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Evaluation of nutritional composition in finger millet (*Eleusine coracana* L.) genotypes

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Abstract
Finger millet (*Eleusine coracana* L.) is a nutrient-dense, climate-resilient cereal crop that plays a crucial role in sustaining food and nutritional security in semi-arid regions of India. Known for its rich content of calcium, dietary fiber, and bioactive compounds, finger millet contributes to improved metabolic health and reduced risks of non-communicable diseases. Despite its importance, there is limited systematic evaluation of the nutritional diversity among genotypes grown in Telangana, one of the major finger millet-producing regions. The present study investigated the proximate composition of six finger millet genotypes cultivated during the rabi (Yasangi) season of 2020 at the Regional Agricultural Research Station, Palem, PJTSAU, Telangana, under a randomized block design with three replications. Grain samples were processed into flour and analyzed for moisture, protein, fat, fiber, ash, and carbohydrate contents using standard AOAC protocols. Significant variation was recorded among the genotypes, with moisture content ranging from 9.82% to 12.65%, carbohydrates from 70.10% to 76.42%, protein from 4.42% to 6.37%, fat from 1.24% to 2.19%, crude fiber from 2.31% to 8.56%, and ash from 2.11% to 2.80%. Among the tested genotypes, VR 1099 was distinguished by superior nutritional values, showing the highest carbohydrate (76.42%), protein (6.37%), fat (2.19%), and ash (2.80%) contents, whereas VR 1174 exhibited an exceptionally high fiber content (8.56%). These findings reveal the presence of substantial nutritional variability among finger millet genotypes cultivated under semi-arid conditions, highlighting their potential for targeted dietary applications and genetic improvement. Genotypes with superior profiles, such as VR 1099 and VR 1174, could serve as valuable candidates for functional food development, biofortification, and breeding strategies aimed at enhancing dietary quality. Overall, the study emphasizes the role of finger millet as a sustainable, health-promoting cereal that can contribute to improved nutrition and resilience in dryland farming systems.

Keywords: Finger millet (*Eleusine coracana* L.), nutritional composition, protein conten

Introduction

Millets are a diverse group of small-grained cereals collectively referred to as *nutri-cereals*, which include sorghum, pearl millet, finger millet, foxtail millet, little millet, barnyard millet, kodo millet, proso millet, and brown top millet. These crops have gained global importance owing to their ability to withstand climate variability, low input requirements, and high nutritional quality (Numan *et al*., 2021; Singh *et al*., 2021) [15, 19]. As C4 plants, millets demonstrate higher photosynthetic efficiency, improved water-use efficiency, and greater tolerance to heat stress, enabling them to adapt to marginal environments with limited resources (Wilson and VanBuren, 2022) [20]. Due to these adaptive traits, millets are often referred to as "famine crops," as they are capable of producing stable yields even under adverse conditions (Grovermann *et al*., 2018) [8]. In recognition of their role in sustainable food systems, the United Nations declared 2023 as the International Year of Millets with the aim of promoting their production and utilization worldwide.

India is a major center for millet cultivation, where these crops have historically formed an integral part of semi-arid and rainfed farming systems. In Telangana, millets such as sorghum, pearl millet, finger millet, foxtail millet, and little millet were traditionally cultivated across dryland regions, contributing both to household nutrition and livestock feed. However, following the Green Revolution, the area under millet cultivation declined considerably due to the expansion of rice and maize, supported by irrigation, procurement policies, and subsidies (Grovermann *et al*., 2018) [8]. In recent years, government initiatives and awareness programs have renewed attention toward millets in Telangana, emphasizing their role in climate resilience, nutritional security, and sustainable agriculture.

