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Elemental Composition of Potash (Kanwa) Varieties: Implications for Food Safety and Public Health

*Fatima S. Mohammed[1], A. S. Tsumba[1], Dori Ahmed[2]**

[1]Federal University of Health Sciences, Azare, Nigeria
[2]Federal Polytechnic, Damaturu, Nigeria

Correspondence: E-mail: fatima.mohammed@fuhsa.edu.ng

ABSTRACT

Potash, locally known as *kanwa*, is widely used in northern Nigeria as a food additive and traditional processing aid. This study evaluated the elemental composition of Jarkanwa, Ungurno, and Mangul varieties marketed in Yobe State. Samples were prepared by microwave-assisted acid digestion and analyzed for major elements, anions, and trace metals. The results revealed clear compositional differences among the three varieties, particularly in potassium, sodium, sulphate, copper, lead, and cadmium. These differences indicate that crude potash products should not be considered chemically uniform. The presence of toxic trace metals and substantial variation in sodium content also raise food-safety concerns. The findings support improved quality control, consumer awareness, and further assessment of dietary exposure associated with crude potash consumption.

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1. INTRODUCTION

Potash is a general term for naturally occurring or processed alkaline mineral materials containing varying proportions of potassium, sodium, carbonate, chloride, sulphate, and other inorganic constituents. In several West African communities, crude potash is traditionally used as a food-processing aid for softening legumes, modifying texture, improving cooking characteristics, and preparing indigenous foods. Kanwa has also been used in traditional preparations, which contributes to its continued availability and consumption in local markets.

The chemical and functional characteristics of potash depend strongly on its source and preparation. Potassium-containing alkaline materials can be produced or recovered from plant-derived ashes, while naturally occurring potash deposits may contain mixtures of soluble mineral salts [1, 2]. Comparative analysis of different potash varieties has further demonstrated that materials marketed under the same general name may differ substantially in their chemical composition [3]. From a food-chemistry perspective, the chemical constituents introduced during processing are also important because reactive compounds may participate in undesirable reactions under particular food-processing conditions [4]. Studies of *kanwa* have demonstrated its direct role in food preparation, including changes in the chemical characteristics of foods during alkaline cooking [5].

Traditional food-softening agents may also differ in their physicochemical and elemental characteristics, indicating that functional similarity does not necessarily imply chemical equivalence [6]. This distinction is important from a food-safety perspective because metals detected in food materials can contribute to dietary exposure depending on their concentration and consumption patterns [7]. Experimental investigations of Nigerian potash products have additionally examined biochemical, hematological, and histopathological responses associated with exposure [8]. Toxicological studies of *Jar Kanwa* similarly indicate that the safety of crude potash should not be assumed solely on the basis of its long-standing traditional use [9]. These findings are consistent with the broader need for safe food-processing practices, appropriate quality control, and protection of consumers from potentially undesirable chemical constituents [10].

In northern Nigeria, potash is consumed in several locally recognized forms. Jarkanwa, Ungurno, and Mangul differ in physical appearance, traditional use, and likely mineral composition. The study samples showed visibly different characteristics, with Ungurno appearing as dense greyish crystalline material, Jarkanwa as a lighter fibrous and translucent mineral, and Mangul as a darker mineral matrix containing fine sediment and evaporite residues. Such physical differences provide an initial indication that locally recognized *kanwa* varieties may represent compositionally distinct mineral materials.

Geographical origin may further contribute to compositional variability. Yobe State is part of the Chad Basin and includes alluvial, aeolian, lacustrine, and evaporitic environments that can favor mineral accumulation under arid and semi-arid conditions. Previous analysis of potash deposits from Yobe State has confirmed that locally occurring materials contain important mineral elements and can differ in elemental composition [11]. Consequently, geographical origin and mineral formation may influence the potassium, sodium, and trace-element profiles of crude potash.

From a food-safety perspective, this variability is important because crude potash is commonly used without standardized purification, compositional labeling, or dosage. Other studies of commercial potash preparations in Nigeria have also reported microbial or heavy-metal contamination, demonstrating that unrefined mineral food additives may represent potential exposure pathways for undesirable contaminants [12].

