

Comprehensive nutritional and phytochemical characterization of Barnyard and Kodo millets with emphasis on secondary metabolites and mineral composition

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Abstract

The present study evaluated the nutritional, phytochemical, secondary metabolites and mineral composition of Barnyard millet and Kodo millet collected from the Kalaburagi region of Karnataka, India. Nutritional analysis revealed that barnyard millet contained 62% carbohydrates, 11.5% protein, 3.4% lipid, 25% total ash, 1.6% acid-insoluble ash, 28% watersoluble ash, and 4.6% crude fibre, whereas kodo millet contained 55.3% carbohydrate, 7.9% protein, 3.6% lipid, 3% total ash, 1.2% acid-insoluble ash, 45% water-soluble ash, 3.54% crude fibre. Preliminary phytochemical screening revealed the presence of alkaloids, flavonoids, phenols, glycosides, sterol and triterpenoids. Quantitative estimation showed alkaloid, flavonoid, phenol, glycoside and sterol contents of 0.085%, 0.83% and 11.92% respectively, in barnyard millet and 0.3305%, 0.92% and 11.58% respectively, in kodo millet. Mineral analysis confirmed the presence of chromium (Cr), copper (Cu), zinc (Zn), aluminium (Al), potassium (K), cadmium (Cd), magnesium (Mg), manganese (Mn), calcium (Ca), and iron (Fe) in both milletes. Overall, the results demonstrates that barnyard and kodo millets possess appreciable nutritional value, diverse phytochemicals, bioactive secondary metabolites, and essential minerals, supporting their potential as nutritionally valuable and functional food resources.

Key words; *Echinochloa frumentacea*, *Paspalum scrobiculatum*, Mineral analysis, Phytochemical analysis.

1. INTRODUCTION

Millets are among the oldest cultivated cereals crops known to humankind and have been grown for more than 10,000 years in Asia due to their remarkable adaptability to drought-prone and marginal environments (Saleh et al., 2013; Paschapur et al., 2021). These climate-resilient grains possess a short growing period, often reaching maturity within 60-90 days, making them highly suitable for sustainable agriculture under changing climatic conditions. In recent years, millets have gained renewed attention because of their superior nutritional composition, health-promoting properties, and potential role in addressing food and nutritional security (Kasanaboina et al., 2025). Among the various millet species, Barnyard millet (*Echinochloa frumentacea*) and Kodo millet (*Paspalum scrobiculatum*) are considered important minor millets cultivated predominately in India and several Asian and African countries (Ranganathan et al., 2020; Peethambaran et al., 2024). Barnyard millet is recognized as one of the fastest-growing and hardiest millet crops, capable of

thriving under adverse agro-climatic conditions with minimal agricultural inputs. It is valued for its high dietary fibre content, low carbohydrate digestibility, and excellent nutritional profile, making it particularly beneficial for individuals with diabetes and other metabolic disorders (Bhatt et al., 2023). Similarly, Kodo millet is a drought-tolerant cereal rich in dietary fibre, minerals, phenolic compounds, and antioxidants, which contribute to its significant health-promoting properties (Nirubana et al., 2021).

The increasing prevalence of non-communicable diseases (NCDs) such as diabetes mellitus, cardiovascular diseases, obesity, and cancer has intensified the search for functional foods capable of improving health outcomes (WHO 2023). Dietary interventions remain one of the most effective strategies for managing these chronic disorders, and millets have emerged as promising functional foods because of their low glycemic index, high fibre content, and abundance of bioactive compounds (Gupta et al., 2023). Consumption of millet-based diets has been reported to improve glycemic control, reduce oxidative stress, enhance gut health, and lower the risk of lifestyle-related diseases (Rajalakshmi., 2026).

Barnyard millet contains substantial amounts of dietary fibre, iron, and essential nutrients while being naturally gluten-free, making it suitable for individuals suffering from celiac disease and gluten intolerance (Kumar et al., 2023). Likewise, Kodo millet exhibits strong antioxidant activity and possesses several medicinal properties, including antidiabetic, antiinflammatory, wound healing, and weight-management benefits (Prashanth et al., 2025). These nutritional and therapeutic attributes have led to increasing interest in incorporating millets into modern diets and value-added food products.

Despite their exceptional nutritional superiority and adaptability, the cultivation and consumption of minor millets have declined over the past few decades due to changing food habits, urbanization, and the labor-intensive nature of traditional processing methods (Jayaprasanna et al., 2025). Therefore, the present study aims to evaluate the phytochemical constituents, Nutraceutical analysis, and mineral profile of Barnyard millet and Kodo millet to provide scientific supporting their nutritional significance and potential health benefits.

