



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 6, June 2026

The Nutritional Journey of Split Green Gram Dal (Vigna Radiata): Comparative Analysis of Different Processing Methods on Phytochemicals, Nutrient Quality, and Iron Bioavailability

G Keerthana¹, Dr. Prabhavati S Erimani², Yashwanth PS¹, Harshitha BT¹, Challa Likitha¹

PG Final Year Student, Department of Food Science and Nutrition, Padmashree Institute of Management and Sciences, Kommaghatta Main Rd, Kengeri, Kommaghatta, Karnataka, India¹

Assistant Professor, Department of Food Science and Nutrition, Padmashree Institute of Management and Sciences, Kommaghatta Main Rd, Kengeri, Kommaghatta, Karnataka, India²

ABSTRACT: Split green gram dal (*Vigna radiata*) or mung bean is a staple pulse used in the Indian diet, known for its high protein content (21-25 %), easy digestibility and high nutritional value. However, the health benefits of this grain are somewhat limited by the presence of anti-nutritional factors like phenols and tannins, which can interfere with the absorption of essential nutrients, especially minerals such as iron. The present study was conducted to systematically evaluate the impact of five different processing methods (raw, roasted, soaked, raw-cooked and roasted-cooked) on the phytochemical composition, total phenolic and tannin content, iron bioavailability and physio-chemical properties and nutritive value of split green gram dal. The results indicated that roasting-cooking significantly decreased anti-nutritional components. For example, the total phenolic content reduced from 281.57 µg GAE in raw samples to 38.71 µg GAE in roasted-cooked samples and the total tannins reduced from 245.88 µg TAE to 33.38 µg TAE in roasted-cooked samples. The marked decrease in anti-nutrients resulted to an increase in the bioavailability of iron in the processed samples. In addition, physio-chemical properties such as water absorption and solubility were enhanced in cooked samples due to structural changes such as starch gelatinization and protein denaturation. The roasted-cooked split green gram dal showed the highest improvement in the nutritional and functional properties among all the treatments showing the significance of optimized traditional processing to enhance the health benefits of this staple food.

KEYWORDS: Split Green Gram Dal, Proximate Analysis, Physio-Chemical Properties, Anti-Nutritional Properties, Iron Bioavailability.

I. INTRODUCTION

Split green gram (*Vigna radiata*) is one of the most highly valued and widely consumed pulse crops throughout India and most of Asia, mainly due to its naturally high content of plant-based protein (21–25%) complex carbohydrates, dietary fiber, essential minerals and a host of bioactive compounds with antioxidant and anti-inflammatory effects (Directorate of Pulses Development, n.d.; Roy & Roy, 2022; Kishore & Sharma, 2023). It is an all-age staple ingredient, particularly for children, the elderly and the nutritionally vulnerable, due to its affordability and versatility. However, green gram dal contains significant amounts of anti-nutritional compounds (such as tannins, phenolic compounds, phytates and saponins) that can bind proteins and minerals, thus considerably lowering the bioavailability of essential nutrients such as iron, despite its nutritional strengths. This is of concern in areas where pulses are the major source of dietary protein and where iron deficiency is still a continuing public health problem (Lombardi-Boccia *et al.*, 2002; Shimelis & Rakshit, 2007).

Traditional household processing methods, such as soaking, roasting and cooking, are commonly used to reduce the levels of these anti-nutritional factors through mechanisms such as thermal degradation and leaching. These methods enhance digestibility as well as the overall nutritional quality of the dal (Xu & Chang, 2008; Khandelwal *et al.*, 2010). Nevertheless, there is a lack of literature on a comprehensive comparative understanding of the impact of each

individual processing technique on the phytochemical composition, total phenolic and tannin content, and iron bioavailability in split green gram dal.

Hence, the present study was planned in a manner to systematically examine the effects of five processing treatments (raw, roasted, soaked, raw-cooked and roasted-cooked) on the nutritional quality, phytochemical profile and iron bioavailability of split green gram dal. The main aim is to determine the best preparation method for maximizing the nutritional benefits and minimizing the anti-nutritional factors thereby providing practical dietary recommendations for enhancing the health value of this widely consumed pulse.

