Proximate, Mineral, and Antinutritional Analysis of Selected Mungbean Varieties from Vidarbha Region (MS) India: A Step Toward Nutritional Security

Akshay Deshmukh and Dipak Koche

Department of Botany, Shri Shivaji College of Arts, Commerce and Science, Akola (MS) India 444003

ABSTRACT

Malnutrition remains a persistent challenge among marginalized and tribal populations in developing regions, largely due to limited access to nutrient-rich food sources. Mungbean (*Vigna radiata* L. Wilczek), a short-duration legume with high protein and micronutrient content, offers significant potential to address these nutritional deficiencies. This study assessed the proximate composition, mineral content, and antinutritional factors of seven mungbean varieties cultivated in the Vidarbha region of Maharashtra, India.

Proximate analysis revealed variation in moisture (8.2–9.3%), protein (20.5–25.3%), carbohydrates (46.4–48.6%), fat (1.1–1.5%), ash (3.4–4.3%), and fiber (3.8–4.4%) contents. The variety Utkarsha recorded the highest protein concentration (25.3%). Mineral profiling indicated significant genotypic differences, with zinc ranging from 2.94 to 4.50 mg/100 g, iron from 6.50 to 8.75 mg/100 g, and copper from 0.65 to 0.75 mg/100 g. *Utkarsha* again showed the highest levels of Fe, Zn, and Cu.

Antinutrient analysis showed phytic acid levels between 1.55–1.78%, and tannins between 0.58–0.70%. PKV Green Gold exhibited the lowest concentrations of both antinutrients, enhancing its potential bioavailability of essential minerals. Despite *Utkarsha* having high nutrient density, its elevated phytic acid content may limit mineral absorption without processing or breeding interventions.

In conclusion, the study highlights significant nutritional variability among mungbean genotypes, identifying Utkarsha and AKM-4 as nutrient-dense cultivars. Varieties with lower antinutrient content, such as PKV Green Gold, offer promise for biofortification and dietary diversification strategies aimed at improving food and nutritional security.

Keywords**:** Proximate analysis, Anti-nutrients, Mungbean (*Vigna radiata* L.), Nutritional security.

HIGHLIGHT

Proximate Composition: Protein content ranged from 20.5% to 25.3%, with Utkarsha showing the highest (25.3%) and BM-4 the lowest (20.5%). Carbohydrate content averaged 47.54%, and crude fiber ranged between 3.8%–4.4%.

Moisture and Fat: Moisture content varied between 8.2%–9.3%, while fat content was relatively low, ranging from 1.1%–1.5% across varieties.

Mineral Variation: Zinc content ranged from 2.94–4.50 mg/100g, iron from 6.50–8.75 mg/100g, and copper from 0.65–0.75 mg/100g, with Utkarsha generally having higher mineral concentrations.

Antinutrients: Phytic acid ranged from 1.55%–1.78%, with Utkarsha highest and PKV Green Gold lowest. Tannin content ranged from 0.58%–0.70%, with AKM-4 highest and PKV Green Gold lowest.

Nutritional Implications: Utkarsha is rich in protein and minerals but has higher antinutrient levels, whereas PKV Green Gold has the lowest antinutrients, making it better for mineral bioavailability.

INTRODUCTION

Limited access to nutritionally adequate food remains a primary contributor to malnutrition among marginalized local and tribal populations in many developing nations (Siddique et al. 2020). To address this issue, numerous global health institutions have advocated for the inclusion of nutrient-dense, plant-based foods in daily diets (Ezekekwu et al. 2021). Among various leguminous crops, mungbean (*Vigna radiata* L. Wilczek) is recognized for its high protein content and nutritional value (Anwar et al. 2007). It is a short-duration, annual pulse crop that is extensively cultivated in tropical and subtropical regions due to its adaptability to semi-arid environments and its contribution to food security, particularly in predominantly vegetarian populations.

Mungbean is consumed in various culinary forms, including cooked dishes, preparations with meat and vegetables, and as an ingredient in bakery products. It is widely cultivated across dry southern regions of Europe, several Asian countries including the Indian subcontinent, and warm regions of North America (Sehrish et al. 2023). The crop, typically reaching 80–90 cm in height, thrives across diverse soil types and demonstrates considerable yield potential.