2. RESEARCH METHODOLOGY

2.1 Collection and identification of millets

Minor millets, namely Barnyard millet and kodo millet were collected from ICAR Krish Vigyan Kendra, Kalaburagi, India. The millets were botanically identified with the assistance of Dr. Raju G. Tegalli, Coordinator, ICAR Krishi Vigyan Kendra, and by referring to the floras available in the Department of Botany, Gulbarga University, Kalaburagi.

The collected millet grains were shade-dried at room temperature for two days. The outer husk was removed using a hulling machine, and the dehulled grains were subsequently ground into a fine powder using a grinding mill. The resulting flour was collected and stored in airtight containers for further analysis.

2.2 Extraction of millet samples

Powdered samples of Barnyard millet and kodo millet were extracted using petroleum ether, methanol, and distilled water as solvents. Briefly, 10g of each powdered sample was mixed with 100ml of respective solvents and subjected to extraction on a rotary shaker at room temperature for 48h. The resulting extracts

were filtered through Whatman No. 1 filter paper, and the filtrates were collected for subsequent phytochemical screening and quantitative estimation of secondary metabolites.

2.3 Nutritional analysis of millets

2.3.1 Estimation of Proteins.

The estimation of protein from minor millet was carried out using Folin- Ciocalteu reagent (FCR) method (Lowry et al., 1951). Briefly, 500mg of powdered millet sample was homogenized in Tris buffer (pH 6.0) and centrifuged at 20000 rpm for 15 min. The supernatant obtained was used for protein estimation. An aliquot of 0.1 ml of extract was mixed with 0.9ml of distilled water to make final volume of 1ml. To this add 5ml of alkaline copper reagent was added and incubated for 10 min at room temperature followed by 0.5ml of FCR was added to the mixture thoroughly and kept in dark for 30 min. After incubation the absorbance was measured at 660nm using UV-Visible spectrophotometer. Bovine serum albumin (BSA) was used as the standard, and a calibration curve was prepared for the quantification. The protein content of the samples was calculated from the standard curve and expressed as mg/100 gm dry weight of the sample.

$$\text{Proteins in mg/100gm} = \frac{\text{Graphical value}}{\text{Wt. of the powdered millet}} \times \frac{\text{Volume of total content}}{\text{Volume of content taken for reading}} \times 100$$

2.3.2 Estimation of Carbohydrates

The total carbohydrate content of Barnyard millet and kodo millet was estimated by the Anthrone method (Susmitha et al., 2025). Briefly, 500 mg of powdered sample was hydrolyzed with 2.5 N hydrochloric acid, neutralized, and centrifuged. The resulting supernatant was used for carbohydrate estimation. An aliquot of 0.1 ml of supernatant was mixed with 0.9ml of distilled water to make final volume of 1ml. To this add 4ml of anthrone reagent and kept in water bath for 8 min the contents were cooled rapidly under the cooling water bath appearance of green to dark green colour. The absorbance was measured at 630 nm using a UV-Visible spectrophotometer. Glucose was used as the standard, and a calibration curve was prepared for quantification.

$$\text{Carbohydrates in mg/100gm} = \frac{\text{Graphical value}}{\text{Wt of the powdered material}} \times \frac{\text{Volume of total content}}{\text{Volume of content taken for reading}} \times 100$$

2.3.3 Determination of Total Lipid Content

The total lipid content of Barnyard millet and kodo millet was determined using petroleum ether extraction (Jenipher et al., 2024). Briefly, 2 g of powdered samples was extracted with 25ml of petroleum ether for 12h on a rotary shaker. The extract was filtered, the filtrate was transferred to a pre-weighed petridish. The solvent was allowed to drain off completely, and the residue obtained was weighed.

$$\text{Wt. of the lipid} = \text{Wt. of petriplate with lipid} - \text{Wt. of empty petriplate}$$

$$\text{Percentage of lipid} = \frac{\text{Wt. of lipid}}{\text{Wt. of the sample}} \times 100$$

2.3.4 Determination of Total Ash Content

The total ash content of Barnyard millet and kodo millet was determined following the method of Jenipher et al., (2024). A known quantity of dried powdered sample was incinerated in a silica crucible and ashed in a muffle furnace at 400-450 °C until a constant weight was obtained. The crucibles were cooled in a desiccator and weighed. The total ash content was calculated and expressed as percentage of dry weight.

$$\text{Total ash value of the sample} = \frac{Z-X}{Y} \times 100$$

Where, X= weight of the empty crucible, Y = weight of the powdered material (g), Z= weight of the crucible with ash