Heavy metals are especially relevant when mineral additives are consumed repeatedly. Lead (Pb) and cadmium (Cd) are of concern because chronic exposure can produce adverse effects even though actual health risk depends on concentration, consumption quantity, frequency of exposure, body weight, and other dietary sources. Studies of Nigerian food materials have demonstrated the importance of assessing metal concentrations together with potential dietary exposure rather than relying only on visual appearance or traditional classification [7].

Food safety is also influenced by the concentrations of major dietary electrolytes. Sodium and potassium are physiologically important, but their nutritional effects depend on intake and balance. Therefore, a potash material dominated by sodium may have different dietary implications from one dominated by potassium. This issue is particularly relevant where potash is added repeatedly to meals or used without standardized quantities.

The food-processing function of mineral additives should therefore be considered together with compositional safety. Chemical substances added during food preparation may modify food properties while simultaneously introducing additional chemical constituents. Broader food-safety studies emphasize the need for appropriate treatment, monitoring, and control of chemical hazards in foods to support safe food-processing practices and consumer protection [10].

Comparative characterization is particularly important because different locally recognized potash varieties may not present the same elemental profile. Previous studies have reported substantial compositional variability among Nigerian potash materials [3, 11]. Such evidence supports direct analytical comparison rather than treating all forms of *kanwa* as chemically equivalent.

In addition, the presence of nitrate and other reactive food constituents can have broader food-safety relevance. Food-chemistry studies have highlighted the importance of controlling compounds associated with undesirable reactions during food processing [4]. Although the present study does not evaluate reaction products or dietary exposure directly, measuring nitrate together with major elements and trace metals provides a broader characterization of the tested potash samples.

Despite the widespread culinary use of potash in northern Nigeria, comparative information on Jarkanwa, Ungurno, and Mangul remains limited. The original experimental data show substantial differences among these varieties in potassium, sodium, sulphate, copper, lead, and cadmium concentrations. However, elemental concentration alone should not be interpreted as proof of clinical disease because the present study did not quantify individual consumption, bioavailability, total dietary exposure, or health outcomes.

this study aimed to determine and compare the elemental composition of Jarkanwa, Ungurno, and Mangul potash varieties marketed in Yobe State, Nigeria. Particular attention was given to potassium (K), sodium (Na), nitrate (NO_3^-), sulphate (SO_4^{2-}), copper (Cu), lead (Pb), and cadmium (Cd). The study further evaluates the implications of the observed compositional differences for food safety, consumer awareness, and future dietary-exposure assessment.

2. LITERATURE REVIEW

2.1. Potash as a Traditional Food-Processing Material

Potash is widely used in West African food preparation as an alkaline processing material. Its applications include softening legumes, reducing cooking time, modifying texture, and facilitating the preparation of traditional foods. Potassium-containing alkaline materials can originate from plant ashes or naturally occurring mineral deposits, and their composition depends on raw material source and processing conditions [1, 2]. The addition of kanwa during cooking can alter the chemical and physical characteristics of foods. Previous research has demonstrated that alkaline salt treatment can influence the composition of foods during processing, indicating that potash should be considered not only as a traditional additive but also as a chemically active processing material [3]. The culinary function of potash is summarized in **Table 1**.

Table 1. Principal functions and considerations associated with traditional potash use.

ASPECT	FUNCTION OR CHARACTERISTIC	FOOD-SAFETY CONSIDERATION
Food tenderization	Softening legumes and other foods	Quantity added is generally not standardized
Cooking aid	Reduction of cooking time	Composition varies among potash sources
Texture modification	Changes food consistency	Mineral salts may be transferred into food
Traditional preparation	Used in indigenous dishes and remedies	Repeated consumption may increase elemental exposure
Mineral source	Contains potassium, sodium, and other constituents	Trace metals may also be present

2.2. Geological Origin and Elemental Variability

Naturally occurring potash is chemically heterogeneous because its composition reflects mineral origin, geological conditions, weathering, and environmental exposure. Yobe State lies within the Chad Basin, where arid and semi-arid conditions can promote evaporative concentration and precipitation of mineral salts. Previous analysis of potash deposits from Yobe State has demonstrated the occurrence of important mineral elements and compositional differences among locally available materials [11]. This geographical evidence is particularly relevant to the present study because Jarkanwa, Ungurno, and Mangul were obtained from markets within the same region. Crude potash is generally marketed with limited refining or compositional standardization. Consequently, variations in potassium, sodium, sulphate, nitrate, and trace-metal concentrations may occur among products that are all locally classified as kanwa. Direct elemental analysis is therefore necessary to establish whether different varieties have comparable chemical profiles.