In addition to its agricultural importance, mungbean possesses significant nutraceutical properties. It is a rich source of high-quality protein and essential amino acids, particularly lysine, which complements cereal-based diets. Nutritionally, mungbean is low in saturated fat and sodium, contains negligible cholesterol, and is a good source of thiamin, niacin, vitamin B6, pantothenic acid, iron, magnesium, phosphorus, and potassium. Furthermore, it provides substantial amounts of dietary fiber, vitamin C, vitamin K, riboflavin, folate, copper, and manganese (Khalil and Khan, 1994; Mohan and Janardhanan, 1993; Sehrish et al. 2023).

In the Vidarbha region of Maharashtra, mungbean is cultivated during both the *kharif* and *Rabi* seasons under rainfed and irrigated conditions. Its proximate composition is influenced by genetic variability, soil type, and environmental factors. The present report provides a comprehensive analysis of the proximate composition, mineral content, and antinutritional factors of selected mungbean varieties grown in this region.

MATERIAL AND METHODS

Germplasm Collection and Sample Preparation

The germplasm of seven mungbean (*Vigna radiata* L.) varieties—BM-4, Vaibhav, Utkarsha, PKV Green Gold, AKM-8802, AKM-4, and Kopergaon—was obtained from the Pulse Research Center, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India. The collected seeds were thoroughly cleaned, dried, and subsequently milled into a fine homogeneous powder using a high-speed grinder equipped with titanium blades to prevent metal contamination. The resulting seed flour was stored in airtight polyethylene pouches at ambient room temperature until further use.

Reagents and Standard Solution Preparation

All chemicals and reagents used in this study were of analytical reagent (AR) grade and procured from Merck and Sigma-Aldrich through local authorized distributors. Ultra-pure nitric acid (65%), sulphuric acid (98%), and perchloric acid (72%) were employed for digestion and sample preparation. Double distilled water was utilized for all reagent preparations and dilutions.

For mineral analysis, working standard solutions were prepared using 2% nitric acid. High-purity analytical standard salts of copper (Cu), iron (Fe), and zinc (Zn) obtained from Merck were used to prepare stock solutions (100 mg/L). These were further diluted with 2% nitric acid to obtain the required concentrations for calibration and analysis. The sample inlet system of the atomic absorption spectrometer (AA-7800 Series, Shimadzu) was routinely washed with 2–4% nitric acid to avoid cross-contamination and ensure accurate readings.

Proximate, Mineral, and Antinutrient Analysis

Proximate analysis of mungbean seed samples was conducted following the standard procedures outlined by the Association of Official Analytical Chemists (AOAC, 2016) and Kavanagh (1981).

- Moisture content was determined gravimetrically by drying the samples in a hot air oven at 105 °C until a constant weight was achieved.
- Ash content was measured by incinerating samples in a muffle furnace at 550 °C.
- Crude protein was estimated using the Kjeldahl method (Devani et al., 1989), where total nitrogen content was determined and multiplied by a conversion factor of 6.25.
- Crude fiber content was analyzed by sequential acid and alkali digestion followed by ashing of the residue, according to standard protocols.
- Total carbohydrate content was determined using the anthrone method (Sadasivam and Manickam, 2005).

For mineral content analysis, 2 g of powdered seed sample was digested using a mixture of 8 mL nitric acid and 5 mL perchloric acid at 160 ± 5 °C for 4 hours. The digested solutions were analyzed using an atomic absorption spectrometer (AA-7800 Series, Shimadzu) to quantify Zn, Fe, and Cu. Reagent blanks and duplicate samples were included to ensure precision and reproducibility (Sehrish et al. 2023).

Phytic acid was quantified using the Wade reagent method (Gao and Maroof, 2007; Shi et al. 2018), while tannin content was estimated by the Folin–Denis method as described in AOAC (1990). All analyses were performed in triplicate to enhance accuracy and statistical reliability.

RESULTS AND DISCUSSION

Proximate analysis of Selected Mungbean Varieties

The results of the proximate analysis of the selected mungbean (*Vigna radiata* L.) varieties are presented in Table 1. The moisture content across the varieties ranged from 8.60% to 9.10%, with a mean value of 8.88%. The highest moisture content was recorded in the variety Utkarsha, while the lowest was observed in BM-4. The ash content among the varieties showed a mean value of 3.71 ± 0.27%, indicating moderate variability in total mineral content.