2.3.5 Determination of Acid Insoluble Ash Value

The total ash obtained was treated with 25ml of 25% HCl and boiled for 15 min. After cooling, the mixture was filtered through Whatman No 1 filter paper. The residue retained on the filter paper was transferred to pre-weighed sintered crucible and ignited at 100 °C to a constant weight. The crucible was cooled in a desiccator for 30 min and weighed. The acid-insoluble ash content was calculated and expressed as a percentage of the air-dried sample (Shreya et al., 2019) .

$$\text{AI ash value} = \frac{\text{Weight of the acid insoluble ash}}{\text{Weight of the sample}} \times 100$$

2.3.6 Determination of H₂O Soluble Ash Value

The total ash obtained was boiled with 25ml of distilled water for 5 min and filtered through ashless filter paper. The insoluble residue was washed with hot water, transferred to a silica crucible, and ignited at a temperature not exceeding 450°C for 15 min. The crucible was cooled in a desiccator and weighed. The water-soluble ash content was calculated by subtracting the weight of the insoluble residue from the total ash and expressed as a percentage of the air-dried sample (Angelina et al., 2021).

$$\text{Percentage of H}_2\text{O Soluble Ash Value} = \frac{\text{Total Ash- Obtained Ash}}{\text{Total Ash}} \times 100$$

2.3.7 Acid Digestion of Millet

One gram of ash sample was digested with a mixture of concentrated H₂SO₄ and HNO₃(4:1,v/v). After cooling, the digest was diluted to a final volume of 1000ml with distilled water and filtered through Whatman No. 1 filter paper. The filtrate was analyzed for elemental composition using an atomic absorption spectrophotometer (AAS). A reagent blank prepared with double distilled water was processed and analyzed under identical conditions (Gong et al., 2020).

2.3.8 Determination of Crude Fibre

Two grams of the sample were treated with 1.25% H₂SO₄ and heated for 30 min. The mixture was filtered, and the residue was washed with distilled water until free of acid, as confirmed by pH paper. The residue was then treated with 1.25% NaOH and heated for a further 30 min. After filtration, the residue was thoroughly washed, transferred to a pre-weighed crucible. And dried in a hot air oven at 120°C. The dried sample was

subsequently incinerated in a muffle furnace at 550°C for 12 h, cooled in a desiccator, and weighed. The crude fibre content was calculated and expressed as a percentage of the sample weight (Jenipher et al., 2024).

$$\text{Crude fibre content (\%)} = 100 \frac{(A-B)}{C}$$

Where as, A= Weight of crucible with dry residue (g), B=Weight of crucible with ash, C= Weight of sample (g)

2.4 Preliminary Screening of Secondary Metabolites

Preliminary phytochemical screening of the millet extracts was carried out using standard protocol (Singh and Vidyasagar, 2018; Shaikh & Patil, 2020)

2.4.1 Test for Alkaloids

The stock solution of petroleum ether, chloroform, ethyl acetate, methanol and aqueous extracts were further mixed with the required quantity of ammonia solution followed by acidified chloroform (0.1N HCl) and filtered thus, the filtrates used as test solution for alkaloid detection using following tests.

a. Mayer's Test: (1.36grms HgCl₂ in 60ml of distilled water was mixed with 5grms of KI in 20ml of distilled water, makeup volume to 100ml) few drops of Mayer's reagent was added to 2ml of test solution the formation cream/pale yellow precipitate indicated the presence of alkaloid.

b. Dragendroff's reagent Test: (4grms of KI with 5.2grms of bismuth carbonate in 50ml of glacial acid) few drops of dragendroff's reagent and 2ml of dilute HCl were added to the solution. An orange red coloured precipitate indicates the presence of alkaloid.

c. Wagner's Test: (1.27grms of Iodine and 2grms of KI in 5ml distilled water and makeup the volume to 100ml of distilled water) 2ml of Wagner's reagent was added to 2ml of test solution. The formation of reddish brown precipitate indicates the presence of alkaloid.

2.4.2 Test for flavonoids (Peach and Tracy 1959)

a. Pew's Test (Zn/HCl): A pinch of Zinc powder and about 5 drops of 5N HCl were added to the test solution it results deep purple red (dihydroquercetin) or cherry red (dihydrokaempferol flavanones). Dihydrochalcones and other flavonoids get most at pinkish/brownish colours (Dey and Harborne 1989).

b. Shinoda Test(mg/HCl): A pinch of magnesium powder and 5N HCl were added to the test solution formation of deep red/magenta colour indicates the presence of flavones/ dihydroflavonol. However, dihydrochalcones and other flavonoids did not react with this reagent (Dey and Harborne 1989)

c. NaOH Test: 1ml of 1N NaOH solution was added to the 1ml of test solution formation of yellow colour indicates the presence of flavonoids.

d. Lead acetate Test: To the successive plant test solution add few drops of 10% lead acetate solution appearance of yellow colour precipitation indicate the presence of flavonoids

e. FeCl₃ Test: Take 2ml of test solution and FeCl₃ solution appearance of intense green colour indicates the presence of flavonoids.

