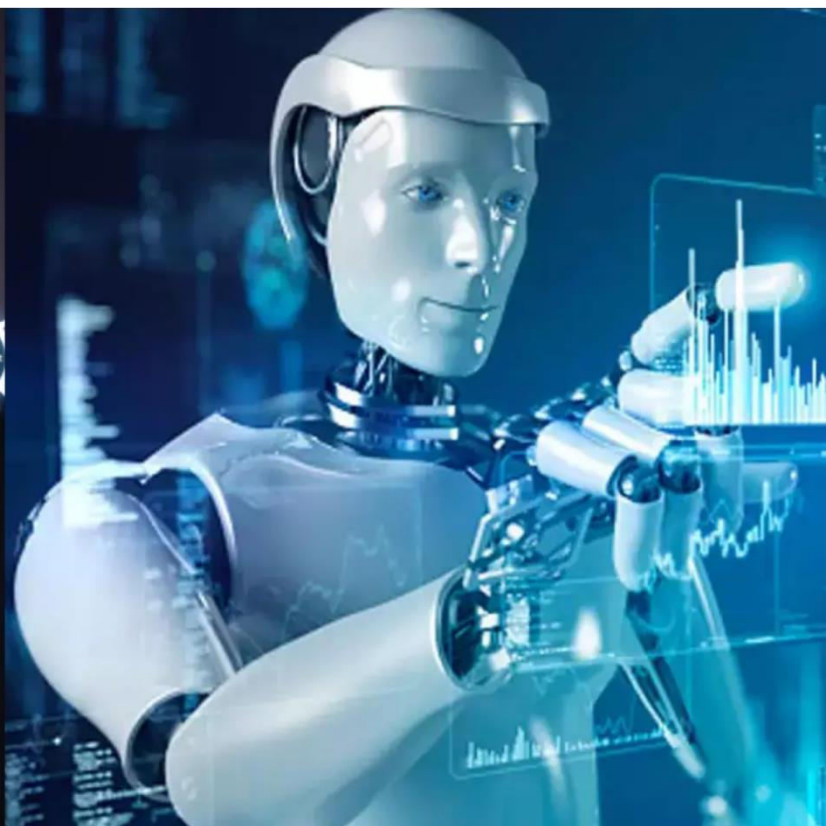




International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 9.935

Volume 15, Issue 8, August 2026

Effect of Processing Methods on the Nutritional, Physicochemical and Functional Properties of Black Gram (*Vigna mungo* L.)

Harshita Parakh, Dhanya M Hosoklu

MSc. Final Year Student, Dept. of Food science and Nutrition, Padmashree Institute of Management and Sciences,
Kommaghatta, Karnataka, India

Assistant Professor, Padmashree Institute of Management and Sciences, Kommaghatta, Karnataka, India

ABSTRACT: Black gram (*Vigna mungo* L.) is an important pulse crop valued for its high protein, carbohydrate and dietary fibre content, although its nutritional potential and food uses can be limited by anti-nutritional factors and processing-induced changes. This study evaluated the nutritional composition, physicochemical and functional properties of black gram, and the effect of roasting, soaking, germination and cooking on these properties, with the aim of identifying processing methods that enhance its nutritional and functional quality. Protein content remained relatively stable across treatments, with raw, roasted and germinated black gram containing approximately 22.16%, 23.2% and 23.1% protein respectively, while soaked and cooked samples retained over 21% protein. Roasting sharply reduced moisture from 8.88% to 0.99%, concentrating the other proximate fractions. Functional properties were also altered by processing: germinated black gram showed the highest water absorption capacity (598%), while soaking gave the highest oil absorption capacity (462%). Anti-nutritional and bioactive components changed with treatment — polyphenol content decreased from 130.72 µg GAE in the raw sample to 120.72 µg GAE after soaking and 108.22 µg GAE after germination, while roasting increased it to 153.22 µg GAE. Tannin content decreased from 210.25 µg TAE (raw) to 186.25 µg TAE (soaked) and 156.25 µg TAE (germinated), but increased after roasting (219.25 µg TAE) and cooking (232.25 µg TAE). Ascorbic acid increased with germination (0.65 mg/mL) but decreased with roasting (0.36 mg/mL) and cooking (0.20 mg/mL). Germination emerged as the most favourable processing method overall, preserving protein content, increasing water absorption capacity, reducing tannins, and enhancing ascorbic acid retention, indicating its potential for improving the nutritional and functional suitability of black gram in food applications.