The crude fiber content averaged 4.05 ± 0.04%, with values ranging from 3.8% to 4.4%. The variety AKM-4 exhibited the highest crude fiber content (4.4 ± 0.15%), whereas *Utkarsha* recorded the lowest (4.0 ± 0.10%). These findings are consistent with those of Baiyeri et al. (2018), Blessing and Gregory (2010), and Sehrish et al. (2023), reinforcing the role of mungbean as a valuable source of dietary fiber (Paul et al. 2011).

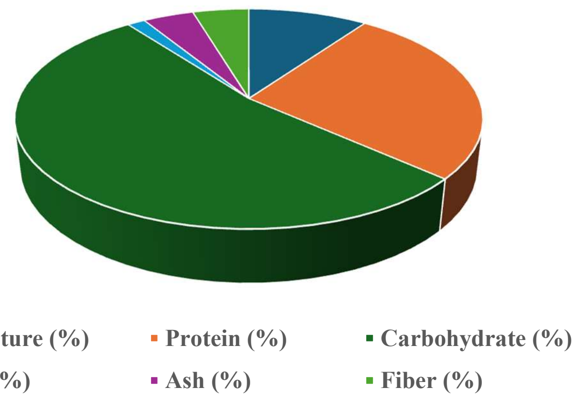
The crude protein content varied between 23.50% and 25.30%, with *Utkarsha* showing the highest protein concentration and BM-4 the lowest. These values are comparable to earlier reports by Baiyeri et al. (2018) and Sehrish et al. (2023). As per earlier reports globulins, albumin, prolamins with little glutelins are the major proteins in mungbean (Tang et al. 2014 and USDA, 2024). The total carbohydrate content averaged 47.55% across the evaluated varieties. The major carbs includes starch and soluble sugars while linolic acid and oleic acid are the major major fat components (Tang et al. 2014 and USDA, 2024). The average proximate content in selected varieties of mungbean is presented in fig. 1. These results are in alignment with the findings of Nagarale et al. (2018), and Idris et al. (2025) who reported similar proximate profiles in a broader set of mungbean genotypes.

Table- 1. Proximate content of some selected Mungbean varieties

Variety	Moisture (%)	Protein (%)	Carbohydrate (%)	Fat (%)	Ash (%)	Fiber (%)
BM-4	9.1	20.5	48.6	1.2	3.4	4.1
Vaibhav	8.4	24.1	47.9	1.5	3.6	4.3
Utkarsha	9.3	25.3	46.8	1.1	3.8	4.0
PKV Green Gold	8.9	24.8	46.4	1.3	3.5	4.2
AKM 8802	8.6	23.9	48.1	1.4	3.7	4.2
AKM 4	9.1	24.8	46.5	1.5	4.3	4.4
Kopargaon	8.2	24.2	48.5	1.3	3.9	3.8
Range	8.2 – 9.3	20.5 – 25.3	46.4-48.6	1.1- 1.5	3.4- 4.3	3.8-4.4
Mean	8.8	23.94	47.54	1.32	3.74	4.14
Standard Error	0.15	0.60	0.36	0.057	0.11	0.075

Note: The results are mean of triplicate analysis.

Fig. 1 Average proximate composition of selected Mungbean varieties



Mineral analysis

The mineral composition of the selected mungbean varieties exhibited statistically significant variation ($P < 0.05$), likely attributable to genotypic differences in mineral uptake efficiency. The data detailing micronutrient concentrations are presented in Table 2.

The concentrations of essential micronutrients varied markedly among the varieties, with zinc (Zn**)** ranging from 2.94 to 4.50 mg/100 g (mean: 3.72 mg/100 g), iron (Fe) from 6.50 to 7.80 mg/100 g (mean: 7.15 mg/100 g), and copper (Cu) from 0.65 to 0.75 mg/100 g (mean: 0.70 mg/100 g). These findings highlight substantial genotypic variation and suggest that targeted biofortification strategies—particularly for zinc—could enhance crop nutritional value and productivity (Koc and Karayigit, 2022).

The iron content across varieties was comparable to earlier findings by Anwar et al. (2007) and exceeded levels commonly reported in other leguminous crops. The highest iron concentration (7.80 ± 0.150 mg/100 g) was observed in Utkarsha, while BM-4 exhibited the lowest (6.50 ± 0.175 mg/100 g). This variation may be influenced by both genetic potential and favorable edaphic conditions for iron uptake (Zhang et al., 2019).