2.3. Toxicological and Heavy-Metal Considerations

The main groups of chemical parameters commonly evaluated in food testing include nutritional components, basic chemical properties, food additives, chemical contaminants, and process-related safety compounds, as summarized in **Figure 1**. This figure illustrates the broad range of chemical parameters commonly examined in food analysis. Nutritional composition includes moisture, ash, protein, fat, carbohydrates, and fiber, while basic chemical properties include pH, acidity, salt content, and total sugar. Food additives such as colorants, artificial sweeteners, preservatives, flavor enhancers, and antioxidants may also be evaluated. Chemical contaminants, including heavy metals, pesticide residues, veterinary drug residues, mycotoxins, formalin, and borax, are particularly important for food-safety assessment. In addition, process-related compounds such as nitrite, nitrate, sulfite, peroxide, and acrylamide may be monitored depending on the type of food and processing conditions. These analyses collectively support food-safety evaluation, product-quality assessment, regulatory compliance, and consumer protection.

Figure 1. Major chemical parameters commonly evaluated in food testing for quality and safety assessment.

Table 2 shows elemental groups considered in the food-safety evaluation. Traditional use does not necessarily establish the chemical safety of crude potash. Toxicological studies of *Jar Kanwa* have demonstrated the need to evaluate the biological implications of potash consumption rather than assuming that traditional materials are inherently safe [9]. Experimental studies of Nigerian potash products have also examined biochemical, hematological, and histopathological responses associated with exposure [8]. Heavy-metal contamination represents an additional concern. Commercial potash preparations have been reported to contain potentially undesirable metallic contaminants, demonstrating that crude mineral additives may act as sources of dietary exposure [12]. Similar concerns are relevant to other Nigerian foods because foodborne exposure to metals depends on both contaminant concentration and consumption patterns [7]. Lead and cadmium are particularly important because they have no required nutritional function at the concentrations relevant to contamination. Copper differs because it is an essential micronutrient, although excessive exposure may also be undesirable. Accordingly, determination of Cu, Pb, and Cd provides complementary information regarding the trace-element characteristics of potash.

Table 2. Elemental groups considered in the food-safety evaluation of potash.

ELEMENTAL GROUP	ELEMENTS/SPECIES	PRINCIPAL RELEVANCE
Major electrolytes	K, Na	Mineral composition and potential dietary contribution
Inorganic anions	NO_3^-, SO_4^{2-}	Chemical characterization of potash varieties
Essential trace element	Cu	Nutritional element but undesirable at excessive exposure
Potentially toxic metals	Pb, Cd	Food-safety and repeated-exposure concern

2.4. Sodium, Potassium, and Food-Safety Implications

Sodium and potassium are physiologically important electrolytes, but the food-safety implications of potash depend on their relative concentrations and the quantity of potash consumed. A potassium-dominant material may have a substantially different chemical profile from a sodium-dominant material even though both are marketed under the same general name. Studies evaluating traditional food-softening materials demonstrate that mineral additives can differ substantially in their elemental characteristics [6]. Therefore, visual appearance or traditional classification alone cannot establish the nutritional or chemical properties of an individual potash variety. Safe food processing requires attention not only to microbiological hazards but also to chemical constituents introduced during preparation [10]. This consideration is especially important when crude mineral additives are used repeatedly without compositional labeling or standardized dosage.

2.5. Need for Comparative Characterization

Comparative studies of Nigerian potash materials have shown that different varieties may contain substantially different proportions of major and trace elements [3, 11]. Consequently, treating all kanwa products as chemically equivalent can obscure differences that may be important for food processing and consumer exposure. Nitrate is also relevant to broader food chemistry because nitrogen-containing compounds can participate in undesirable reactions under particular food-processing conditions [4].

3. MATERIALS AND METHODS

3.1. Sample Collection

Three commercially available potash varieties, namely Jarkanwa, Ungurno, and Mangul, were collected from major retail markets in Yobe State, Nigeria. Sampling locations included Damaturu, Gashua, and Potiskum. Triplicate samples were obtained for each variety to support comparative elemental analysis. The samples showed visibly different physical characteristics. Ungurno consisted primarily of dense light-grey to dirty-white crystalline aggregates, Jarkanwa appeared as lighter fibrous and translucent crystalline material, and Mangul consisted of a darker grey-to-brown mineral matrix containing fine sediment and evaporite residues. Although the present study does not evaluate reaction products, inclusion of nitrate together with sulphate, major electrolytes, and trace metals provides a broader compositional assessment. Based on these considerations, the present study compares Jarkanwa, Ungurno, and Mangul using the analytical framework summarized in **Table 3**.