1. MATERIAL AND METHODS

1.1 Raw Materials Procurement

Split green gram dal was purchased from local super market for the study. All the samples were cleaned and stored in air tight containers. Analytical chemicals for other tests were purchased from a scientific vendor in Bangalore.

1.2 Preparation of Samples

The seeds were studied with respect to weight and density. They were divided into five groups as raw, roasted, soaked (2 hour), raw-cooked (pressure cooked) and roasted-cooked (roasted and then cooked). All samples, except those to be analyzed for moisture, were tray dried before further analysis.

1.3 Physio-chemical Properties

The physio-chemical properties of seeds such as water and oil absorption capacities, solubility index, 1000 seed weight, bulk density and true density were determined by standard AOAC methods. (Borhande et al., 1983).

1.4 Proximate Nutrient Composition

Moisture, ash, crude protein, crude fat and fibre contents were determined by using standard AOAC methods (Kaundal & Kumar, 2020). Moisture was determined by oven drying, ash by incineration in a muffle furnace, protein by digest-distil-titrate process (%N x 6.25), fat by Soxhlet extraction and fibre by igniting after treatment with acid and alkali.

1.5 Estimation of Iron

Iron was estimated by dissolving the ashed samples in hydrochloric acid and estimating colorimetrically with standard iron solutions, nitric acid and ammonium thiocyanate (D C Goswami and H Kalita).

1.6 Phytochemical Screening

Phytochemicals like flavonoids, phenols, tannins, alkaloids, saponins, steroids, glycosides, terpenoids were identified using the classical qualitative tests (Edeoga et al., 2005).

1.7 Total Phenolic Content

Total phenolics were determined by Folin-Ciocalteu method with gallic acid as standard and absorbance was measured at 650 nm (Sankhalkar & Vernekar, 2016).

1.8 Total Tannin Content

Tannic acid was used as a standard and the tannins were determined by the Folin-Ciocalteu method and the absorbance was measured at 720 nm (Sankhalkar and Vernekar, 2016).

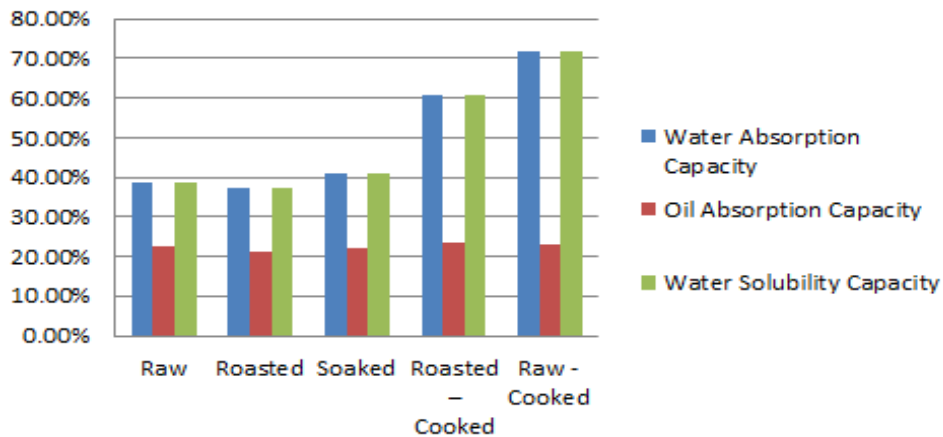
II. RESULTS AND DISCUSSION

2.1 Physio-chemical Properties

The physical and chemical properties of split green gram dal were significantly affected by processing methods. The raw samples exhibited moderate water and oil absorption and solubility, characteristics of an intact protein-starch matrix. Roasting caused partial denaturation of proteins and hardening of starch, which slightly decreased water and oil absorption and reduced hydrophilicity of the structure. Soaking improved water uptake and solubility by hydrating and softening the cell walls, exposing more water-binding sites. Highest water absorption was observed after soaking or roasting and was attributed to starch gelatinization and protein denaturation during cooking. The oil absorption was fairly constant across all treatments indicating that processing methods did not affect the fat binding hydrophobic amino acid sites much. The overall effect of dry heat (roasting) caused moderate decreases in hydration properties

while moist heat (cooking) significantly enhanced hydration properties indicating heat induced modifications in the macromolecular structure of starches and proteins (Kaur & Singh, 2005).

