

# Prospecting the levels of some macroelements (sodium, calcium, potassium, magnesium) and possible goitrogenic effects of calcium and magnesium on iodine in herbal snuff in Sokoto State, Nigeria

Yusuf Sarkingobir<sup>1\*</sup>, Yusuf Yahaya Miya<sup>2</sup>

<sup>1</sup>Shehu Shagari University of Education, Sokoto, Sokoto State, Nigeria

<sup>2</sup>Galaxy College of Health Technology Bauchi, Bauchi State, Nigeria

\*Corresponding author: superoxidisedismutase594@gmail.com

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## ABSTRACT

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The elements sodium, calcium, potassium, iodine, and magnesium are essential in our diets for nutritional guidance and avoiding excessive intake and effects. Among other factors, healthcare and the high cost of conventional medicines compelled many people to use herbal snuffs for medicinal or psychoactive means. Likewise, sodium, potassium, calcium, and magnesium pollution levels could be exaggerated and harm humans. The objective of this work was to detect the levels of sodium, potassium, calcium, magnesium, and iodine present in four different types of herbal snuffs consumed in Sokoto and nearby in Nigeria by using atomic absorption spectroscopy and prospect the effect of calcium and magnesium on iodine. Four brands of herbal snuffs bought in Sokoto were used for this work. The highest sodium was detected in herbal two and the lowest in herbal 1. The potassium was highest in herb 2 ( $39.41 \pm 1.4\text{ppm}$ ) and lowest in herbal snuffs 3 ( $6.61 + 1.4\text{ppm}$ ). The lowest levels of Ca and Mg were determined in herbal snuff brands sold in Sokoto, Nigeria. The highest calcium was detected in herbal snuff 4 ( $35.51 \pm 6.10\text{ppm}$ ), and the lowest was in snuff 1 ( $31.00 \pm 9.10\text{ppm}$ ). The magnesium concentration was highest in herbal stock 4 ( $9.31 \pm 1.11\text{ppm}$ ) and lowest in herbal stuff 3 ( $3.05 \pm 0.60\text{ppm}$ ). Generally, the levels of the analyzed elements are in the order of sodium > calcium > potassium > magnesium. Thus, there are significant ( $p < 0.05$ ) sodium, potassium, calcium, and magnesium levels in herbal snuffs in Sokoto, Nigeria, and may contribute to the daily elemental requirements of consumers in the state and nearby.

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## 1. Introduction

Approximately, humans relate with plants for over 1.2 million years or more. About 70% to 80% of humans' daily energy demand is met by plant-based materials (Dikko, 2021; Prabahar, 2012). Recently, demand for plant-based medicines has increased. The side effects of synthetic products, pollution effects, poverty, antibiotic resistance, cost of healthcare, poor social amenities, scientific advancements, and many other reasons are behind the aggravated use of herbal plant medicines (Sen et al., 2021).

Nevertheless, the essential role of plants in the ecosystem, especially in humans, cannot be overstated. Plants are vital in the ecosystem, transferring elements from the environment's abiotic (inorganic) component to the biotic component (Ngumah et al., 2022). Mainly, plants acquired elements into their fold through the growth media. Many of the elements are absorbed and gathered from the soil, and in a specific concentration, plants gather metals from the atmospheric media (Hu et al., 2014; Njoga et al., 2021; Olagunju et al., 2020; Quds et al., 2021; Sen et al., 2021; Umar et al., 2022). The accumulation of elements in plants is an important aspect. The animals, especially humans, using plants as foods and medicines are to benefit from the levels of elements accumulated by the plants from the ecosystem (Murphy et al., 2021; Saxena et al., 2013; Seiyaboh et al., 2020; Tukur et al., 2023).

Basic mineral elements in the soil environment are essential in plants/herbs; they must be removed from the soil. Potassium, calcium, and magnesium are macroelements required and taken up by herbs. Meanwhile, iodine is a micronutrient in herbal nutrition (Alaoui et al., 2022). In plants, sodium is functional in controlling osmotic pressure; potassium is functional in ensuring optimal growth; calcium is needed for the structure of cell walls and membranes; magnesium participates in many reactions such as chlorophyll synthesis, synthesis, transportation, enzyme activation, and protein synthesis (Afuape et al., 2022; Alaoui et al., 2022). Similarly, to humans, elements are needed for innumerable purposes. Magnesium is an electrolytic part of blood and body fluid, and sodium is required to transmit nerve impulses, water balance, and muscle activities. Potassium is essential in maintaining normal body fluids, and calcium is vital in metabolism and in structures such as bones, muscles, and teeth (Dahlawi et al., 2021; Garba et al., 2013; Muhammad & Umar, 2013; Saeed et al., 2011; Sarkingobir et al., 2023).