KEYWORDS: Black gram, *Vigna mungo*, processing, germination, proximate composition, anti-nutritional factors, functional properties.

I. INTRODUCTION

Pulses are dried edible seeds of leguminous plants that have formed a major component of the human diet for nearly 10,000 years and remain an important food source, particularly where vegetarian diets predominate. They are a source of high-quality plant protein and are rich in complex carbohydrates, dietary fibre, vitamins and minerals such as iron, zinc, magnesium, calcium and folate, while being naturally low in fat and calories. Pulses also contain bioactive substances such as polyphenols, saponins and tannins that are linked to various health-promoting benefits, and they contribute to sustainable agriculture through biological nitrogen fixation and crop rotation.

Black gram (*Vigna mungo*) is a nutrient-rich leguminous crop grown mainly in tropical countries, especially India, and is a good source of protein, carbohydrates, vitamins and minerals including calcium, magnesium, phosphorus, zinc and iron. Like other legumes, however, it contains anti-nutritional factors such as phytic acid, tannins, phytohemagglutinins and enzyme inhibitors that can reduce nutrient availability and digestibility. Conventional processing techniques such as soaking, germination, cooking and fermentation can reduce these anti-nutritional compounds and enhance digestibility and nutritional quality, yet comparatively little research has focused on the bioactive compounds, health benefits and optimised processing of black gram. The present study therefore evaluated the nutritional composition, physicochemical and functional properties of raw black gram, and examined the effect of roasting, soaking,

germination and cooking on these properties, in order to identify processing methods that improve the nutritional and functional quality of black gram.

II. MATERIALS AND METHODS

2.1. Sample Collection and Preparation

Black gram samples were procured from a regional Agricultural Produce Market in Bengaluru and manually cleaned to remove dust and other impurities. The cleaned grain was divided into five equal portions: raw/untreated (RBG), roasted (RSBG), soaked for eight hours (SBG), pressure-cooked (CBG) and germinated (GBG). Germination was carried out following the method of Patil and Jena (2023): grains were soaked for 12 hours, spread on a tray lined with a damp cloth, and allowed to germinate at room temperature ($25 \pm 2^\circ\text{C}$) for 20 hours. All processed samples were tray-dried, ground into fine powder, and stored in sealed pouches prior to analysis.

2.2. Physical Properties

True density was determined by the liquid displacement method using toluene, and calculated as the ratio of seed mass to the volume of liquid displaced. Bulk density was determined by filling a graduated cylinder with seeds poured from a fixed height without compaction, and calculated as the ratio of seed mass to volume occupied. The 1000-seed weight was obtained by weighing 1000 randomly counted, clean, undamaged seeds on an electronic balance. Porosity was derived from the true and bulk density values.

2.3. Physicochemical (Functional) Properties

Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined following the method of Borhande et al. (1983). A 0.5 g sample was mixed with 10 mL distilled water (or 10 mL sunflower refined oil for OAC), vortexed, and centrifuged at 3500 rpm for 15 minutes. The supernatant was decanted, and the tubes were drained and reweighed to determine the amount of water or oil absorbed.

2.4. Anti-nutritional Factors

Total polyphenol content was determined by the Folin–Ciocalteu colourimetric method using gallic acid as the standard, with absorbance measured at 765 nm and results expressed as μg gallic acid equivalents (GAE) (Sankhalkar and Vernekar, 2016). Total tannin content was determined by the Folin–Ciocalteu method using tannic acid as the standard, with absorbance measured at 720 nm and results expressed as μg tannic acid equivalents (TAE) (Sankhalkar and Vernekar, 2016).

2.5. Proximate Composition

Moisture, ash, protein, fat and crude fibre were determined by standard AOAC procedures. Moisture was determined by oven-drying at 105°C to constant weight; ash by muffle-furnace ignition at 500°C for 3 hours; crude protein by the Kjeldahl method (digestion, distillation and titration, $\text{N} \times 6.25$); crude fat by Soxhlet extraction with petroleum ether; and crude fibre by acid–alkali digestion followed by ignition at 600°C . Nitrogen-free extract (NFE), representing the estimated carbohydrate fraction, was calculated by difference. Ascorbic acid was estimated by 2,6-dichlorophenol indophenol (DCPIP) dye titration, in which ascorbic acid reduces the blue dye to a colourless leuco-base, with the endpoint indicated by a persistent pink colour.

