

Mineral Composition of Commonly Consumed Fruits and Vegetables in Hyderabad, Sindh

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Abstract

Minerals are essential micronutrients that control metabolic balance and cardiovascular physiology. To prevent cardiometabolic illnesses, which are common in Pakistan, adequate dietary intake from natural food sources is essential. In order to evaluate the nutritional value, twelve regularly consumed fruits and vegetables; spinach, carrot, mint, ginger, tomato, ladyfinger, potato, cucumber, apple, banana, grapes, and date were collected from Hyderabad, Sindh, Pakistan, to determine calcium (Ca), magnesium (Mg), nickel (Ni), and cobalt (Co) by using Flame Atomic Absorption Spectrometry (FAAS). Spinach had the highest calcium content (0.99 mg/g) and banana and grapes had the lowest (0.05 mg/g). Spinach had the highest concentration of magnesium (0.79 mg/g) while mint and ginger had the

higher concentration of nickel (0.35×10^{-3} mg/g). Spinach had the highest concentration of cobalt (0.20×10^{-4} mg/g). The data showed that mineral content was below WHO toxicity criteria, indicating that it is safe to eat. To support daily mineral requirements and cardiometabolic health in the local population, regular consumption of fruits and vegetables are advised.

Introduction

Minerals are essential components for variety of physiological processes such as enzyme catalysis, membrane integrity, neuromuscular transmission, and hematopoiesis (Beal & Ortenzi, 2022; Berdanier, Dwyer, & Feldman, 2007). Deficits in vital minerals like calcium and magnesium are becoming more widely acknowledged as major causes of cardiovascular illness and mortality worldwide (Razzaque & Wimalawansa, 2025). The burden of micronutrient malnutrition is exacerbated in underdeveloped countries, such as Pakistan, by a high reliance on monotonous staple-based diets and a lack of dietary diversity (M. N. Khan, Aslam, Muhsinah, & Uddin, 2023). A thorough understanding of the micronutrient composition of various fruits and vegetables is

essential to facilitate the appropriate selection of produce, thereby mitigating potential health risks (Nair, Augustine, & Konapur, 2016)

Calcium (Ca) is the most abundant mineral in the human body, with approximately 99% of its total amount stored in the skeletal system (Pravina, Sayaji, & Avinash, 2013). In addition to its structural function, calcium is involved in intracellular signaling, blood clotting, and heart muscle contraction (Gupta & Badami, 2024). Various disease such as hypocalcemia, osteoporosis, hypertension, and elevated cardiovascular risk are linked to chronic calcium deficiency (KD, 2002; Shlisky et al., 2022). Magnesium (Mg) is another important mineral involved in more than 300 enzymatic processes (Pasternak, Kocot, & Horecka, 2010). It controls most important process like production of ATP, glycolysis (Romani, 2013). Disease such as Cardiac arrhythmias, type 2 diabetes mellitus, and metabolic syndrome are linked to hypomagnesaemia (Costello et al., 2016). Cobalt is the primary metal in vitamin B12 (cobalamin), its deficiency causes neurological impairment and pernicious anemia while, nickel is involved in urease activity and lipid metabolism (El-deeb, El-Bialy, El-Borai, & Elsabbagh, 2025; Scharf et al., 2014). Nickel is being nephrotoxic, genotoxic, and cardiotoxic effects at elevated amounts, therefore dietary monitoring is essential (Aftab et al., 2023)

Determining the mineral content in fruits and vegetable is crucial for both public health and nutritional assessment. Thearfore, this study was conducted to quantify Ca, Mg, Ni, and Co in twelve locally accessible fruits and vegetables using FAAS. The results of this study will influence regional public health policies and dietary guidelines.

Materials and Methods

Chemicals and Reagents

All chemical and reagents used in this study were of analytical grade and used without further purification. For sample digestion, concentrated nitric acid, hydrochloric acid, and perchloric acid and certified multi-element standard solutions (1,000 mg/L for Ca, Mg, Ni, and Co) for calibration were acquired from Sigma Aldrich. Deionized water was used throughout the study.