Physio-Chemical Properties

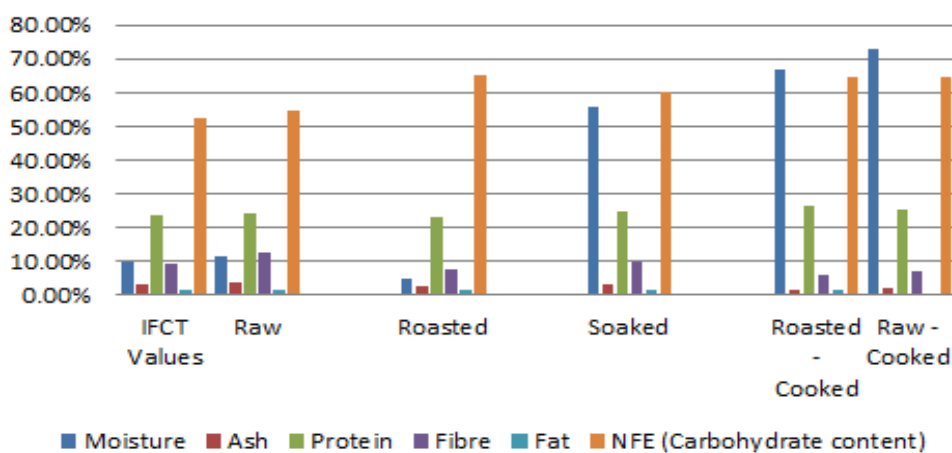


Graph 1: Physio-Chemical Properties

2.2 Nutrient Proximate Analysis

Processing significantly affected the nutrient content of split green gram dal. The moisture content of soaked, roasted-cooked and raw-cooked samples increased as a result of water absorption. However, roasting reduced moisture content drastically through evaporation. The protein content (about 23–26%) was not significantly different between treatments but small increases in cooked samples may indicate increased extractability from protein breakdown of complexes. After roasting and cooking, the ash content was decreasing probably due to mineral leaching in the process water or volatilization at high temperature. The fiber content decreased significantly by roasting and cooking (from 12.82% in raw to as low as 6.14%) due to breakdown and solubilization of carbohydrates during exposure to heat and moisture. Roasting and soaking increased the non-fiber extract (NFE, for carbohydrates), due to the concentration effects of water loss and higher extractability after gelatinization. Processing led to increase in moisture (unless roasted), decrease in ash and fiber and largely unchanged protein, but increased carbohydrate content due to changed matrix structure and water uptake (Grewal and Jood., 2006; Ojo *et al.*, 2019; Chunxue *et al.*, 2023)

Proximate Analysis



Graph 2: Proximate Nutrient Analysis

2.3 Estimation of Iron

The processing methods had mixed effects on the measured iron content. The roasted sample had a slightly higher iron concentration (0.0588 mM/L) than the raw sample (0.0525 mM/L) possibly due to the fact that roasting reduces moisture and concentrates minerals. Iron content in soaked samples was significantly reduced (0.0088 mM/L) due to leaching of minerals into soaking water. Raw-cooked and roasted-cooked samples were found to have the lowest iron contents (0.0025 mM/L), indicating a significant loss of iron during cooking by leaching and decomposition of mineral-organic complexes. This is in line with previous studies which indicate that dry heat (roasting) could enhance the measured mineral content due to solute concentration, whereas wet procedures (soaking and cooking) could decrease the mineral content through leaching (Arumugam & Siddhuraju, 2015; Ojo *et al.*, 2019; Okpanachi *et al.*, 2018; Lombardi-Boccia *et al.*, 2002).