2.6. Statistical Analysis

Data were entered and analysed in Microsoft Excel 2016 to obtain means and standard deviations.

III. RESULTS AND DISCUSSION

3.1. Physical Properties

The physical properties of raw black gram — 1000-seed weight, true density, bulk density and porosity — are presented in Table 1. These parameters help explain the grain's behaviour during post-harvest handling, storage, transportation and processing.

Table.1. Physical properties of raw black gram sample

1000-Seed Weight	True Density	Bulk Density	Porosity	Porosity (%)
49 g	1.38 g/mL	0.867 g/mL	0.3717	37.17%

The 1000-seed weight (49 g) reflects the overall mass of the seeds and indicates seed size and development; it is an important factor in grading, sorting and mechanical handling, since variation in seed size and weight can affect operational efficiency. True density (1.38 g/mL) was higher than bulk density (0.867 g/mL), as true density excludes inter-granular space while bulk density includes it; this difference indicates the presence of void space within the bulk grain mass and is important for the design and capacity calculation of storage bins, hoppers and transport systems. The relatively large inter-granular porosity (37.17%) indicates that the grains were packed with adequate space between them, which affects airflow, aeration, drying, and heat and moisture transfer during storage and handling. These physical properties are of direct relevance to the selection and design of equipment used to clean, grade, convey, dry, store and package black gram.

3.2. Physicochemical (Functional) Properties

Water absorption capacity (WAC) and oil absorption capacity (OAC) of raw and processed black gram were determined to assess the effect of roasting, soaking, germination and cooking on functional properties (Table 2). Results showed significant differences among treatments, indicating that processing altered water and oil interaction.

Table.2. Physicochemical properties of black gram samples

Sample	WAC (%)	OAC (%)
Raw	72	309
Roasted	70	351
Soaked	424	462
Germinated	598	325
Cooked	503	331

WAC of the raw sample was 72%, decreasing slightly to 70% after roasting, possibly due to heat-induced changes in hydrophilic components (especially proteins) that reduce water-binding sites. Soaking markedly increased WAC to 424%, reflecting improved water uptake and retention linked to swelling of starch and other cell constituents and partial disruption of the grain structure, which increases accessibility of hydrophilic groups. The highest WAC was recorded for the germinated sample (598%), which may be attributed to enzymatic and structural changes during germination that alter starch, protein and cell-wall components and make more hydrophilic sites available. Cooking also produced a high WAC (503%), likely related to starch gelatinisation and structural disruption. The overall order of WAC was germinated > cooked > soaked > raw > roasted.

OAC of the raw sample was 309%, increasing to 351% after roasting, possibly due to thermally induced changes in protein structure and disruption of the seed matrix that expose more oil-interacting sites. Soaking produced the highest OAC (462%), indicating that hydration and structural modification during soaking improved oil-binding capacity. Germinated and cooked samples showed moderate OAC values of 325% and 331% respectively, related to changes in protein and carbohydrate structure. The order of OAC was soaked > roasted > cooked > germinated > raw. Overall, soaking and germination markedly enhanced water absorption, while soaking produced the greatest improvement in oil absorption, indicating that processing can be used to tailor the hydration, consistency, texture, moisture retention and oil-binding properties of black gram flour for food applications.

3.3. Total Polyphenol Content

Table.3. Total phenolic content of raw and processed black gram samples

Sample	Conc. of Gallic Acid Std. ($\mu\text{g GAE}$)
Raw	130.72
Roasted	153.22
Soaked	120.72
Germinated	108.22
Cooked	130.72

Total phenolic content of black gram ranged from 108.22 to 153.22 $\mu\text{g GAE}$ depending on processing. The highest value (153.22 $\mu\text{g GAE}$) was recorded for the roasted sample, approximately 17.2% higher than the raw sample (130.72 $\mu\text{g GAE}$), which may be related to heat-induced disruption of the seed matrix improving the extractability of phenolics. Soaking slightly reduced measured phenolics (120.72 $\mu\text{g GAE}$), likely due to leaching of water-soluble phenolics into the soaking medium. The lowest value (108.22 $\mu\text{g GAE}$) was recorded after germination, possibly reflecting metabolic transformation and utilisation of phenolic compounds during sprouting. The cooked sample retained a value similar to the raw sample (130.72 $\mu\text{g GAE}$), suggesting that degradation and/or leaching of bound phenolics may have been offset by structural disruption during cooking. These findings are consistent with reports that processing can markedly alter measurable phenolic content in black gram and other pulses (Kataria et al., 1988).