However, due to pollution and chronic or acute exposure, the levels of sodium, calcium, potassium, and magnesium metals could be unsafe for consumers, and the herbal snuffs could bypass the regulatory bodies in contrast to the conventional drugs (Al-Thani et al., 2023; Balalimood et al., 2021). Moreover, iodine, an essential micronutrient in the human biological system for growth and development, can be inhibited from its usual activities by consumption of excess calcium and magnesium (Hamza et al., 2023; Tschinkel et al., 2020). Likewise, there is scarce information about the constituents of herbal snuff in Nigeria and Sokoto in particular.

Macroelements are required by biological systems comparatively in large quantities, while micronutrients are needed in minute amounts. Plants are primary sources of herbal snuffs (Johnson & Mirza, 2020). Plants obtain macroelements and microelements from the environment, mainly soil and water (Johnson & Mirza, 2020). Therefore, the elemental entities (such as calcium, potassium, magnesium, sodium, and iodine) in herbal snuff being consumed by the locals are either because of pollution, contamination and uptake from soils and water (usual plant nutrition) (Godswill et al., 2020; Kumar et al., 2022; Sarkingobir et al., 2022). The need to consume plant-based products has intensified (Mohammed, 2019).

Approximately 300 million people globally use snuff products, with at least one in ten adults in low-income countries using these products. The use of snuff products has significant health consequences, including six million disability-adjusted life years, 266,592 cancers, and heart disease-related deaths worldwide (Salifu et al., 2023). Snuff is a powdered product made from herbs, plants, or tobacco, often mixed with other ingredients. While snuffing has been used as an alternative therapy for various ailments, it has been linked to cardiovascular diseases and

cancers (Ajayi et al., 2023; Prabhakar et al., 2012). Studies have shown that snuff products contain toxic levels of heavy metals, posing health risks to users. For instance, research in India, Ghana, and Nigeria has detected high levels of heavy metals like arsenic, cadmium, lead, and chromium in snuff products (Salifu et al., 2023). A study in Ghana found a high prevalence of snuff use among participants, coupled with a lack of awareness about the associated health hazards. Another study in Nigeria found that exposure to snuff products may cause non-cancer health risks. Experimental research has also shown that certain snuff products can cause oxidative stress in the brain. Overall, the available evidence highlights the need for increased awareness about the health risks associated with snuff use and for regulatory measures to ensure the safety of these products (Owusu-Asante et al., 2022; Salifu et al., 2023).

Calcium has a Recommended Daily Intake (RDI) of 1000 mg/day for adult humans (up to 50 years old), and it is obtained from green leafy vegetables, seeds, nuts, etc. The role of calcium includes building bones, supporting the synthesis of blood cells, heart health, and muscle health, among other things (Godswill et al., 2020; Michigan WIC Program, 2022). Magnesium has a 350mg Recommended Dietary Allowance (RDA) (for 19+ and above old males) (Duruibe et al., 2007). It is required to act as an enzyme cofactor in the synthesis of ATP and glucose metabolism to pyruvate. This fundamental platform releases ATP to humans from glucose (Godswill et al., 2020). The sodium is required for electrolyte balance and co-regulating ATP when acting with potassium. Potassium is an electrolyte essential in the co-regulation of ATP. However, despite the critical functions of these elements, their presence in the herbal snuff could spur concern. Calcium and magnesium may cause antinutritional activity against the micronutrient iodine (Bonga et al., 2015). Some antinutrients act as goitrogens, and goitrogens lead to iodine deficiency disorders. Iodine deficiency has been due to factors such as the consumption of excessive amounts of antinutrients (goitrogens) in foods or drugs. Iodine deficiency can also result from chronic intake of goitrogens. Iodine deficiency could lead to damage to the brain, poor fetal development, poor growth, cretinism, dwarfism, and mental derangements. The effects are more pronounced or specific in young ones (Abu Bashar & Begam, 2020). Thus, the objective of this work was to detect the levels of sodium, potassium, calcium, magnesium, and iodine present in four different types of herbal snuffs consumed in Sokoto and nearby in Nigeria by using atomic absorption spectroscopy and prospect the effect of calcium and magnesium on iodine.