Sample Collection

During the summer harvest season 2020-2022, thirty-six fresh samples of spinach (*Spinacia oleracea*), carrot (*Daucus carota*), mint (*Mentha spicata*), ginger (*Zingiber officinale*), tomato (*Solanum lycopersicum*), ladyfinger/okra (*Abelmoschus esculentus*), potato (*Solanum tuberosum*), cucumber (*Cucumis sativus*), apple (*Malus domestica*), banana (*Musa acuminata*), dates (*Phoenix dactylifera*) were collected. To minimize mineral degradation, samples were kept in acid-washed polyethylene bags at 4°C until analysis.

Sample Preparation and determination

Sample were acid digested prior to analysis as described by AOAC Official Method 975.03 (Chemists, 1988). Briefly 1.0 g of the dried sample was digested in ten milliliters of concentrated HNO₃, followed by the addition of three milliliter of 60% HClO₄ and allowed to heating on hot plate until the solution turned into clear. After cooling, the resulting digest was solubilized with ten milliliters of HCl (1+1) and quantitatively transferred to fifty milliliter volumetric flaks and diluted to the mark. Metal content were determined by using A Shimadzu Flame Atomic Absorption Spectrometer equipped with cathode lamps as described in our previous study (Zahid H. Shar, 2026)

Statistical Analysis

The results are presented as mean \pm standard deviation (SD). To find statistically significant differences in mineral concentrations between sample types ($p < 0.05$) one-way analysis of variance (ANOVA) and Tukey's Honest Significant Difference post-hoc test were employed.

Results and Discussion

The mineral content in different fruits and vegetables was determined by using FAAS and presented in Table 1. Calcium content was detected in highest in spinach 0.99 ± 0.05 mg/g followed by ladyfinger and date (Table 1) with statistically significant inter-sample variation (ANOVA, $p < 0.001$). The elevated values of calcium in Spinach (0.99 ± 0.05 mg/g) consistent with the calcareous alluvial soils of the Indus floodplain of Sindh (Naz, Anjum, Naqvi, Siddique, & Zulfiqar, 2018). Proshad et al 2023 reported calcium in the Spinach in the range of 0.07–0.29 mg/g using ICP-MS in Bangladesh (Proshad & Idris, 2023), while Naz et al, 2018 documented ladyfinger Ca of 0.81 mg/g which is similar to our results 0.82 mg/g (Naz et al., 2018). Banana had the lowest Ca (0.05 ± 0.01 mg/g), consistent with (Yami, Chandravanshi, Wondimu, & Abuye, 2016) who reported Ca 0.075 mg/g in banana. (Maitlo et al., 2023) reported carrot Ca of 1.67 mg/g from Sindh which is higher than the values obtained here 0.33 mg/g. Adequate calcium intake supports arterial smooth muscle regulation and blood pressure homeostasis (Health, 2020)

Magnesium was found 0.05 ± 0.01 mg/g in apples to 0.79 ± 0.04 mg/g in spinach (Table 1), with statistically significant inter-sample variation (ANOVA, $p < 0.001$). Mint (0.63 ± 0.03 mg/g), ladyfinger (0.57 ± 0.03 mg/g) showed higher magnesium content. Yami et al (2016) reported lower banana Mg 0.281 ug/g from Ethiopia due cultivar differences and superior soil Mg content of the Hyderabad floodplain (Yami et al., 2016). The FAO database value for spinach Mg (approximately 0.08 mg/g) is substantially lower than our 0.79 mg/g, likely attributable to the Mg-rich calcareous Indus alluvial soils of Sindh versus temperate European reference conditions (Lisciani, Toti, Camilli, Marconi, & Leclercq). Magnesium is essential for cardiac electrophysiology and its deficiency is linked to ventricular arrhythmias and coronary artery disease (Afshin et al., 2019; Tangvoraphonkchai & Davenport, 2018).

Nickel was detected in the range of 0.05 in apple to 0.35 ug/g in mint. (M. N. Khan et al., 2023) documented spinach Ni of 25 mg/g from Bhakkar which is higher than our value of 0.34 ug/g confirming that canal-irrigated Sindhi produce carries a substantially lower Ni contamination burden. All values remained within WHO maximum permissible limits. Given nickel's haematotoxin, genotoxic, and carcinogenic potential at elevated exposures (Organization, 2011) which needs continued dietary Ni monitoring.