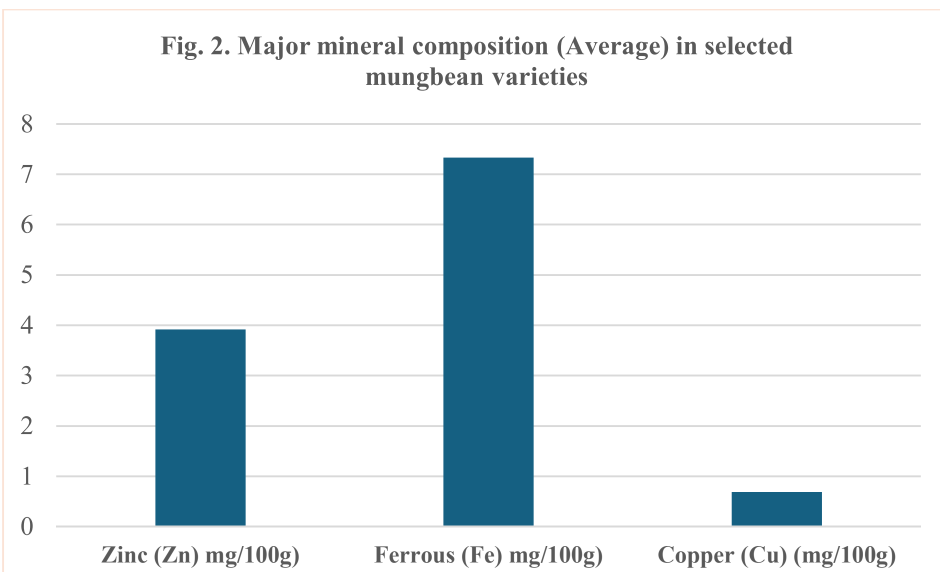
The copper content ranged from 0.65 ± 0.015 mg/100 g in Kopergaon to 0.75 ± 0.017 mg/100 g in Utkarsha. The average mineral content i.e. Zn, Fe and Cu is presented in the fig. 2. These values are consistent with previous studies on mungbean mineral profiles (Alonso et al., 2001; Mubarak, 2005; Singh and Agrawal, 2010).

Furthermore, as reported by Sen Gupta et al. (2022), mineral accumulation and proximate composition in plants are significantly influenced by environmental conditions and cultivation practices. The current findings are also supported by varietal profiling reports of Khandare and Sharma (2018) and the Indian Agricultural Research Institute (IARI, 2020) and Idris et al. (2025), suggesting that both genetic makeup and agroecological factors contribute to the observed variations.

Table-2. Mineral content of some selected mungbean varieties.

Variety	Zinc (Zn) mg/100g)	Ferrous (Fe) mg/100g)	Copper (Cu) (mg/100g)
BM-4	3.90 ± 0.035	6.50 ± 0.175	0.72 ± 0.015
Vaibhav	4.10 ± 0.080	7.10 ± 0.175	0.70 ± 0.012
Utkarsha	4.50 ± 0.088	7.80 ± 0.150	0.75 ± 0.017
PKV Green Gold	4.00 ± 0.075	7.00 ± 0.150	0.68 ± 0.015
AKM-8802	3.85 ± 0.070	6.60 ± 1.30	0.65 ± 0.012
AKM-4	4.20 ± 0.10	7.60 ± 0.150	0.73 ± 0.017
Kopargaon	2.94 ± 0.15	8.75 ± 1.30	0.65 ± 0.015

Note: The results are mean of triplicate analysis.



Antinutrient Content

The mungbean varieties evaluated in this study exhibited considerable variation in antinutrient content, particularly phytic acid and tannins (Table 3). The **phytic acid** content ranged from 1.55 ± 0.050% to 1.78 ± 0.012%, with a mean value of 1.66%. The highest phytic acid concentration was recorded in the variety *Utkarsha*, whereas the lowest was observed in *PKV Green Gold*. Phytic acid (PA), chemically known as myo-inositol hexakisphosphate, serves as the principal storage form of organic phosphorus in legumes. However, it is considered an antinutrient due to its strong chelating ability, which enables it to bind essential mineral cations such as magnesium (Mg), calcium (Ca), iron (Fe), and zinc (Zn), thereby reducing their bioavailability (Kumar et al. 2021).