## **2. Materials and methods**

Herbal snuffs are famous in Sokoto state, especially in the Sokoto City. Snuffs are made in powder and packaged in small plastic containers to be bought by consumers to solve health needs and elicit psychological feelings. They are used equally for various therapeutic means. Each herbal snuff pack is named after the manufacturer, uses, or relations; the name is denoted in the container. Since the snuffs are from different companies/manufacturers, they may differ in effect and composition, as well as their price and consumer preferences. The four different herbal snuffs were bought from Sokoto Central Market. Three pictures of them, Hajiya Aisha, Hajiya Safiya, and Dr Lambo, are in Figure 1. The determination of metals (sodium, potassium, calcium, and magnesium) and iodine compositions in herbal snuffs were performed by the methods (atomic absorption spectroscopy) of the Association of Analytical Chemists (AOAC) described in Hassan et al. (2011) and Umar et al. (2022).

**Figure 1**

*Some Herbal Snuffs Collected from Sokoto, Nigeria*



*Source.* The data are from “Assessment of proximate and phytochemical contents of some herbal snuffs sold in Sokoto Metropolis, Nigeria” by U. Tukur, A. I. Umar, M. Dikko, Y. Sarkingobir, and A. Zayyanu, 2023, *Indonesian Chimica Letters*, 2(1), pp. 1-5

**Statistical analysis**

The descriptive statistics and one-way analysis of variance (ANOVA) were carried out at ( $p < 0.05$ ) significance level using Microsoft Excel version 7.

**3. Results**

The results determined in this work are shown in Tables 1 - 3.

**Table 1**

*Showing Levels of Na and K Nutrients Detected in Snuff Stocks Collected from Sokoto, Nigeria*

Type of snuff	Na (ppm)	K (ppm)
1 = Snuff herbal powder	16.41 ± 5.10	10.51 ± 0.62
2 = Hajiya Ayisha snuff AK 47	40.10 ± 0.51	39.41 ± 0.81
3 = Dr. Lambo Special Sundu	37.51 ± 3.16	6.61 ± 1.41
4 = Hajiya Ayisha snuff AK47 Blue Cover	26.02 ± 5.51	19.90 ± 0.61

*Source.* Laboratory Work (2024) Values are expressed as mean ± standard deviation

**Table 2***Showing Levels of Ca and Mg Nutrients Detected in Snuff Stocks Collected from Sokoto, Nigeria*

Type of snuff	Ca (ppm)	Mg (ppm)
1 = Snuff herbal powder	31.00 ± 9.10	3.50 ± 0.61
2 = Hajiya Ayisha snuff AK 47	32.00 ± 9.11	9.16 ± 0.11
3 = Dr. Lambo Special Sundu	32.81 ± 1.16	3.05 ± 0.60
4 = Hajiya Ayisha snuff AK47 Blue Cover	35.51 ± 6.10	9.31 ± 1.11

Source. Laboratory Work (2024) Values are expressed as mean ± standard deviation

**Table 3***Showing Values of Iodine, I/Ca, and I/Mg for Snuff Stocks Collected from Sokoto, Nigeria*

Type of snuff	Iodine (ppm)	I/Ca	I/Mg
1 = Snuff herbal powder	20.15 ± 1.5	0.65	5.76
2 = Hajiya Ayisha snuff AK 47	19.11 ± 1.6	0.48	2.09
3 = Dr. Lambo Special Sundu	9.05 ± 0.5	0.28	2.98
4 = Hajiya Ayisha snuff AK47 Blue Cover	11.0 ± 0.10	0.31	1.18

Source. Laboratory Work (2024)