2.4.3 Test for Phenols (Gibb's 1974)

a. Ellagic Test: The test solution was treated with few drops of 5% of (v/v) glacial acid and 5% (W/V) NaNO₂ solution. The solution turns muddy yellow, olive brown, Niger brown and deep chocolate colour depending on the amount of ellagic acid present.

b. Phenol Test: When 0.5ml of FeCl₃ (w/v) solution, was added to 2ml test solution formation of an intense colour indicates the presence of phenols.

2.4.4 Test for Tannins

a. FeCl₃ Test: 2ml of test solution add few drops of 5% of FeCl₃ (w/v) solution added formation of green colour which indicates the presence of tannin.

2.4.5 Test for Glycosides

a. Kellar - Killiani Test: 1ml of glacial acetic acid was carefully added to 2ml of test solution of the extract and mixed well. Further, after cooling 2 drops of ferric chloride solution was added, their contents were transferred carefully to a test containing 2ml of conc. H₂SO₄ a reddish brown ring was observed at the junction of 2 layers indicates the presence of glycosides.

b. Conc. H₂SO₄ Test: 1ml of conc. H₂SO₄ was added to 1ml of test solution and is allowed to stand for 2 min the formation of reddish colour indicates the presence of glycosides.

2.4.6 Test for Saponins (Gibb's 1974)

a. Foam Test: 0.1g crude extract was taken vigorously in 2ml of distilled water formation of honeycomb like foam persist for a few minutes indicates the presence of saponins.

2.4.7 Test for Triterpenoids

a. Liebermann - Burchard Test: To the test solution add few drops of acetic anhydride mix well and add 1ml of concentrated H₂SO₄ from the sides of the test tube formation of violet ring at the junction of 2 layers indicates the presence of Triterpenoids

b. Salkowski Test: Few drops of Conc. H₂SO₄ to the test solution shaken on standing the lower layer turns golden yellow colour indicates the presence of Triterpenoids.

2.4.8 Test for Sterols

a. Liebermann - Burchard Test: A green colour was formed when the Liebermann - Burchard is added to the test solution indicates the presence of sterols.

b. Salkowski Test: A wine colour was developed when chloroform and conc. H₂SO₄ were added to the test solution indicates the presence of steroids.

c. Sulphur Test: A pinch of sulphur powder is added to test solution the sulphur settled down at the bottom of test tube is insoluble in test solution indicates the presence of sterols.

2.5 Quantitative Estimation of Secondary Metabolites

2.5.1 Estimation of Alkaloids

Total alkaloid content was estimated using the method of Ikan (1969). Briefly, 500mg of millet sample was extracted with methanol, homogenized, and centrifuged. The supernatant was concentrated to 1/4 volume, acidified with dilute acetic acid and transferred to a separating funnel. The extract was partitioned with n-Hexane and chloroform (1:1, v/v). The chloroform layer was collected, washed with distilled water and its pH was adjusted to 11-12 using NaOH. The chloroform layer was separated and filtered through Whatman's number 1. The filtrate was finally transferred to pre weighed beaker and dried under pressure at 40°C for 6 hours. The amount of alkaloid was calculated using formula.

$$\text{Total Alkaloids} = \frac{\text{Wt of alkaloid residue (X)}}{\text{Wt of the sample material (Y)}} \times 100$$

2.5.2 Estimation of Flavonoids

Total flavonoid content was determined by the method of Swaim and Hills (1959). 500mg of powdered millet sample was extracted with 10ml methanol, homogenized, and centrifuged at 3000rpm for 20min. The supernatant was evaporated to dryness in a hot water bath (80°C), and the residue was dissolved in 5ml distilled water. Aliquots of 0.1 and 0.2ml extract were diluted to 2ml with distilled water, followed by the addition of 4ml vanillin reagent. The reaction mixture was incubated at 40°C for 15 min, and the absorbance was measured at 500 nm against a reagent blank using a UV-Visible spectrophotometer. The phloroglucinol was used as the standard, and the flavonoid content was calculated from the standard calibration curve and expressed as mg/100 g of sample.

$$\text{Mg/100g} = \frac{\text{Graphical value}}{\text{Weight of the material}} \times \frac{\text{Volume of total content}}{\text{Volume of content taken for reading}} \times 100$$