Finger millet (*Eleusine coracana* L. Gaertn.), locally known as *ragi,* is one of the most important millets cultivated in the state. It is a short-duration crop that matures within 90-120 days, requires relatively low inputs, and is tolerant to drought and several biotic stresses (Bhatt *et al*., 2011; Mude *et al*., 2020) [3, 13]. The crop is nutritionally rich, providing significant amounts of calcium, iron, dietary fiber, protein, and essential amino acids (Bisht *et al*., 2023) [5]. Its gluten-free nature makes it suitable for individuals with gluten intolerance or celiac disease. Moreover, finger millet is resistant to many storage pests, has a long shelf life, and holds relatively high market value compared with other cereals, thereby offering both nutritional and economic benefits.

Although India dominates global finger millet production, wide differences in productivity exist across states, ranging from 1459 kg/ha in Uttarakhand to 3481 kg/ha in Tamil Nadu, with the national average being 1724 kg/ha (Directorate of Millets Development, 2021). Such variability underlines the importance of region-specific studies, particularly focusing on both yield and nutritional attributes.

The present study was conducted to investigate the nutritional composition of local finger millet varieties cultivated in Telangana. Proximate analysis was carried out to determine moisture content, carbohydrate, protein, fat, fiber, and ash levels. The outcomes of this study are expected to provide insights into the nutritional potential of local varieties, contributing to the promotion of finger millet as a health-promoting and climate-resilient cereal crop.

Materials and Methods

The field experiment was conducted during the rabi (Yasangi) season of 2020 at the Regional Agricultural Research Station (RARS), Palem, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Telangana, India. Six finger millet genotypes (*Eleusine coracana* L.) were evaluated in a Randomized Block Design (RBD) with three replications. Each plot consisted of four rows of 4 m length with a spacing of 30 cm × 10 cm between rows and plants. A uniform fertilizer dose of 50:40:25 NPK kg ha^{-1} was applied, and standard agronomic practices were followed to maintain crop health and minimize biotic and abiotic stresses. The D3 experimental field at RARS Palem, representative of the semi-arid tropical climate of Telangana, provided suitable conditions for evaluating finger millet under rainfed rabi cultivation.

Grain samples from each genotype were manually cleaned, air-dried, and stored in dark, dry conditions at room temperature until analysis. For laboratory examination, grains were ground into fine flour using a mortar and pestle, sieved through a 0.6 mm mesh, and preserved in airtight containers under cool, dry conditions. Nutritional composition was assessed according to standard AOAC methods, including moisture, dry matter, crude protein, crude fat, crude fibre, crude ash, and carbohydrate content.

Moisture content was determined by oven-drying approximately 5 g of flour in pre-weighed aluminum cups at 134 °C for 2 hours (AOAC 930.15). After cooling in a desiccator, moisture percentage was calculated as the loss in weight relative to the initial sample.

Dry matter content was estimated as the complement of moisture content. Flour samples were oven-dried at 134 °C until constant weight was achieved, and the percentage of dry matter was calculated according to AOAC 930.15.

Crude protein was measured using the Kjeldahl method (AOAC 981.10). Defatted flour samples (0.5 g) were digested with K_2SO_4 and $CuSO_4$ as catalysts, distilled with 10 M NaOH, and ammonia was trapped in 4% boric acid. Nitrogen content was determined by titration with 0.2 N HCl, and protein content was calculated using a conversion factor of 6.25.

Crude fat was quantified using Soxhlet extraction (AOAC 920.39C). A 3 g flour sample was extracted with petroleum ether for 8 hours, and the solvent was removed. The residue was dried, cooled, and weighed to determine the fat content as a percentage of the original sample weight.

Crude fibre content was determined by sequential acid-alkali digestion (AOAC 978.10). Defatted flour (2 g) was treated with 0.25 N H_2SO_4 followed by 0.313 N NaOH, washed, dried, and weighed. The sample was then incinerated in a muffle furnace at 600 °C, and crude fibre was calculated based on the weight loss after ashing.

Crude ash was estimated by incineration of 3 g flour samples in a muffle furnace at 600 °C for 3 hours (AOAC 942.05). The residue was cooled in a desiccator and weighed to determine total mineral content as a percentage of dry weight.

