role in the regulation of action potentials and intercellular signaling in electrically active cells. In both excitable and non-excitable cells, K channels regulate various functions, including regulation of membrane potential, signal transduction, insulin secretion, hormone release, regulation of vascular tone, cell volume and immune response<sup>24</sup>. The average intake of potassium is 2300 mg/day for adult women and 3100 mg/day for adult men<sup>22</sup>. The study showed that only TS-1 and TS-2 did not exceed the permissible limit by WHO, but all the rest exceed the accepted limit.

**Determination of Micronutrient: Manganese:** The minimum and maximum concentration of manganese varied from 0.054 to 19.38(μg/g) respectively. However the maximum allowable limit for manganese as per WHO is 10mg/kg. Manganese concentration in TS-1 exceed the permissible limit. The concentration of Mn in all the salt samples fall within the WHO guideline for table salt quality. Manganese is an essential metallic element for both plant and animal growth. Mn intoxication leads to Parkinsonism which usually is progressive and irreversible, reflecting to some extent the permanent damage of neurologic structures<sup>26</sup>.

**Iron:** The minimum and maximum concentration of iron varied from 3.899 to 30.94 (μg/g) respectively whereas the maximum allowable limit for iron as per WHO guidelines is 30.0mg/kg. The concentration Fe in TS-1 exceeds the permissible limit with a difference of about 0.01 μg/g, and Fe was not detected in TS-4. The level of Fe in other salt samples fall within the permissible limit for iron as per WHO quality (30.0mg/kg) standard which is in close agreement to what was reported by Vogel<sup>33</sup>. Iron is the most abundant essential micronutrient in body tissues. Optimal Fe concentration is required for the endurance of plants, animals and microorganisms<sup>24</sup>. WHO has reported that approximately 46 % of the world's children and 48 % of pregnant women suffer from anaemia. Fe deficiency causes irreversible alteration of brain functions and affects immune response in many ways<sup>27,28</sup>.

**Copper:** Copper was not detected in all the five salt samples. WHO and SON recommended 2.0mg/kg as the maximum of copper content. Copper is a heavy metal and much consumption of it can be dangerous to human health. It is advisable that salt contains less quantity of this metal or if possible not to contain it at all.

**Anions [SO<sub>4</sub><sup>2-</sup>, Cl<sup>-</sup>, and I<sup>-</sup>]:** All the ions found are not unexpected as some of them are naturally associated with salt, while some are added to improve its quality. Iodine is a key constituent of thyroid hormones, deficiency leads to hypothyroidism, goiter and high levels of iodine can effect thyroid function<sup>29</sup>. Iodine was found to be present in all the salt samples; SON recommended iodine content in salt at factory level to be 50 ppm and not less than 30 ppm at market level. Iodine content was high in TS-4; this might be due to too much iodine during iodization. The result agrees with the findings of Hurlbut and Cornelius<sup>2</sup> who reported iodine content of 42 ppm.

TS-4 was found without sulphate [SO<sub>4</sub><sup>2-</sup>]. Sulphate has numerous roles in human metabolism<sup>30</sup>. The recommended sulphate content set by SON was 5.0 mg/kg; WHO and NAFDAC specifies a lower sulphate content value of 2.0 mg/kg. The salt samples conform with the standards of the regulatory bodies. Laszlo and Pierre<sup>3</sup> found that the sulphate content in salt should not exceed 1.10 mg/kg. This observed value fall within the range obtained for all the samples.

The salt samples analyzed contain chloride ions which play a key role in cellular functions including neurotransmission, and are needed for making hydrochloric acid in stomach<sup>32</sup>. TS-3 fall below the recommended percentage of chloride in salt. SON recommended an average value of 97.00 % of sodium chloride in salt. Gary<sup>33</sup> obtained a closely related value of 98 % in a sample of salt analyzed.

## Conclusion

In conclusion, most commonly salts consumed in the Sokoto market had greater moisture content value which could make them get classified as either table or cooking salt. The pH tends towards alkaline value from neutral as a result of different keeping conditions in the households which may lead to inability of important components. Trace metals: Na, K, Mn, Fe, Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup> and I<sup>-</sup> are present in salt samples at different concentrations, which in some cases exceeded the permissible levels set by World Health Organization (WHO).

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