#### 4. Discussion

Plants are versatile parts of the ecosystem. Herbs are valuable plants in the ecosystem that provide medicines and other essential chemical constituents for human consumption (Hassan, 2013; Khare et al., 2021; Pham et al., 2023). Many people use herbal medicine due to reasons such as poverty, food insecurity, the burden of communicable diseases, pollution, drug resistance, cost of conventional health care, poor healthcare, etc.; therewith, many people are compelled to use alternative medicine. While many people use herbal medicines for their psychoactive effects as well (Chukwuebuka & Chinenye, 2015; Dikko, 2021; Umar, Shehu, et al., 2023; Umar, Sarkingobir, Gobir, et al., 2023; Umar, Sarkingobir, Tambari, et al., 2023; Wang et al., 2021). However, there is growing concern about the safety of these herbal products because they can escape the eagle eye of regulatory agencies in contrast to conventional drugs (Al-Thani et al., 2023). Knowing fully that herbs live in an environment that might be susceptible to pollution, it is pertinent to measure the levels of metals such as sodium, potassium, calcium, and magnesium in herbal snuffs in Sokoto State, Nigeria, to safeguard public health because low or excess metals intake in humans is dangerous (Godswill et al., 2020). Thus, this work aimed to detect the levels of calcium and magnesium consumed in Sokoto and nearby Nigeria and to prospect the effect of calcium and magnesium on iodine.

Table 1 shows the sodium and potassium levels in four different types of herbal snuffs consumed in Sokoto and nearby Nigeria. The highest Na was detected in herbal 2, and the lowest Na was detected in herbal 1. The K was highest in herb 2 ( $39.41 \pm 1.4\text{ppm}$ ) and lowest in herbal snuffs 3 ( $6.61 \pm 1.4\text{ppm}$ ).

In Table 2, the lowest levels of calcium and magnesium were determined in herbal snuff brands sold in Sokoto, Nigeria. The highest calcium was detected in herbal snuff 4

( $35.51 \pm 6.10$ ppm), and the lowest calcium was detected in snuff 1 ( $31.00 \pm 9.10$ ppm) ( $p < 0.05$ ). The magnesium concentration was highest in herbal stock 4 ( $9.31 \pm 1.11$ ppm) and lowest in herbal stuff 3 ( $3.05 \pm 0.60$ ppm) ( $p < 0.05$ ). Generally, the levels of the analyzed elements are in the order of sodium > calcium > potassium > magnesium.

In terms of abundance in the earth's crust, sodium is the 6th element known. Sodium salts are the most abundant salts found in the ecosystem. In humans and other mammals, sodium and potassium metals are utilized to build an electrostatic charge in the cellular membranes, allowing the transmission of nerve impulses. Sodium is a vital monovalent cation in the blood that deals with metabolic and enzyme activities and is required in blood clotting and protein activation. However, excessive sodium intake in humans raises blood pressure, causing heart failure (Constantin & Alexandra, 2011; Hamza et al., 2023). The sodium range of  $16.41 \pm 5.1$ ppm to  $40.10 \pm 5.1$ ppm is lower than the results of medicinal plants (*Achyranthes aspera* L., *Tribulus terrestris*, *Brassica campestris* L., *Cannabis sativa* L., *Peganum harmala*, *Withania somnifera* L.) determined in Pakistan by Ghani et al. (2012); lower than results found in herbs (*L. citriodora*, and *M. officinalis*) defined in a Turkey's study by Kose et al. (2017).

Potassium is essential as a diuretic and helps the brain, nerves, and heart function correctly. It acts in the acid-base balance, water regulation, etc. (Mathew et al., 2021; Nkuba & Mohammed, 2017). The potassium concentrations found in the studies of herbal snuff range from  $6.62 \pm 1.41$  to  $39.41 \pm 0.81$ ppm, which is lower than the results observed in herbal preparations in Turkey by Kose et al. (2017). It is also lower than the results obtained by Kaba et al. (2020) in Ginger from Ethiopia and similar to the potassium level in *Mentha* species from Bosnia and Herzegovina found by Mandal (2021). The values of potassium shown in Table 2 are lower than the recommended amount reported in Nkuba and Mohammed (2017).

Calcium metal is the most abundant element in our body and helps form bones (Hassan et al., 2011; Mandal, 2021). It helps teeth, muscles, and heart function (Ghani et al., 2012). The calcium determined in this work ( $31.00 \pm 9.10$  to  $35.51 \pm 6.10$ ppm) in *Mentha* species in Bosnia and Herzegovina. The result of calcium is lower than the one recorded in Ginger from Ethiopia by Kaba et al. (2020) and lower than the calcium found in herbal products in Turkey's work by Kose et al. (2017). Indeed, the calcium found in this work did not exceed the maximum allowed limit in water (50 mg/l) and is lower than the Recommended Dietary Allowance (RDA) for all ages (Duruibe et al., 2007).