Carbohydrate content was calculated by the difference method, subtracting the sum of protein, fat, and ash contents from the total solids. All analyses were performed in triplicate, and results were expressed on a percentage dry weight basis.

Results

Nutritional composition is a key determinant of the dietary quality of finger millet (*Eleusine coracana* L.). Proximate analysis, including moisture, carbohydrate, protein, fat, fiber, and ash, provides essential information on the grain's health benefits and post-harvest stability. Evaluating these traits among high-yielding genotypes helps identify varieties with superior nutritional quality. The following results present the variation in these components across ten selected finger millet genotypes table 1.

Moisture Content

Moisture content, which is critical for storage stability and shelf life, varied among the genotypes from 9.82% to 12.65%, with a mean value of 11.48%. The genotype VR 1165 exhibited the lowest moisture content (9.82%), whereas VR 1159 recorded the highest (12.65%), indicating variation in potential storage durability among the genotypes.

Carbohydrate Content

Carbohydrate content, important for calorific value and glycemic index, ranged from 70.10% to 76.42%, with an average of 74.80%. Among the genotypes, VR 1099 had the highest carbohydrate content (76.42%), whereas VR 1174 had the lowest (70.10%). The results suggest that these genotypes are a good source of slowly digestible carbohydrates, contributing to their nutritional significance.

Crude Protein
Protein content of the evaluated genotypes ranged from 4.42% to 6.37%, with a mean of 5.63%. The genotype VR 1099 exhibited the highest protein content (6.37%), while VR 1149 had the lowest (4.42%), highlighting variability in protein accumulation among genotypes.

Crude Fat
Fat content ranged from 1.24% to 2.19%, with a mean of 1.74%. VR 1099 recorded the highest fat content (2.19%), whereas VR 1146 had the lowest (1.24%). The low lipid content of finger millet is consistent with its characterization as a low-fat cereal.

Crude Fiber
Crude fiber content ranged from 2.31% to 8.56%, with an average of 3.81%. VR 1174 exhibited the highest fiber content (8.56%), while VR 1099 had the lowest (2.31%). This variation indicates differences in the dietary fiber contribution of the genotypes.

Ash Content
Ash content, indicative of total mineral concentration, ranged from 2.11% to 2.80%, with a mean of 2.39%. VR 1099 recorded the highest ash content (2.80%), and VR 1150 had the lowest (2.11%).

Table 1: Nutritional Profiling of finger millet genotypes

S.no	Genotype	Moisture (%)	Carbohydrate (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)
01.	VR 1149	10.38	76.22	4.42	1.80	4.41	2.77
02.	VR 1152	11.68	75.85	5.27	2.00	2.78	2.42
03.	VR 1159	12.65	73.93	5.84	1.54	3.44	2.60
04.	VR 1163	12.17	75.02	5.69	1.63	3.14	2.35
05.	VR 1147	12.32	74.62	6.09	1.73	3.75	2.12
06.	VR 1146	12.65	75.64	5.54	1.24	3.28	2.27
07.	VR 1099	9.91	76.42	6.37	2.19	2.31	2.80
08.	VR 1165	9.82	75.26	5.88	1.84	4.91	2.29
09.	VR 1174	11.61	70.10	5.70	1.80	8.56	2.24
10.	VR 1150	11.61	74.94	5.50	1.64	4.20	2.11
	Range	9.82-12.65	70.10-76.42	4.42-6.37	1.24-2.19	2.31-8.56	2.11-2.80
	Mean	11.48	74.80	5.63	1.74	3.81	2.39