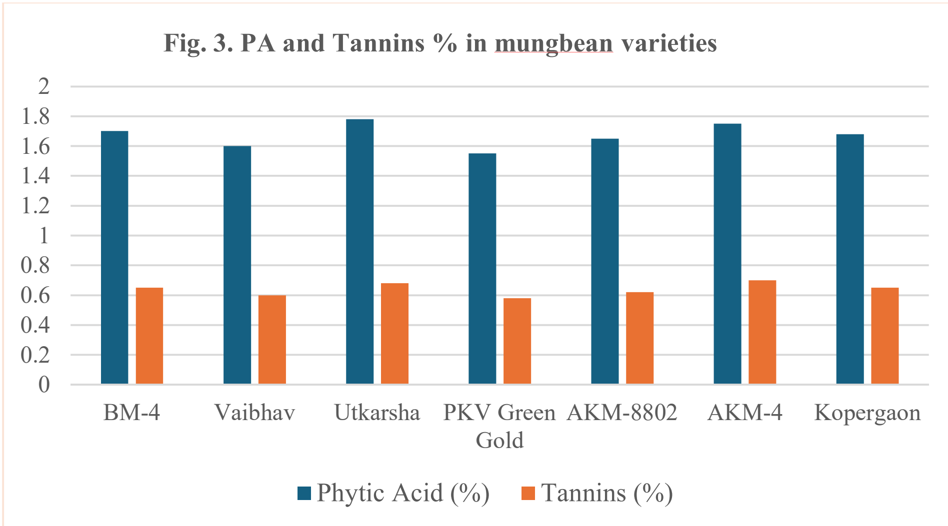
Humans and monogastric animals—including poultry, swine, and fish—lack endogenous phytase enzymes capable of hydrolyzing phytic acid to release bound minerals. Consequently, high levels of phytic acid in food can contribute to deficiencies in key micronutrients, particularly Fe and Zn. In contrast, low-phytate mungbean varieties are preferable from a nutritional standpoint, as they are associated with improved mineral bioavailability. In addition to its mineral-binding capacity, phytic acid can also interfere with protein digestibility by forming insoluble phytate–protein and phytate–mineral–protein complexes that inhibit digestive enzymes (Alsalman and Rangaswamy, 2020).

The tannin content of the studied varieties ranged from 0.58 ± 0.017% to 0.70 ± 0.020%, with AKM-4 showing the highest level and PKV Green Gold the lowest. Tannins, like phytic acid, act as antinutritional compounds by forming complexes with proteins and minerals, thereby reducing their digestibility and absorption.

Overall, the relatively low levels of both phytic acid and tannins in several of the evaluated varieties—particularly PKV Green Gold—suggest their potential suitability for dietary interventions aimed at improving micronutrient bioavailability. The average % of antinutrients analyzed are presented in fig. 3. These results are consistent with earlier findings reported by Dhole and Reddy (2015) and Sehrish et al. (2023), reinforcing the importance of selecting mungbean genotypes with minimal antinutrient content for nutritional enhancement programs.

Table- 3 Phytic acid (%) and tannin (%) content of selected Mungbean varieties

Variety	**Phytic Acid (%)**	**Tannins (%)**
BM-4	1.70 ± 0.015	0.65 ± 0.008
Vaibhav	1.60 ± 0.050	0.60 ± 0.025
Utkarsha	1.78 ± 0.012	0.68 ± 0.017
PKV Green Gold	1.55 ± 0.050	0.58 ± 0.017
AKM-8802	1.65- ± 0.032	0.62 ± 0.020
AKM-4	1.75 ± 0.027	0.70 ± 0.020
Kopergaon	1.68 ± 0.030	0.65 ± 0.015



CONCLUSION

The proximate, mineral, and antinutrient analysis of selected mungbean (Vigna radiata) varieties revealed significant variability in their nutritional profiles, highlighting their potential as valuable dietary components. Among the varieties studied, Utkarsha emerged as the nutritionally superior cultivar, with the highest protein (25.3%), iron (7.80 mg/100g), zinc (4.50 mg/100g), and copper (0.75 mg/100g) contents, although it also contained the highest phytic acid (1.78%)—a known antinutrient that may affect mineral bioavailability.

