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Physico-chemical properties and nutritional composition of finger millet grains

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Abstract
This study explores the physico-chemical properties of finger millet (*Eleusine coracana* L.), focusing on the VL-380 cultivars. Finger millet is a highly nutritious cereal, recognized for its resilience and health benefits, yet remains underutilized. The research aimed to evaluate the grain's quality through its physical and chemical characteristics. The physical properties measured included bulk density (773.57kg/m^3), true density (1285.53kg/m^3), porosity (39.82%), angle of repose (24.71°), and thousand-grain weight (2.56 g). These values indicate the grain's high quality and suitability for large-scale processing, particularly in starch production. The hydration capacity (65.41%) and swelling capacity (47.88%) further highlight its potential in moisture-sensitive food applications. The chemical analysis revealed the presence of crude protein (6.7%), crude fat (3.64%), crude fiber (3.4%), and total carbohydrates (74.52%), alongside significant amounts of calcium (320 mg/100 g) and iron (4 mg/100 g). The study also identified bioactive compounds, including phytic acid (850mg/100 g) and polyphenols (158 mg GAE/100 g), which contribute to the grain's health-promoting properties. This comprehensive evaluation underscores finger millet's potential as a valuable ingredient in food products, advocating for its wider adoption to enhance food security and nutritional health.

Keywords: Finger millet, grain quality, millets, nutritional composition

Introduction
Millets are widely recognized for their health-promoting properties, and 2023 was designated by the United Nations as the international year of millets (Nanda & Janardhana, 2024) [11]. Millet-based products have seen a surge in popularity due to various factors such as their resilience in the face of population growth, water scarcity, climate change, and health concerns related to gluten-containing foods. Scientifically called *Eleusine coracana*, finger millet is a significant minor cereal grain that is grown throughout the world in tropical and semi-arid climates. This millet is a member of the Poaceae family's Chloridoideae subfamily. In many regions of Asia and Africa, it is a traditional staple crop (FAO, 1995) [6]. Finger millet may have been domesticated and cultivated in Africa before being brought to India, according to archaeological and linguistic data (Dida & Devos, 2006). Nowadays, finger millet is cultivated in more than 25 Asian and African nations (FAOSTAT, 2019) [5]. Finger millet makes up about 12.5% of the approximately 32,554,127 hectares of millet cultivated worldwide. India is the world's top producer of finger millet, with Tamil Nadu (15%), Uttarakhand (10%), Andhra Pradesh (7.5%), and Karnataka contributing 53% of the nation's total production (Kumar, 2020) [9]. Finger millet occupies a distinct position in the market among millets and cereal grains due to its impressive nutritional profile, which includes significant amounts of micronutrients such as calcium, phosphorus, potassium, iron, and manganese (Ceasar *et al*., 2018) [2]. It is also high in dietary fibre, and phytochemicals, and is naturally gluten-free, offering potential health benefits with no known adverse effects (Shobana *et al*., 2013) [13]. Despite of all of its nutritional benefits, finger millet is still underutilised because of problems like threshing and milling difficulties, a lack of improved varieties, low adoption of new technologies, vulnerability to diseases like blast, problems with lodging and moisture stress, and a decrease in research interest (Wambi *et al*., 2021) [17]. In light of these considerations, the present study was conducted to thoroughly investigate the physico-chemical properties of finger millet by delving into its inherent characteristics, this research aims to provide a deeper understanding of finger millet's potential as a nutritious and versatile ingredient.

The study was done with the ultimate goal of promoting its wider adoption in food products and enhancing its contribution to food security and health.

Materials and methods

Material

The grains of VL-380 cultivar of *Eleusine coracana* L., often known as finger millet, were obtained from ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan in Almora, Uttarakhand. The grains were prepared for future use by cleaning, washing, and drying them for three hours at 50° C in a tray drier. They were then placed in airtight glass containers.

Methods

Bulk density, True density and porosity

The average bulk density was determined following the standard test weight procedure. Finger millet grains were carefully poured into a container from a fixed height, with the excess grains levelled off at the top. The total weight of the grains was then recorded. Bulk density was calculated. The average true density was measured using the toluene displacement method. The porosity of the sample was calculated using the relationship between bulk density and true density.

Angle of repose

The angle of repose was determined by allowing finger millet seeds to fall from a height forming a conical heap. The height and diameter of the resulting heap were measured, and the angle of repose (φ) was calculated.

Size of the grain

The size of the finger millet grains, including length, width, and thickness, was measured using a digital vernier caliper.

Thousand-grain weight

The thousand-grain weight, an important indicator of grain quality, was determined by randomly selecting and weighing 100 finger millet grains using an electronic balance

Hydration capacity and swelling capacity

The hydration characteristics and swelling characteristics were ascertained by weighing the 1000-finger millet seeds after a 24-hour soak in water. The difference in weight was calculated using the appropriate formula.

Proximate analysis

AOAC methods were used for the proximate analysis of the finger millet

Results

The word "grain quality" is an ambiguous term that means different things to different people and is often contingent upon the final application of the grain. Grain quality is determined by several factors, which can be divided into intrinsic and extrinsic factors that are indicated by the grain's chemical and physical characteristics.

Bulk density, true density and porosity

The various parameters depicting the physical properties of finger millet grains have been presented in Table 1. The bulk density, true density and porosity % of the finger millet grain were estimated around 773.57 kg/m^3, 1285.53kg/m^3 and 39.82%. The bulk density indicates the specific test weight which usually reduces with an increase in the degradation of grain. However, the bulk density obtained by Belhadi *et al*. (2013) [1] was 692.85 g for white sorghum and 736.55 g for red sorghum, the bulk density recorded was more than the data available which suggested that the grains under study were of good quality.