Discussion
The present study demonstrated substantial variation in the proximate composition of ten finger millet genotypes, underscoring the nutritional diversity that exists within the crop and its potential for dietary and breeding applications.
Moisture content ranged from 9.82% to 12.65%, values that are comparable to previous reports in finger millet and other small millets (Barbeau and Hilu, 1993; David *et al*., 2014; Audu *et al*., 2018) [2, 6, 1]. Genotypes with lower moisture, such as VR 1165, are of particular interest for enhancing storage stability and reducing post-harvest losses, which remains a challenge in millet-based food systems.
Carbohydrates were the major component, contributing 70.10-76.42% of the grain composition. This aligns with earlier studies documenting 71-79% carbohydrates in finger millet (Shibairo *et al*., 2014; Nakarani *et al*., 2020) [18, 14]. The high carbohydrate content of VR 1099 (76.42%) indicates its potential as a high-energy cereal, while the predominance of slowly digestible starch reinforces the role of finger millet in managing metabolic disorders such as type 2 diabetes, as previously suggested by Bhosale *et al*. (2020) [4].
Protein content varied between 4.42% and 6.37%, which is within the range reported across diverse germplasm (Shankaramurthy *et al*., 2018; Jayawardana *et al*., 2019) [17, 10]. Notably, VR 1099 exhibited the highest protein concentration, demonstrating that substantial genetic variability exists for this trait. This variability is nutritionally relevant, as finger millet continues to be promoted as a protein source for populations facing malnutrition.
Fat content was relatively low (1.24-2.19%), in line with the classification of finger millet as a low-fat cereal (Kamatar *et al*., 2015; Kulthe *et al*., 2016) [11, 12]. Although the range was narrow, VR 1099 had a slightly higher fat content, which could enhance energy density without compromising shelf stability.
Crude fiber exhibited the widest variation (2.31-8.56%), exceeding values commonly reported in the literature (3-5%; Pasha *et al*., 2018; Nakarani *et al*., 2020) [16, 14]. VR 1174, with exceptionally high fiber, represents a valuable resource for developing functional foods targeting non-communicable diseases such as obesity and cardiovascular disorders. Conversely, low-fiber genotypes like VR 1099 may have relevance in food processing industries requiring finer grain texture.
Ash content, reflecting total mineral concentration, ranged from 2.11% to 2.80%, consistent with earlier studies (Bhosale *et al*., 2020; Jayawardana *et al*., 2019) [4, 10]. The genotype VR 1099, which recorded the highest ash value, may serve as a candidate for mineral biofortification. Such genotypic variability supports previous findings in millet species showing significant differences in micronutrient density (Jandu and Kawatra, 2019) [9].
Collectively, these findings reinforce the nutritional value of finger millet while highlighting genotype-specific advantages. VR 1099 emerges as a nutritionally superior genotype with high carbohydrate, protein, fat, and ash content, whereas VR 1174 offers exceptionally high dietary fiber. The results are consistent with earlier reports across Africa and Asia (Barbeau and Hilu, 1993; Shibairo *et al*., 2014; Nakarani *et al*., 2020) [2, 18, 14], yet the wider range observed for fiber in this study suggests underexplored diversity in Indian germplasm. From a public health perspective, such diversity enables targeted utilization either for direct consumption or as parental material in breeding programs aimed at enhancing nutritional security.

Conclusion
The present study highlights significant genotypic variability in the proximate composition of finger millet cultivated under semi-arid conditions in Telangana. Key nutritional traits, including carbohydrates, protein, fiber, and minerals, exhibited wide variation, underscoring the potential of finger millet as both a staple cereal and a functional food. Genotype VR 1099 emerged as a nutritionally rich source, combining high carbohydrate, protein, fat, and ash content, while VR 1174 was distinguished by exceptionally high dietary fiber. Such diversity not only supports dietary diversification but also provides a genetic resource for breeding programs targeting enhanced nutritional quality.
Given the increasing emphasis on millets in climate-resilient and health-promoting food systems, the identification of

nutritionally superior genotypes offers scope for promoting finger millet as a sustainable crop that can contribute to both food and nutritional security. Future research should integrate biochemical and genomic approaches to unravel the genetic basis of nutritional traits and to accelerate the development of biofortified finger millet varieties adapted to local agroecologies.

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