The average moisture, protein, carbohydrate, fat, ash, and fiber contents across all varieties were 8.8%, 23.94%, 47.54%, 1.32%, 3.74%, and 4.14% respectively. These findings align with previous studies and confirm mungbean as a good source of plant-based protein, dietary fiber, and essential micronutrients such as iron, zinc, and copper.

The presence of antinutritional factors like phytic acid (range: 1.55–1.78%) and tannins (0.58–0.70%) was within acceptable limits, though lower values—such as those seen in PKV Green Gold—are more desirable for higher mineral bioavailability. These variations suggest a potential for selecting and breeding mungbean varieties with optimal nutritional and antinutritional profiles.

In conclusion, the analysed mungbean varieties demonstrate considerable nutritional diversity. Utkarsha and AKM-4 are particularly noteworthy for their high nutrient content, though further processing or breeding to reduce antinutrients could enhance their utility in food and nutritional security programs.

ACKNOWLEDGEMENT

The authors are grateful to Pulse Research Center, Dr. P. D. K. V. Akola for availing mungbean germplasm. Authors are also acknowledged to Principal, Shri Shivaji College of Arts, Commerce and Science for availing the instrumentation facility of Central Instrumentation Cell.

AUTHORS CONTRIBUTION

Conceptualization: DK, Experimental work and writing original draft: AD, Review and Editing: DK. Both authors read and agreed to publish this version of manuscript.

CONFLICT OF REPORT

The authors declare no conflict of report.

REFERENCES

Alonso R, Rubio LA, Muzquiz M, and Marzo F. 2001. The effect of extrusion cooking on mineral bioavailability in pea and kidney bean seed meals. Animal Feed Science and Technology, **94** (1–2): 1–13. https://doi:10.1016/s0377-8401(01)00302-9

Alsalman FB, and Ramaswamy H. 2020. Reduction in soaking time and anti-nutritional factors by high pressure processing of chickpeas. Journal of Food Science and Technology, **57** (7): 2572–2585. https://doi:10.1007/s13197-020-04294-9 .

Anwar F, Latif S, Przybylski R, Sultana B, and Ashraf M. 2007. Chemical Composition and Antioxidant Activity of Seeds of Different Cultivars of Mungbean. Journal of Food Science **72** (7): S503–S510. https://doi:10.1111/j.1750-3841.2007.00462.x

AOAC 1990. Official Methods of Analysis, 15th Ed. Association of Official Analytical Chemists.

Baiyeri SO, Uguru MI, Ogbonna PE, Samuel-Baiyeri, CCA, Okechukwu R, Kumaga FK. 2018. Evaluation of the nutritional composition ofthe seeds of some selected African yam bean Hochst Ex. A. Rich (Harms) accessions. Agro-Science **17** (2): 37. https://doi:10.4314/as.v17i2.5 .

Blessing IA, and Gregory IO. 2010. Effect of Processing on the Proximate Composition of the Dehulled and Undehulled Mungbean [*Vigna radiata* (L.) Wilczek] Flours. Pakistan Journal of Nutrition **9** (10): 1006–1016. https://doi:10.3923/pjn.2010.1006.1016 .

Deshpande SS. 1992. Food legumes in human nutrition: a personal perspective. *Crit. Reviews Food Sci. Nutritio*n **32:** 333-363.

Devani MB, Shishoo CJ, Shah SA, and. Suhagia BN. 1989. Spectrophotometric method for micro-determination of nitrogen in Kjeldahl digest. Journal of AOAC International **72** (6): 953–956. https://doi:10.1093/jaoac/72.6.953

Dhole VJ, and Reddy KS. 2015. Genetic variation for phytic acid content in mungbean (*Vigna radiata* L. Wilczek). The Crop Journal **3** (2): 157– 162. https://doi:10.1016/j.cj.2014.12.002 .

Ezekekwu E, Salunkhe SS,. Jennings JC, and. Kelly Pryor BN. 2021. Community Based and System-Level Interventions for Improving Food Security and Nutritious Food Consumption: A Systematic Review. Journal of Hunger and Environmental Nutrition **17** (2): 149– 169. https://doi:10.1080/19320248.2021.2021120

Gao Y, Shang C, and Maroof MAS. 2007. A modified colorimetric method for phytic acid analysis in soybean. Crop Science, **47**(5): 1797–1803.