Table 3. Analytical framework for comparative characterization of potash varieties.

ANALYTICAL DIMENSION	MEASURED PARAMETER	PURPOSE
Major mineral composition	K and Na	Distinguish potassium- and sodium-dominant profiles
Inorganic species	NO_3^- and SO_4^{2-}	Characterize compositional variability
Trace-element profile	Cu	Evaluate essential trace-metal content
Potential contamination	Pb and Cd	Identify possible food-safety concerns
Varietal comparison	Jarkanwa, Ungurno, Mangul	Determine whether locally recognized varieties are chemically distinct

3.2. Sample Preparation

All glassware and TFM digestion vessels were soaked in 10% (v/v) nitric acid for 24 h and subsequently rinsed with ultrapure deionized water to minimize contamination. The potash samples were cleaned to remove adhering surface particles and dried in a laboratory oven at 105 °C for 4 h. The dried materials were subsequently pulverized using a clean agate mortar and pestle to obtain homogeneous powders for digestion and elemental analysis.

3.3. Microwave-Assisted Acid Digestion

Approximately 1.0000 g of each pulverized sample was weighed into a high-pressure TFM digestion vessel. Each sample was treated with 6 mL of 65% nitric acid and 2 mL of 30% hydrogen peroxide. Microwave-assisted digestion was performed using a Sineo Master 40 system. The operating conditions are summarized in **Table 4**. Following digestion and cooling, the solutions were quantitatively transferred into 50-mL volumetric flasks and diluted to volume using ultrapure deionized water. The resulting solutions were prepared for instrumental analysis.

3.4. Elemental and Inorganic-Species Analysis

Potassium (K), sodium (Na), copper (Cu), lead (Pb), and cadmium (Cd) were determined using atomic absorption spectrophotometry with element-specific hollow cathode lamps. Nitrate (NO_3^-) and sulphate (SO_4^{2-}) were determined using the spectrophotometric and chromatographic procedures employed in the experimental protocol. Because the available experimental record does not unambiguously assign a specific instrumental technique to each anion, no additional instrument-specific detail was assumed in the present description.

Table 4. Microwave-assisted digestion conditions.

DIGESTION STEP	TARGET TEMPERATURE (°C)	RAMP TIME (min)	HOLD TIME (min)	MAXIMUM PRESSURE (psi)
Step 1	130	8	5	400
Step 2	160	5	5	600
Step 3	190	5	20	800

3.5. Calibration and Quality Control

Daily calibration curves were prepared using certified reference standards, and calibration relationships produced coefficients of determination greater than 0.999. Reagent blanks were processed together with the samples to monitor contamination introduced during sample preparation and digestion. All measurements were performed in triplicate. Results were expressed as mean ± standard deviation where applicable.

3.6. Data Analysis and Comparative Interpretation

The concentrations of K, Na, NO_3^-, SO_4^{2-}, Cu, Pb, and Cd were compared among Jarkanwa, Ungurno, and Mangul. Elemental concentrations were expressed as percentages according to the original analytical dataset. The analytical procedure consisted of four stages, as summarized in **Table 5**. The interpretation focused on compositional differences rather than direct clinical risk. Food-safety implications were therefore discussed as potential exposure considerations because individual potash consumption rates, elemental bioavailability, total dietary intake, and clinical health outcomes were not measured in this study.

Table 5. Analytical stages used in the study.

STAGE	ANALYTICAL ACTIVITY	MAIN OUTPUT
1	Collection and preparation of three potash varieties	Homogeneous analytical samples
2	Microwave-assisted acid digestion	Digested mineral solutions
3	Determination of major elements, anions, and trace metals	Elemental concentration dataset
4	Comparative interpretation	Varietal composition and food-safety considerations

4. RESULTS AND DISCUSSION

4.1. Elemental Composition of the Potash Varieties

The elemental compositions of Jarkanwa, Ungurno, and Mangul are summarized in **Table 6**. The results show clear compositional differences among the three potash varieties. Jarkanwa contained the highest potassium concentration, followed closely by Ungurno, whereas Mangul showed substantially lower potassium content. In contrast, Mangul contained the highest sodium concentration. These differences confirm that locally marketed materials collectively described as *kanwa* are not chemically uniform. The high potassium contents of Jarkanwa and Ungurno are consistent with the characteristics expected for potassium-containing alkaline materials [1-4]. The compositional differences among varieties are also consistent with previous reports showing that potash materials from different sources can vary considerably in their elemental composition [4, 11].