Cobalt was found ranging from 0.002 ug/g in apple to 0.02 ug/g in spinach as shown in table 1. Samoo et al 2022 reported Co 1.46 $\mu\text{g/}$ in vegetable from Hyderabad, substantially higher than our results (Samoo et al., 2022). Cobalt is the central atom of cobalamin (vitamin B₁₂) and an essential for erythropoiesis, neurological function, and DNA synthesis. Co deficiency may causes megaloblastic anemia and elevated cardiovascular risk through hyperhomocysteinemia (M. A. Khan et al.; Oliveira et al., 2018). The high Co content of spinach underscores its value as a plant-based Co source, though bioavailability differs from animal-derived cobalamin. The findings of this study demonstrate that locally grown vegetables and fruits in Hyderabad, Sindh, provide measurable and physiologically meaningful quantities of Ca, Mg, Ni, and Co.

Table 1. Concentrations of Ca, Mg, Ni, and Co in Twelve Vegetables and Fruits

Sample	Botanical Name	Ca	Ni ($\times 10^{-3}$)	Mg	Co ($\times 10^{-4}$)
Spinach	<i>Spinacia oleracea</i>	0.99 ± 0.05	0.45 ± 0.02	0.79 ± 0.04	0.20 ± 0.01

Carrot	<i>Daucus carota</i>	0.33 ± 0.02	0.12 ± 0.01	0.12 ± 0.01	0.10 ± 0.01
Mint	<i>Mentha spicata</i>	0.24 ± 0.01	0.35 ± 0.02	0.63 ± 0.03	0.15 ± 0.01
Ginger	<i>Zingiber officinale</i>	0.16 ± 0.01	0.15 ± 0.01	0.43 ± 0.02	0.12 ± 0.01
Tomato	<i>Solanum lycopersicum</i>	0.10 ± 0.01	0.10 ± 0.01	0.11 ± 0.01	0.05 ± 0.01
Ladyfinger	<i>Abelmoschus esculentus</i>	0.82 ± 0.04	0.25 ± 0.02	0.57 ± 0.03	0.08 ± 0.01
Potato	<i>Solanum tuberosum</i>	0.12 ± 0.01	0.08 ± 0.01	0.23 ± 0.01	0.04 ± 0.01
Cucumber	<i>Cucumis sativus</i>	0.16 ± 0.01	0.11 ± 0.01	0.13 ± 0.01	0.03 ± 0.01
Apple	<i>Malus domestica</i>	0.06 ± 0.01	0.05 ± 0.01	0.05 ± 0.01	0.02 ± 0.01
Banana	<i>Musa acuminata</i>	0.05 ± 0.01	0.12 ± 0.01	0.27 ± 0.02	0.03 ± 0.01
Grapes	<i>Vitis vinifera</i>	0.10 ± 0.01	0.15 ± 0.01	0.07 ± 0.01	0.02 ± 0.01
Date	<i>Phoenix dactylifera</i>	0.64 ± 0.03	0.22 ± 0.02	0.54 ± 0.03	0.18 ± 0.01

Conclusion

This study provides systematic mineral profiling of twelve locally consumed vegetables and fruits from Hyderabad, Sindh, Pakistan. The results showed that spinach was confirmed as the richest source of calcium (0.99 ± 0.05 mg/g), mint provided the highest magnesium (0.35 ± 0.02 mg/g), mint and okra exhibited the highest nickel and spinach displayed the greatest cobalt concentration (0.20 ± 0.01 ug/g). Method validation demonstrated excellent linearity ($R^2 \geq 0.997$), recoveries of 96.9–103.2%, and precision within 2.7% RSD, affirming the accuracy of the method. All mineral levels remained within WHO/FAO safe consumption limits, affirming the suitability of these local foods as dietary mineral sources. These findings underscore the nutritional value of indigenous Sindhi produce and support its integration into population-level dietary strategies for the prevention of calcium- and magnesium-related cardiometabolic disorders.

Conflicts of Interest

The authors declare no conflicts of interest.

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