3.4. Total Tannin Content

Table.4. Total tannin content of raw and processed black gram samples

Sample	Conc. of Tannic Acid Std. ($\mu\text{g TAE}$)
Raw	210.25
Roasted	219.25
Soaked	186.25
Germinated	156.25
Cooked	232.25

Total tannin content ranged from 156.25 to 232.25 $\mu\text{g TAE}$ across treatments. The raw sample contained 210.25 $\mu\text{g TAE}$, which increased slightly after roasting (219.25 $\mu\text{g TAE}$), possibly reflecting heat-induced changes in the seed matrix that enhance tannin extractability during analysis. Soaking reduced tannin content to 186.25 $\mu\text{g TAE}$, likely due to diffusion or leaching of water-soluble tannins, consistent with the roughly 25% reduction reported after overnight soaking of black gram by Rao and Deosthale (1982). The lowest tannin content (156.25 $\mu\text{g TAE}$) was observed after germination — about 25.7% lower than the raw sample — likely due to metabolic transformation and enzymatic degradation of tannins during sprouting. In contrast, the cooked sample showed the highest tannin content (232.25 $\mu\text{g TAE}$); although most earlier studies report a decrease in tannin content after cooking, the increase observed here may reflect differences in cooking conditions and greater extractability of tannins following thermal disruption of the grain matrix, in line with the observation of Zia-ur-Rehman and Shah (2001) that the extent of tannin reduction after soaking and cooking of black gram depends on processing conditions.

3.5. Proximate Composition

Moisture, protein, fat, ash and fibre content of raw and processed black gram were determined by AOAC methods and compared with values reported in the Indian Food Composition Tables (IFCT) (Table 5).

Table.5. Proximate composition of black gram samples in comparison with IFCT values

Sample	Moisture (%)	Ash (%)	Protein (%)	Fibre (%)	Fat (%)	Carbohydrate (%)
IFCT Values	8.7	3.35	21.97	20.41	1.58	43.99
Raw	8.88	3.84	22.16	6.795	2.5	56.185
Roasted	0.99	10.65	23.2	9.608	2.97	52.582
Soaked	-	2.95	21.7	7.882	1.49	-
Cooked	2.73	21.2	7.199	0.4	-	-
Germinated	3.24	23.1	8.197	0.99	-	-

Protein, fat, ash, crude fibre, moisture and nitrogen-free extract (NFE, the estimated carbohydrate fraction) were determined for raw and processed samples. Changes in the proximate profile across treatments reflect four underlying processes: moisture loss or gain, leaching of soluble components into water, thermal concentration effects, and biochemical changes associated with germination.

Raw black gram was rich in protein (22.2%) compared with the IFCT reference value of 21.7%. Protein content decreased slightly to 21.4% and 21.0% after soaking and cooking respectively, presumably because soluble nitrogenous compounds leach into the processing water (Wani et al., 2013). Both roasting and germination increased protein content to about 23.0%, though for different reasons: roasting removes moisture, thereby concentrating the solid protein fraction, while germination activates proteolytic enzymes that transform storage proteins (Wani et al., 2013; Ghazali and Cheng, 1991). Protein content remained high across all samples, supporting black gram as a good source of plant protein.

Fat content decreased in the soaked sample and further in the cooked sample (0.4%) relative to the raw sample (2.4%), consistent with the reduction in extractable fat reported by Wani et al. (2013). Germination further reduced fat content to 1.1%, possibly due to mobilisation of stored fats to support sprout growth (Ghazali and Cheng, 1991). Roasting, in contrast, increased apparent fat content, which is best interpreted as an artefact of moisture removal concentrating the remaining solids rather than a true increase in fat.