2.5.3 Estimation of Phenols

500mg of the powdered sample was macerated with 10ml of methanol using a pestle and mortar. The homogenate was centrifuged at 10,000 rpm for 20 min, and the supernatant was collected. The residue was re-extracted with 10ml of 80% ethanol and centrifuged under the same conditions. The pooled supernatant were evaporated to dryness, the residue was redissolved in 5ml distilled water. Aliquots of 0.1 and 0.5 ml were taken, and the volume was made up to 3ml with distilled water. Then, 0.5 ml of Folin-Ciocalteu reagent (FCR) was added. After 3 min, 2 ml of 20% w/v sodium carbonate (Na₂CO₃) solution was added. The mixture was incubated in a boiling water bath for 1 min, cooled, and the absorbance was measured at 650 nm against a reagent blank using a spectrophotometer. A blue coloured complex was developed due to the reduction of FCR reagent. A standard calibration curve was prepared using phenol as the standard, and the total phenolic content of the samples was calculated from the calibration curve.

$$\text{Mg/100g} = \frac{\text{Graphical value}}{\text{Wt of plant material}} \times \frac{\text{Volume of total content}}{\text{Volume of content taking reading}} \times 100$$

2.5.4 Estimation of Glycosides

The total glycoside content was estimated by extracting 25g of powdered millet sample was extracted with 200ml of methanol and kept on rotatory shaker at 3000rpm for 6 hours at room temperature. The extract was filtered, diluted with distilled water, and treated with 12.5% lead acetate to precipitate tannins, resins and pigments. Excess lead ions were precipitated by adding 4.77% disodium hydrogen phosphate (Na_2HPO_3) solution. The resulting mixture was filtered, and the filtrate was evaporated to dryness. The dried residue was weighed, and the glycoside content was calculated using the following formula:

$$\text{Percentage of glycoside} = \frac{\text{Wt of dried extract}}{\text{Weight of the material}} \times 100$$

2.5.5 Estimation of sterols

500mg of dried plant material was homogenized with methanol and filtered. 1 ml of extract was mixed with 4ml of chloroform, followed by the addition of 2 ml of Liebermann-Burchard reagent. The mixture was shaken well, covered with black paper, and incubated in the dark for 15min. The development of a green-coloured complex indicated the presence of sterols. The absorbance was measured at 640 nm using a spectrophotometer against a reagent blank

2.6 Mineral Analysis

The ash obtained from the samples was digested using sulfuric acid and diluted with double-distilled water to a known volume. The resulting solution was filtered and used for mineral analysis. The concentrations of mineral elements were determined using an Atomic Absorption Spectrophotometer (AAS) and their respective wavelengths and expressed as mg/L. Elemental analysis was carried out at the University Science Instrumentation Centre (USIC), Gulbarga University, Kalaburagi (Tontapur & Kerur 2023).

3 RESULT

The nutraceutical composition of Barnyard and kodo were evaluated to determine their nutritional potential and suitability as functional food ingredients. The nutraceutical parameters are summarized in **Tables 1**. The analysis revealed notable variations in the nutritional composition of the two millet species. Among the nutrients analyzed, barnyard exhibited a higher carbohydrates (62%) than kodo (55.3%), indicating that barnyard is a higher source of energy. Similarly, the protein content was higher in barnyard (11.5%) compared to kodo (7.9%), suggesting its greater nutritional value as a plant-based protein source. The lipid content was relatively low in both millet species, with 3.4% in barnyard and 3.6% kodo, confirming that both grains are naturally low in fat. The crude fibre content was 4.6% in barnyard and 3.54% in kodo, indicating that barnyard contains slightly higher dietary fibre, which may contribute to improved digestive health and glycaemic control. The total ash value, an indicator of total mineral content, was higher in barnyard (3.5%) than in kodo (2.3%). The acid-insoluble ash values were reported as 1.6% and 1.2%, while the water-soluble

ash values were 28% and 45% for barnyard and kodo, respectively. These observations indicate differences in the inorganic constituents and mineral fractions between the two millet species. Overall, the results demonstrate that barnyard possesses a superior nutritional profile with higher carbohydrate, protein, fibre and total ash content, whereas kodo showed slightly higher lipid content and water-soluble ash. These findings suggest that both millet species are valuable nutraceutical grains and can serve as important dietary sources of energy, proteins, minerals, and dietary fibre, supporting their use in the development of functional foods and health-promoting diets.

The preliminary phytochemical screening and quantitative estimation of secondary metabolites were carried out to evaluate the bioactive constituents present in barnyard and kodo. The qualitative analysis of aqueous, petroleum ether, and methanolic extracts revealed the presence of several important secondary metabolites, including alkaloids, flavonoids, phenols, glycosides, triterpenoids, sterols, tannins and saponins. The occurrence of these phytochemicals varied among the extraction solvents and between the two millet species (**Table 2A and 2B**).