Physical properties

The l x b x h of the VL-380 grains determined were 0.19 x 0.16 x 0.18. The thousand grain weight of VL-380 cultivar finger millet grain was 2.56 g. However, Ramappa *et al*. (2011) [12] reported 1000 grains weight of GPU-28 was 3.39 g and 3.27 g for L-15 ragi. This is an indirect measure of the hardness of grain as hard grains are suitable for large-scale manufacturing because they may resist breaking during processing. Consequently, the grains can be utilised to produce starch on a huge scale. The difference in test weight could be due to difference in variety. The angle of repose determined in present study was 24.71 which was within the range reported by Ramappa *et al*. (2011) [12] as 17°-58′ for GPU-28 variety and 17°-31 for L-15 ragi variety of finger millet. The sphericity of finger millet grains was 0.0017.

Hydration and swelling capacity

The hydration and swelling capacity of the finger millet grain were reported as 65.41% and 47.88 % respectively. Hydration capacity of finger millets were lower than amaranth while higher than buckwheat grains as reported by Sindhu and Khatkar (2016a) [14]. The hydration index and swelling index of the grain was around 0.65 and 0.47 respectively. The observed values were in alignment with the values of hydration capacity of raw, malted and popped finger millet varieties ranged from 0.63 to 0.75, 1.15 to 1.81 and 0.51 to 0.69 respectively as reported by Hiremath & Geetha (2020) [17].

Table 1: Physical properties of finger millet grain

S. No.	Parameters	Value
1	Bulk density (kg/m^3)	773.57±4.68
2	True density (kg/m^3)	1285.53±4.41
3	Porosity %	39.82±0.55
4	Angle of repose (°)	24.71±0.37
5	Size l x b x h (mm)	(0.19±0.02 x 0.16±0.01 x 0.18±0.01)
6	Sphericity	0.0017±0.00
7	Thousand grain weight (g)	2.56±0.01
8	Hydration capacity (%)	65.41±1.05
9	Hydration capacity/seed (g)	0.001678±0.00
10	Hydration Index	0.65±0.01
11	Swelling capacity (%)	47.88±0.36
12	Swelling capacity / seed	0.0017±0.01
13	Swelling Index	0.47±0.0036

All the values expressed are (mean±SD) and n=3

Proximate analysis, mineral content and bioactive compounds

The cude protein, fat, fibre, ash and total carbohydrate estimated in VL-380 cultivar of finger millet were 6.7, 3.64, 3.4, 1.74 and 74.52%, respectively. The proximate composition by David *et al*. (2020) [3] revealed the presence of moisture 6.99%, ash 2.37%, crude protein 10.28%, crude fibre 3.10%, crude lipid 0.83% and carbohydrate 76.43%.

The protein content in finger millet was lower as compared with pseufocereals (Sindhu and Khatkar 2016b, 2016c) [15, 16]. The estimated values for calcium and iron was 320 mg/100 g and 4mg/100 g respectively. The calcium content of Vl-380 as reported by Joshi *et al*. (2020) [8] was 322.5 mg/100, which is in line with the values determined. Phytic acid determined in VL-380 from this study was 850 mg/100 g and the polyphenol content was 158 mg GAE/100 g. The determined value of phytic acid was also within the range reported by Makokha *et al*., (2002) [10] 851.6 mg/100 g DM in Ikhulule variety and 1,419.4 mg/100 g DM in EKR 227 variety.

Table 2: Chemical properties of finger millet grain

S. No.	Parameters	Value
1	Crude Protein (%)	6.7±0.48
2	Crude Fat (%)	3.64±0.25
3	Crude Fibre (%)	3.4±0.43
4	Total Ash Content (%)	1.74±0.23
5	Total Carbohydrate (%)	74.52±2.7
6	Calcium (mg/100 g)	320±10
7	Iron (mg/100 g)	4.0±0.38
8	Phytic Acid (mg/100 g)	850
9	Polyphenol (mg GAE/100 g)	158±4

All the values expressed are (mean±SD) and n=3

Conclusion

The present study comprehensively explored the physico-chemical properties of finger millet, specifically the VL-380 cultivar, to evaluate its potential as a nutritious and versatile food ingredient. The physical properties such as bulk density, true density, porosity, angle of repose, size, sphericity, and thousand grain weight were systematically measured, revealing the good quality of the grains. The bulk density was found to be 773.57 kg/m³, and the true density was 1285.53 kg/m³, indicating a high grain quality that resists degradation during processing. The grain's small size and high sphericity suggested suitability for large-scale processing, particularly in starch production. In terms of hydration and swelling capacities, finger millet grains exhibited values of 65.41% and 47.88%, respectively, indicating its potential for use in food products where moisture absorption is critical. The chemical analysis further reinforced the nutritional value of finger millet, with significant amounts of crude protein (6.7%), crude fat (3.64%), crude fiber (3.4%), and total carbohydrates (74.52%). The mineral content, particularly calcium (320 mg/100 g) and iron (4 mg/100 g), highlights its importance in addressing micronutrient deficiencies. Additionally, the presence of bioactive compounds such as phytic acid (850 mg/100 g) and polyphenols (158 mg GAE/100 g) points to finger millet's potential health benefits. Overall, the study underscores finger millet's valuable contribution to food security and health, advocating for its wider adoption in food products and further research to enhance its utilization and overcome existing challenges.

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