Ash content decreased from 3.2% in the raw sample to 2.8% after soaking and 2.3% after cooking, indicating loss of water-soluble minerals (Wani et al., 2013), and returned to 3.2% after germination. Roasting produced a marked rise in ash content, from 6.2% to 10.2%, which is likely a concentration effect resulting from substantial moisture loss during roasting; this value is notably high compared with published values for black gram (Wani et al., 2013; Soharu et al., 2024) and warrants verification against the original laboratory calculation before being presented as a final result.

Crude fibre content ranged narrowly from 6.8% (raw, cooked) to 7.6–7.9% (soaked, germinated), rising further to 9.2% in the roasted sample. The increase after roasting corresponds to moisture concentration (Wani et al., 2013), while the change during germination may reflect modification of cell-wall polysaccharides during sprout growth (Ghazali and Cheng, 1991); these values fall within the range reported for other black gram cultivars (Wani et al., 2013).

Moisture decreased from 8.1% in the raw sample to approximately 1% after roasting, reflecting evaporation of free and loosely bound water under dry heat. This substantial moisture loss is the principal cause of the apparent increases observed in the other proximate fractions of the roasted sample, indicating that actual nutrient content has probably not increased to the extent suggested by the percentage values.

NFE constituted the major fraction of raw black gram (55.8%), higher than the IFCT reference value (43.5%), consistent with the naturally high carbohydrate content of black gram (Wani et al., 2013). NFE decreased after soaking and cooking as soluble sugars leach out and starch gelatinises (Zia-ur-Rehman et al., 2003), and decreased further after germination as starch is enzymatically broken down and utilised for sprout growth (Ghazali and Cheng, 1991). The apparent increase in NFE in the roasted sample again reflects moisture concentration rather than an actual gain in carbohydrate, since NFE is calculated by difference (Wani et al., 2013).

3.6. Estimation of Ascorbic Acid

Table.6. Ascorbic acid content of black gram samples

Sample	Conc. of Ascorbic Acid (mg/mL)
Raw	0.47
Roasted	0.36
Soaked	0.56
Germinated	0.65
Cooked	0.2

Ascorbic acid content varied considerably with processing, ranging from 0.20 to 0.65 mg/mL. The raw sample contained 0.47 mg/mL, increasing to 0.56 mg/mL after soaking and reaching its highest value in the germinated sample (0.65 mg/mL). This increase during soaking and germination may relate to rehydration of the seed and activation of metabolic processes during germination that promote synthesis and accumulation of ascorbic acid (Ghazali and Cheng, 1991), consistent with reported increases in vitamin C during legume germination (Moriyama and Oba, 2008). Roasting reduced ascorbic acid content to 0.36 mg/mL, likely because vitamin C is heat-sensitive and undergoes thermal and oxidative degradation during dry-heat treatment. The lowest concentration was observed in the cooked sample (0.20 mg/mL), which may be explained by the combined effects of heat degradation and leaching of water-soluble ascorbic acid into the cooking water (Khatoon and Prakash, 2006). Overall, germination was the most favourable treatment for retaining and enhancing ascorbic acid content, whereas cooking produced the greatest reduction, illustrating the sensitivity of vitamin C to processing conditions.

IV. CONCLUSION

This study evaluated the nutritional composition, physicochemical and functional properties, and the effect of different processing methods on black gram (*Vigna mungo* L.). Black gram was found to have appreciable nutritional value, particularly as a source of protein, carbohydrate and dietary fibre, and processing was shown to substantially modify its nutritional and functional characteristics. Protein content remained relatively high across treatments, while moisture, fat, ash, fibre and carbohydrate contents varied with processing method: roasting caused substantial moisture loss, and soaking and cooking led to changes associated with loss of soluble components, whereas germination maintained high protein content and produced favourable changes in the nutritional profile.

Processing also modified functional properties: germination produced the highest water absorption capacity, while soaking produced the highest oil absorption capacity, indicating potential for improving the functional suitability of black gram in food formulations. Soaking and germination reduced measured polyphenols and tannins, with germination producing the lowest tannin content, whereas roasting slightly increased measured polyphenol and tannin content and cooking recorded the highest measured tannin content under the conditions studied. Germination also produced the highest measured ascorbic acid content, while cooking caused the greatest reduction. Overall, germination emerged as the most favourable processing method for nutritional and functional enhancement of black gram, through its favourable effects on protein retention, water absorption, tannin reduction and ascorbic acid content, supporting its potential as a nutritious, functional ingredient for plant-based food product development.