In barnyard, the methanolic extract exhibited the highest number of phytochemical constituents, with positive reactions for alkaloids, flavonoid, phenols, glycosides and sterols. The aqueous extract also showed the presence of alkaloids, flavonoids, glycosides, and sterols, whereas the petroleum ether extract contained comparatively fewer phytochemicals, mainly triterpenoids and sterols. Tannins and saponins were not detected in any of the extract of barnyard. Similarly, kodo exhibited the presence of several bioactive compounds in different solvent extracts. The methanolic extract showed positive reactions for flavonoids, phenols, glycosides and sterols, while the aqueous extract contained alkaloids, flavonoids, glycosides, and triterpenoids. The petroleum ether extract showed only a flavonoid. Overall, methanol proved to be the most millet species, indicating its suitability for phytochemical investigations. Based on the results of the preliminary phytochemical screening, the methanolic extracts of barnyard and kodo millet were further subjected to quantitative estimation of the detected secondary metabolites. The quantitative analysis revealed variations in the levels of alkaloids, flavonoids, phenolic compounds, glycosides and sterols between the two millet species. The results obtained from the quantitative estimation are presented in **Figure 1A & B**. The combined qualitative and quantitative analyses demonstrate that both millet species are valuable sources of biologically active secondary metabolites. While barnyard showed comparatively higher levels of alkaloids, flavonoids, glycosides, and sterols, whereas kodo was richer in phenolic compounds. Overall, both millets demonstrated a diverse phytochemical profile, with phenols being the predominant phytoconstituents in both species. The abundance of these phytochemicals highlights the nutraceutical significance of both millets and suggests their potential application in the development of functional foods and natural health-promoting products.

The elemental composition of barnyard and kodo is shown in **Figure 2**. Both millet species contained essential minerals, including chromium (Cr), copper (Cu), zinc (Zn), aluminium (Al), potassium (K), cadmium (Cd), magnesium (Mg), manganese (Mn), calcium (Ca), and iron (Fe). Among these, calcium was the most abundant element in both millets, followed by iron and magnesium. barnyard exhibited higher

concentrations of aluminium and iron, whereas kodo showed relatively higher levels of magnesium and potassium. Trace amounts of chromium, copper, manganese, and cadmium were detected in both samples. Overall, the results indicate that both millet species are rich sources of essential minerals, highlighting their nutritional significance.

4 DISCUSSION

The nutritional analysis of barnyard and kodo highlights their potential as nutritionally valuable minor millets. Both grains provide important nutrients, including carbohydrates, proteins, lipids, crude fibre, minerals and vitamins. Barnyard millet is particularly recognized as a good source of protein, fibre and essential amino acids such as leucine, isoleucine, lysine, methionine, threonine and valine. Its lipid fraction contains mainly linoleic and oleic acids, along with palmitic, stearic and linolenic acids (Renganathan et al., 2020).

The presence of dietary fibre and slowly digestible carbohydrates contributes to the nutritional and functional importance of these millets and may supports digestive health and better glycaemic regulation. Barnyard millet also contains vitamins such as thiamine, riboflavin, niacin and tocopherol, together with important minerals. Similary, kodo millet is reported to contain appreciable nutrients and bioactive compounds, including phenolics and flavonoids, which may contribute to its functional properities (Dey et al., 2022).

Despite their nutritional benefits, these millets contain antinutritional factors such as phytates, tannins, trypsin inhibitors, and α -amylase inhibitors, which can affect nutrient bioavailability. Processing methods such as soaking, germination, fermentation and cooking can help reduce these compounds and improve nutritional quality. Overall, barnyard and kodo have considerable potential as nutritious, gluten-free and functional food grains, and their composition can vary with genotype, geographical location, soil, maturity, processing and analytical methods (Bhatt et al., 2023; Renganathan et al., 2020).

The qualitative and quantitative phytochemical analysis indicates that barnyard and kodo contain diverse secondary metabolites, particularly phenolics, flavonoids, tannins, alkaloids, terpenoids and glycosides. These metabolities are important because they can contribute to the biological activities of millet grains, including antioxidant, antimicrobial, anti inflammatory and anti diabetic effects. Sharma and Saxena (2016) reported phenolics and flavonoids in kodo, while Watanabe (1999) identifies bioactive phenolic compounds such as N-(p-coumaroy) serotonin, luteolin, and tricin in barnyard millet, with demonstrated antioxidant activity (Sharma and Saxena, 2016). Recent research further demonstrated that the polyphenol and flavonoid contents are associated with antioxidant activity, although their levels vary among millet varieties. Individual compounds such as phenolic acids and flavonoids may therefore contribute significantly to the biological activity of these grains rather than the total phytochemical content alone (Sundarappa et al., 2026). This, the presence of these phytochemicals supports the potential of both millets as functional foods and sources of nutraceutically important bioactive compounds.