Table 6. Elemental composition of potash varieties from Yobe State.

ELEMENT/SPECIES	JARKANWA (%)	UNGURNO (%)	MANGUL (%)	MEAN ± SD (%)
Potassium (K)	2.138	2.048	1.102	1.763 ± 0.56
Sodium (Na)	1.545	1.738	2.413	1.898 ± 0.46
Nitrate (NO_3^-)	0.718	0.689	0.563	0.656 ± 0.08
Sulphate (SO_4^{2-})	0.925	0.913	0.075	0.637 ± 0.48
Copper (Cu)	0.648	0.361	0.112	0.373 ± 0.26
Lead (Pb)	0.011	0.014	ND	0.008 ± 0.007
Cadmium (Cd)	0.002	ND	0.001	0.001 ± 0.001

Note: ND = not detected at the reported detection limit.

4.2. Potassium and Sodium Profiles

The contrasting potassium and sodium profiles represent one of the most important findings. Jarkanwa and Ungurno were potassium-dominant, whereas Mangul was sodium-dominant. This difference is relevant because the same traditional name may be applied to mineral materials with substantially different electrolyte compositions. Studies of food-processing potash have shown that alkaline salts can influence food composition during cooking [5]. The relatively high sodium concentration in Mangul therefore represents a potential source of additional dietary sodium when the material is used repeatedly or without standardized dosage. However, the present results should be interpreted as compositional evidence rather than direct evidence of cardiovascular risk. Actual dietary exposure would depend on the quantity of potash used, frequency of consumption, transfer of sodium into the prepared food, background dietary intake, and individual physiological factors. The potassium and sodium differences among the three varieties are summarized in **Figure 2**. This figure highlights the contrast between the potassium-rich profiles of Jarkanwa and Ungurno and the sodium-rich profile of Mangul. This visual comparison further demonstrates that the three varieties should not be treated as chemically equivalent.

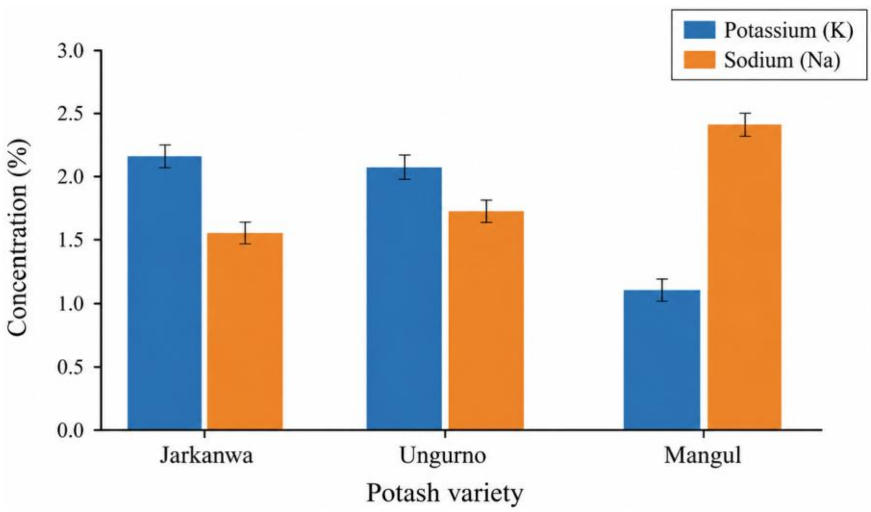

Figure 2. Comparative potassium and sodium concentrations in Jarkanwa, Ungurno, and Mangul potash varieties.