Table 1: Iron Estimation

Samples	Conc. of 0.001M Fe(NO ₃) ₃ (mM/L)
Raw	0.0525
Roasted	0.0588
Soaked	0.0088
Roasted – Cooked	0.0025
Raw - Cooked	0.0025

2.4 Phytochemical Test

The raw split green gram dal was found to contain large amounts of alkaloids, tannins, saponins, flavonoids, phenols, glycosides, steroids and terpenoids as shown by phytochemical screening (Xu & Chang, 2008; Shimelis & Rakshit, 2007). Roasting resulted in moderate reduction in heat-labile compounds such as tannins, flavonoids, phenols and saponins but heat-stable compounds such as alkaloids, steroids and terpenoids were less affected (Khandelwal *et al.*, 2010). Soaking resulted in a significant loss of water-soluble phytochemicals, especially tannins, saponins, flavonoids and glycosides, mainly due to leaching, whereas compounds of low water solubility were less affected. The combined effect of leaching and heat degradation resulted in the lowest concentrations of anti-nutritional phytochemicals during cooking after soaking or roasting. This reduction is beneficial as it allows for improved nutrient bioavailability, especially iron (Arumugam & Siddhuraju, 2015; Khandelwal *et al.*, 2010).

2.5 Total Phenolic Content

The total phenolic content (TPC) expressed as gallic acid equivalents was highest in the raw sample (281.57µg GAE) and decreased significantly with processing, roasted (138.71µg), soaked (124.43µg), raw-cooked (53µg) and roasted-cooked (38.71µg). The reduction in phenolic content was gradual which is attributed to loss during soaking and degradation during thermal processing. This is important because, while phenolics are valuable antioxidants, they also function as anti-nutrients, binding minerals. The lowest phenolic content was observed in the combined method of roasting and cooking, which supports previous research findings (Xu & Chang, 2008; Khandelwal *et al.*, 2010) and confirms the effectiveness of the method in reducing the anti-nutritional factors.

Table 2: Total Phenolic Content

Samples	Conc. of Gallic Acid Std (µg)
Raw	281.57
Roasted	138.71
Soaked	124.43
Roasted – Cooked	38.71
Raw - Cooked	53

2.6 Total Tannin Content

Tannin content (as tannic acid equivalents) followed a similar trend being the highest in raw dal (245.88 μg TAE) to decrease in roasted (120.88 μg), soaked (108.38 μg), raw-cooked (45.88 μg) and roasted-cooked (33.38 μg) samples. Dry and moist heat greatly reduced the content of tannins (which inhibit the absorption of proteins and minerals) with the greatest reduction in the roasted-cooked treatment. The significant reduction of tannins is important in improving the nutritional quality of green gram dal by increasing mineral bioavailability and reducing anti-nutritional effects (Shimelis & Rakshit, 2007; Khandelwal *et al.*, 2010).

Table 3: Total Tannin Content

Samples	Conc. of Tannic Acid Std (μg)
Raw	245.88
Roasted	120.88
Soaked	108.38
Roasted – Cooked	33.38
Raw - Cooked	45.88

III. CONCLUSION

This study revealed that the traditional methods of processing, in particular the method of combined roasting and cooking, can greatly improve the nutritional, phytochemical and functional properties of the split green gram dal. The study revealed that the raw samples had the highest total phenolic content (281.57 μg GAE) and tannin content (245.88 μg TAE). Both are antioxidants, but also have adverse effects on mineral bioavailability (Shimelis & Rakshit, 2007; Xu & Chang, 2008). The anti-nutritional factors were gradually reduced through sequential processing (roasting, soaking and especially roasting and cooking). The roasted-cooked method produced the lowest values: total phenolic content was reduced to 38.71 μg GAE and tannin content to 33.38 μg TAE. The reduction was marked and resulted in the increased bioavailability of iron because of the reduction of anti-nutritional compounds available for chelating and inhibiting the mineral absorption (Lombardi-Boccia *et al.*, 2002). Processing methods especially moist heat processing also improved the functional properties such as water absorption and solubility considerably due to starch gelatinization and protein denaturation mainly (Kaur & Singh, 2005). Phytochemical screening also revealed a gradual reduction in tannins, flavonoids, saponins and phenols with increase in processing intensity. In conclusion, the results strongly suggest that combined roasting and cooking is the most suitable method for reducing the anti-nutritional factors and improving the nutritional quality and health promoting properties of split green gram dal. The results suggest the potential of optimized traditional processing methods to improve the health benefits of this pulse, widely consumed, especially in areas where nutrient deficiencies are a major public health problem (Khandelwal *et al.*, 2010).

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