The elemental profile of barnyard and kodo provides important information about their mineral and nutritional quality. Essential elements such as Ca, Mg and P support bone development and metabolism, while Fe, Zn,

Cu and Mn act as co-factors in enzymatic processes. Potassium contributes to electrolyte balance, nerve function and normal cellular function (Panwar et al., 2016; Jenipher et al., 2024). Mineral accumulation in millet grains depends on the soil-plant relationship, including the availability and mobility of elements. Elemental composition may also vary with cultivar, fertilization, environmental conditions and grain maturity. The presence of minerals does not always indicate their bioavailability, as phytate, tannins and other compounds may reduce mineral absorption (Dey et al., 2021). Therefore, elemental composition should be considered along with antinutritional factors when evaluating millet nutritional quality. Overall, elemental profiling provides a useful basis for identifying barnyard and kodo as potential sources of dietary minerals and for selecting nutritionally promising varieties. It can also support the development of mineral-enriched foods and nutritionally targeted millet-based products.

5 CONCLUSION

Barnyard millet and kodo millet showed good nutritional and phytochemical potential. Both contained appreciable carbohydrates, proteins, lipids, minerals and bioactive compounds such as alkaloids, flavonoids, phenols, glycosides, triterpenoids, and sterols. These findings indicate that both millets can serve as valuable nutrient-rich and functional food sources with potential health benefits.

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Declaration of competing interest

The authors declare that they have no potential competing financial interests

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Table 1. Nutraceutical analysis of Barnyard and Kodo millet

Estimation Result (in %)			
Sl. No	Test	Barnyard millet	Kodo millet
1	Carbohydrate	62%	55.3%
2	Protein	11.5%	7.9%
3	Lipid Content	3.4%	3.6%
4	Ash Value	3.5%	2.3%
5	Acid Insoluble Ash Value	1.6%	1.2%
6	H ₂ O Soluble Ash Value	28%	45%
7	Crude fiber	4.6%	3.54%

Table 2A. Preliminary Screening of Secondary metabolites of Barnyard millet

Sl. No	Test	Aqueous solution	Petroleum ether	Methanol
1	Alkaloids			
	1. Mayer's	(-)	(-)	(+)
	2. Dragendorff's	(+)	(-)	(+) (-)
	3. Wagners	(+)	(-)	
2	Flavonoids			
	1. Pew	(+)	(-)	(+)
	2. Shinoda	(-)	(-)	(+)
	3. NaOH	(-) (+)	(-)	(+) (-)
	4. Lead acetate	(+)	(-) (-)	(+)
	5. FeCl ₃			
3	Phenols			
	1. Ellagic acid	(-)	(-)	(-) (+)
	2. Phenol	(-)	(-)	
4	Tannins			
	1. FeCl ₃	(-)	(-)	(-)
5	Glycosides			
	1. Kellar-Killer	(+)	(-)	(-) (+)
	2. H ₂ SO ₄	(+)	(-)	
6	Saponins			
	1. Foam test	(-)	(-)	(-)
7	Triterpenoids			
	1. Libermann-Burchard test	(-)	(+)	(-)
	2. Salkowski test	(-)	(+)	(-)

8	Sterols			
	1. Libermann-Burchard test	(-) (+) (-)	(-)	(-) (+)
	2. Salkowski test		(-) (+)	(+)
	3. Sulphur test			

Table 2B. Preliminary Screening of Secondary metabolites of Kodo millet

Sl. No	Test	Aqueous solution	Petroleum ether	Methanol
1	Alkaloids			
	1. Mayer's	(-)	(-)	(-)
	2. Dragendorff's	(-) (+)	(-)	(-)
	3. Wagners		(-)	(-)
2	Flavonoids			
	1. Pew	(-)	(-)	(-) (+)
	2. Shinoda	(-) (+)	(-)	(+)
	3. NaOH	(+) (-)	(-)	(+) (-)
	4. Lead acetate		(-) (+)	
	5. FeCl ₃			
3	Phenols			
	1. Ellagic acid	(-) (-)	(-)	(+)
	2. Phenol		(-)	(+)
4	Tannins			
	1. FeCl ₃	(-)	(-)	(-)
5	Glycosides			
	1. Kellar-Killer	(+)	(-)	(-)
	2. H ₂ SO ₄	(-)	(-)	(+)
6	Saponins			
	1. Foam test	(-)	(-)	(-)
7	Triterpenoids			
	1. Libermann-Burchard test	(+) (-)	(-)	(-)
	2. Salkowski test		(-)	(-)
8	Sterols			
	1. Libermann-Burchard test	(-) (-)	(-)	(-)
	2. Salkowski test	(-)	(-)	(+)
	3. Sulphur test		(-)	(-)