Habibullah, Abbas M, and Shah HU. 2007. Proximate and mineral composition of Mungbean. Sarhad Journal of Agriculture **23:** 463.-466.

IARI. 2020. Varietal Profile of Pulses. Indian Agricultural Research Institute, New Delhi.

Idris FM, Urga K, Admassu HE, Fentie G, Kwon SM, Shin JH. 2025. Profiling the Nutritional, Phytochemical, and Functional Properties of Mung Bean Varieties. Foods **14** (4): 571. https://doi:10.3390/foods14040571

Kavanagh F. 1981. Official methods of analysis of the aoac. (13th ed.). William Horwitz The Association of Official Analytical Chemists, Washington, DC, 7, 56–132. https://doi.org/10.1002/jps.2600700437

Khalil IA, and Mannan F. 1990. Colorimetry and Flame photometry. In: Chemistry One (Bio analytical chemistry) 2nd edition. Taj printing press, Peshawar, Pakistan. pp. 131-157.

Khalil IA, and Khan S. 1994. Protein quality of Asian beans and their wild progenitor, Vigna Sublobata (Roxb). Food Chemistry **52**: 327-330.

Khandare, A. and M. Sharma (2018). Nutritional Composition of Different Pulses Grown in Central India. *Journal of Food Legumes*, 31(1), 22–27. https://doi:10.3389/fsufs.2022.878269

Koç E, and Karayiğit B. 2022. Assessment of Biofortification Approaches Used to Improve Micronutrient-Dense Plants That Are a Sustainable Solution to Combat Hidden Hunger. Journal of Soil Science and Plant Nutrition **22** (1): 475–500. https://doi:10.1007/s42729-021-00663-1

Kumar A, Singh B, Raigond P, Sahu C, Mishra UN, Sharma S. 2021. Phytic acid: Blessing in disguise, a prime compound required for both plant and human nutrition. Food Research International **142:** Article 110193. https://doi:10.1016/j.foodres.2021.110193

Mohan VR, and Janardhanan K. 1993. Chemical composition and nutritional evaluation of two little known species of Vigna". Food chemistry **48:** 367-371.

Paul T, Rubel Mozumder NHM, Syed MA, and Akhtaruzzaman M. 2011. Proximate composition, mineral contents and determination of protease activity from green gram (*Vigna radiata* L. Wilczek). Bangladesh Research Publications Journal **5** (3): 207– 213.

Sadasivam S, and Manickam A. 2015. Biochemical methods. New Delhi: New age international publishers.

Sehrish HZ, Muhammad U, and Muhammad A. 2023. Nutritional evaluation, proximate and chemical composition of mungbean varieties/cultivars pertaining to food quality characterization. Food Chemistry Advances **2 :** 100160. https://doi.org/10.1016/j.focha.2022.100160

Sen Gupta D, Dutta A, Sharanagat VS, Kumar J, Kumar A, Kumar, V. 2022. Effect of growing environments on the minerals and proximate composition of urdbeans (*Vigna mungo* L. Hepper). Journal of Food Composition and Analysis **114:** Article 104746. https://doi:10.1016/j.jfca.2022.104746

Shi L, Arntfield SD, and Nickerson M 2018. Changes in levels of phytic acid, lectins and oxalates during soaking and cooking of Canadian pulses. Food Research International, **107**: 660–668. https://doi:10.1016/j.foodres.2018.02.056

Siddiqui F, Salam RA, Lassi ZS and Das JK. 2020. The Intertwined Relationship Between Malnutrition and Poverty. Frontiers in Public Health, **8:** 453. https://doi:10.3389/fpubh.2020.00453

Tang D, Dong Y, Ren H, Li L and He C. 2014. A review of phytochemistry, metabolite changes, and medicinal uses of the common mung bean and its sprouts. Chemistry Central Journal, **8** (1): 4. https://doi:10.1186/1752-153X-8-4

USDA Food Data Central. 2024. *Mungbean, raw*. https://fdc.nal.usda.gov

Zhang XD, Zhang WS, and Wang T. 2019. The adaptive mechanism of plants to iron deficiency via iron uptake, transport, and homeostasis. International Journal of Molecular Sciences **20** (10): 2424. http://doi:10.3390/ijms20102424