REFERENCES

- [1] Borhande, S. et al. (1983). Method for determination of water and oil absorption capacity (full publication details not specified in the source study).
- [2] Fuller, D. Q., & Harvey, E. L. (2006). The archaeobotany of Indian pulses: Identification, processing and evidence for cultivation. *Environmental Archaeology*, 11(2), 219–246.
- [3] Ghazali, H. M., & Cheng, S. C. (1991). The effect of germination on the physicochemical properties of black gram (*Vigna mungo* L.). *Food Chemistry*, 41(1), 99–106.
- [4] Kataria, A., Chauhan, B. M., & Gandhi, S. (1988). Effect of domestic processing and cooking on the antinutrients of black gram. *Food Chemistry*, 30(2), 149–156.

- [5] Kebede, E. (2021). Contribution, utilization, and improvement of legumes-driven biological nitrogen fixation in agricultural systems. *Frontiers in Sustainable Food Systems*, 5, 767998.
- [6] Khatoon, N., & Prakash, J. (2006). Nutrient retention in microwave cooked germinated legumes. *Food Chemistry*, 97(1), 115–121.
- [7] Moriyama, M., & Oba, K. (2008). Comparative study on the vitamin C contents of the food legume seeds. *Journal of Nutritional Science and Vitaminology*, 54(1), 1–6.
- [8] Mudryj, A. N., Yu, N., & Aukema, H. M. (2014). Nutritional and health benefits of pulses. *Applied Physiology, Nutrition, and Metabolism*, 39(11), 1197–1204.
- [9] Patil, S. B., & Jena, S. (2023). Effects of soaking and sprouting time on nutritional parameters of sprouted green colour black gram of Sikkim region. *Journal of Agricultural Engineering (India)*, 60(2), 153–164.
- [10] Rao, P. U., & Deosthale, Y. G. (1982). Tannin content of pulses: Varietal differences and effects of germination and cooking. *Journal of the Science of Food and Agriculture*, 33(10), 1013–1016.
- [11] Reddy, N. R., Salunkhe, D. K., Sathe, S. K., & Kon, S. (1982). Biochemistry of black gram (*Phaseolus mungo* L.): A review. *Critical Reviews in Food Science and Nutrition*, 16(1), 49–114.
- [12] Sankhalkar, S., & Vernekar, V. (2016). Quantitative and qualitative analysis of phenolic and flavonoid content in *Moringa oleifera* Lam and *Ocimum tenuiflorum* L. *Pharmacognosy Research*, 8(1), 16–21.
- [13] Singh, B., Singh, J. P., Shevkani, K., Singh, N., & Kaur, A. (2017). Bioactive constituents in pulses and their health benefits. *Journal of Food Science and Technology*, 54(4), 858–870.
- [14] Singh, B., & Kaur, G. (2021). Black gram: Bioactive components for human health and their functions. In *Handbook of Cereals, Pulses, Roots, and Tubers* (pp. 377–392).
- [15] Soharu, A., Mittal, R. K., Sood, V. K., Dhaliwal, Y. S., & Sharma, S. (2024). Evaluation of proximate composition, cooking quality, and texture profile analysis in Himalayan landraces of black gram (*Vigna mungo*). *Plant Foods for Human Nutrition*, 79(4), 819–826.
- [16] Suneja, Y., Kaur, S., Gupta, A. K., & Kaur, N. (2011). Levels of nutritional constituents and antinutritional factors in black gram (*Vigna mungo* L. Hepper). *Food Research International*, 44(2), 621–628.
- [17] Wani, I. A., Sogi, D. S., & Shivhare, U. S. (2013). Physical and cooking characteristics of black gram (*Phaseolus mungo* L.) cultivars grown in India. *International Journal of Food Science & Technology*, 48(12), 2557–2563.
- [18] Zia-ur-Rehman, M., Rashid, M., & Salariya, A. M. (2003). Available and unavailable carbohydrate content of black gram (*Vigna mungo*) and chickpea as affected by soaking and cooking processes. *Pakistan Journal of Scientific and Industrial Research*, 46(6), 457–461.
- [19] Zia-ur-Rehman, & Shah, W. H. (2001). Tannin contents and protein digestibility of black grams (*Vigna mungo*) after soaking and cooking. *Plant Foods for Human Nutrition*, 56(3), 265–273.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details