Figure

1. Quantitative estimation of Barnyard and Kodo millet

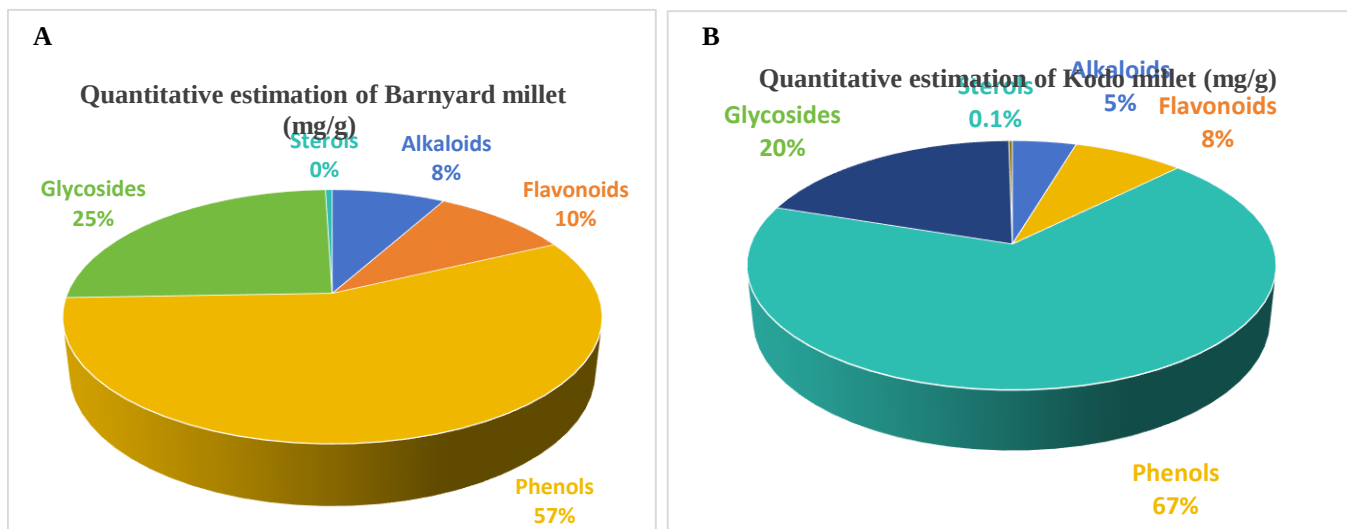
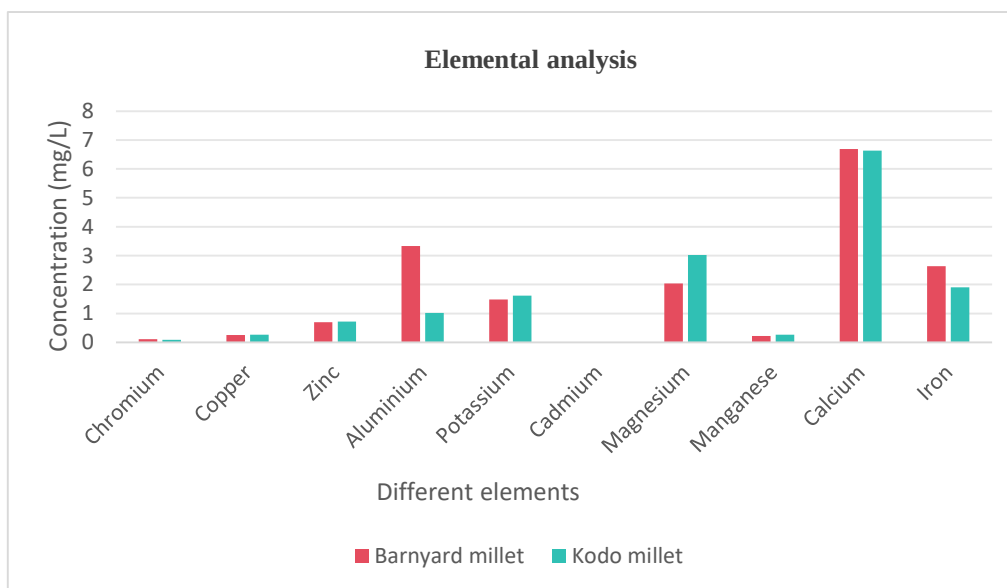


Figure 2. Elemental Analysis of Barnyard and Kodo millet



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