Magnesium is needed for plasma and extracellular fluid to maintain osmotic pressure. For instance, many enzymatic reactions are speeded by Mg activation in ATP synthesis (Khare et al., 2021; Mohammed, 2019; Nkuba & Mohammed, 2017). Magnesium determined in this work (Table 2) ranges from  $3.05 \pm 0.60$  to  $9.31 \pm 1.11$ ppm. This is lower than many herbal plants in Pakistan, as Ghani et al. (2012) show. The result (Table 2) is lower in commonly used plants for herbal preparations (*Moringa oleifera* and *Hibiscus sabsdariffa* from Tanzania), as found by Nkuba and Mohammed (2017). Nevertheless, the Mg-determined values are lower than the RDA of 60.00 (Nkuba & Mohammed, 2017). Similarly, the magnesium determined in this work is lower than the maximum acceptable concentration in water set by WHO (50 mg/l) and lower than the RDA for all ages (Duruibe et al., 2007).

Generally, the presence of sodium, potassium, calcium, and magnesium in herbal snuff could principally be due to the uptake of these elements by the plants from the environment (Halder & Khaled, 2021; Kumar et al., 2022; Labbo et al., 2021). The uptake is meant to help in

the biochemical activities of the herbs and is also beneficial to the animals (particularly humans) that consume the herbal products; therewith, the elements are required by the human body for various biochemical processes (Al-Thani et al., 2023; Arsene et al., 2022; Benson et al., 2017). Similarly, the levels of the elements are within limits, which shows that these metals did not pollute the herbs or their products and may invariably help meet the daily requirements of the sodium, potassium, calcium, and magnesium metals.

Table 3 shows the I and I/goitrogen ratio (I/Mg and I/Ca) in the herbal snuffs. In the Table, the I levels are above 15ppm in snuffs 1 and 2 and therefore suitable; while in snuffs 3 and 4, the levels of iodine are below 15ppm, and consequently, it is a thing of concern (Chandra et al., 2010; Lopez-Moreno et al., 2022). However, the levels of Ca and Mg (the potential antinutrients in other sense) are of slight concern because the I/goitrogen ratio is less than 7 and may elicit some effects if other I sources are insufficient (Chandra et al., 2010).

Snuff is a product obtained mainly by pulverizing plant-based material into powder. Additive additives may be added for various reasons (Muhammad et al., 2021). There is the claim the use of snuff for medicinal purposes and to elicit The ability of snuff to cause pleasure contributes to its abuse, subsequently leading to addiction among many of the users (Salifu et al., 2023). In northern Nigeria, such as Sokoto, herbal medicine preparations are rising (Muhammad et al., 2021). Therefore, despite the biological essentiality of the determined elements (calcium, sodium, magnesium, and iodine) found in the analyzed herbal snuffs collected from Sokoto, Nigeria, it is essential to prospect the possibility of causing adverse effects because there is rare data and information about herbal snuff and impact in the region (Muhammad et al., 2021). The elements (calcium, magnesium, potassium, and sodium) are below their Recommended Dietary Allowance (RDA). Still, their presence may raise concern amidst rapid abuse of the snuff by people since the snuffs are prone to be addictive or consumed excessively. The macroelements may lead to inevitable misadventures. The macroelements may serve as antinutrients (goitrogens). Goitrogens act to interfere with the iodine metabolism, leading to iodine lesions in that regard, thereby putting the consumers at risk of iodine deficiency disorders such as goiter, cretinism, dwarfism, poor academic performance, poor fetal health, etc. (Bonga et al., 2015; Oladejo et al., 2018).

## 5. Conclusion

Herbal snuffs are made from plants and are common among many in Northern Nigeria, particularly in Sokoto. The utilization of these substances is due to lapses in healthcare and psychoactive properties. However, due to pollution, soils could have polluted the products. The snuffs that could be polluted could contain sodium, potassium, calcium, and magnesium, an array of essential and dangerous elements when consumed too little or too much. Thus, this study aimed to measure the amounts of sodium, potassium, calcium, and magnesium in herbal snuff sold in Sokoto, Nigeria. Therefore, there are significant levels of sodium, potassium, calcium, and magnesium in herbal snuff in Sokoto, Nigeria, and can contribute to the daily elemental requirements of consumers in the state and nearby.

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