4.3. Trace Metals and Food-Safety Considerations

Trace-metal concentrations also differed among the three varieties. Copper was detected in all samples, with Jarkanwa showing the highest concentration. Lead was detected in Jarkanwa and Ungurno, while cadmium was detected in Jarkanwa and Mangul. These findings are important because Pb and Cd are recognized as potentially toxic contaminants in food-related materials. Toxicological studies of Nigerian potash products have previously raised concerns regarding repeated exposure to crude potash [8, 9]. Other investigations have also reported heavy-metal contamination in commercial potash preparations [12]. The results are summarized in **Table 7**. The detection of Pb and Cd does not by itself establish individual health risk because exposure depends on consumption rate, bioavailability, frequency of intake, body weight, and other sources of exposure. Nevertheless, the presence of these metals supports the need for improved quality control and further dietary-exposure assessment.

Table 7. Trace-metal profile and potential food-safety interpretation.

POTASH VARIETY	Cu (%)	Pb (%)	Cd (%)	MAIN FOOD-SAFETY CONSIDERATION
Jarkanwa	0.648	0.011	0.002	Detectable Pb and Cd
Ungurno	0.361	0.014	ND	Highest measured Pb concentration
Mangul	0.112	ND	0.001	Detectable Cd

4.4. Nitrate and Sulphate Variability

Nitrate concentrations showed relatively small differences among the three potash varieties, whereas sulphate concentrations varied markedly. Jarkanwa and Ungurno contained substantially higher sulphate concentrations than Mangul. The inclusion of nitrate and sulphate broadens the chemical characterization of the potash varieties beyond major cations and trace metals. Nitrate is relevant to food chemistry because nitrogen-containing compounds can participate in reactions of food-safety interest under specific processing conditions [4]. However, the present study measured nitrate concentration only and did not assess reaction products or processing-induced transformations. The marked sulphate difference further supports the conclusion that Jarkanwa, Ungurno, and Mangul represent compositionally distinct mineral materials.

4.5. Comparative Profiles and Traditional Use

The measured compositional characteristics and their potential implications are summarized in **Table 8**. The traditional uses should be interpreted together with the elemental results. Food-processing materials are often selected based on appearance, texture, or customary function, but chemical composition cannot be reliably inferred from these characteristics alone. Broader food-safety research emphasizes the importance of controlling chemical hazards introduced during food preparation [10]. Comparative studies of potash materials likewise support direct analytical characterization rather than assuming chemical equivalence among locally recognized varieties [3, 11].

4.6. Implications for Food Safety and Quality Control

Taken together, the results identify two principal food-safety considerations. First, the strong differences in potassium and sodium concentrations indicate that different kanwa varieties can contribute different electrolyte profiles to prepared foods. Second, the detection of Pb and Cd in some samples indicates a potential route of exposure to toxic trace metals. These findings support routine compositional monitoring of crude potash intended for culinary use. Quality-control programs should prioritize major electrolytes and toxic metals, particularly Na, Pb, and Cd. Safe food-processing practices and consumer awareness are also important because traditional additives may be used without standardized dosage or compositional labeling [9, 10]. The present study does not quantify actual dietary exposure. Future work should therefore determine typical household consumption rates, elemental transfer during cooking, bioavailability, and estimated intake across different age groups. These data would allow a more quantitative assessment of food-safety risk.

Table 8. Comparative composition and food-safety considerations of the three potash varieties.

POTASH VARIETY	MAIN COMPOSITIONAL CHARACTERISTIC	POTENTIAL CONSIDERATION	REPORTED TRADITIONAL USE
Jarkanwa	Highest K and Cu; detectable Pb and Cd	Potential repeated exposure to Pb and Cd	Tenderizing legumes and other foods
Ungurno	High K; highest measured Pb	Potential Pb exposure	Thickening and emulsifying traditional foods
Mangul	Highest Na; lower K; detectable Cd	Additional sodium exposure and Cd presence	Weaning foods and traditional preparations

5. CONCLUSION

This study demonstrated substantial compositional differences among Jarkanwa, Ungurno, and Mangul potash varieties from Yobe State. Jarkanwa and Ungurno were relatively potassium-rich, whereas Mangul showed the highest sodium concentration. Lead and cadmium were detected in some samples, highlighting potential food-safety concerns associated with repeated consumption of crude potash. The results confirm that locally marketed kanwa varieties should not be regarded as chemically uniform. Routine compositional monitoring, improved quality control, and consumer awareness are therefore recommended. Future studies should quantify household use, elemental transfer during cooking, bioavailability, and dietary exposure to support more reliable health-risk assessment.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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