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Biochemical and nutritional profiling of finger millet genotypes

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Abstract
The present study was conducted on 15 genotypes of Finger millet collected from Hill Millet Research Station, NAU, Waghai, Dang, using a CRD design with three replications. Biochemical analysis of fifteen finger millet genotypes **(**WN-583, WN-586, WN-587, WN-599, WN-601, WN-609, WN-657, WN-664, WN-665, DN-6, CFMV-1, CFMV-2, GNN-6, GN-8, and GN-10**)** was conducted using seeds for six key parameters moisture, carbohydrate, protein, fat, fiber and ash content. Significant variability was observed among the genotypes for all traits studied. The observed ranges were 7.08 to 11.08% for moisture**,** 65.35 to 75.47% for carbohydrate, 4.15 to 6.35% for protein, 1.74 to 5.07% for fat**,** 2.74 to 3.97% for fiber and 2.25 to 4.53% for ash. In addition, mineral content was analyzed from the dry seed powder, calcium ranged from 0.25 to 0.38%, phosphorus from 0.16 to 0.29%, iron from 41.20 to 47.63 $mgkg^{-1}$ and zinc from 11.96 to 17.63 $mgkg^{-1}$. Among all fifteen finger millet genotypes CFMV-2 have good source of moisture (11.08%), protein (6.35%), fiber (3.97%), phosphorus (0.29%), iron (47.63 mg kg^{-1}) and zinc (17.63 mg kg^{-1}). WN-583 have higher carbohydrate (75.47%). CFMV-1 have higher fat content (5.07%). GN-10 have higher calcium content (0.38%) which is promote bone health.
The study highlights the existence of finger millet genotypes showed its potentiality to become source of health promoting food. It can be effectively utilized in breeding programs to enhance yield and quality in finger millet.

Keywords: Finger millet, zinc, protein and minerals

Introduction

Millets are one of the oldest foods known to humans and possibly the first among cereal grains to be cultivated for domestic purposes. Millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture. Millets are also unique due to their short growing season. Important millet crops grown in India are Sorghum (Jowar), Bajra (Pearl millet), Ragi (Finger millet) and small millets viz., Korra (Foxtail millet), Little millet, Kodo millet, Proso millet and Barnyard millet. such as foxtail millet (*Setaria italica*), finger millet (*Eleusine coracana*), pearl millet (*Pennisetum glaucum*), proso millet (*Panicum miliaceum*), kodo millet (*Paspalum scrobiculatum*), barnyard millet (*Echinochloa esculenta*) among others (Dwivedi *et al.* 2012) [8]. These were often referred to as coarse cereals but realizing the nutrient richness of the grains they are now gazetted as “Nutricereals” by Government of India. Millets are also rich in minerals like iron, magnesium, calcium, phosphorous and potassium. Finger millet is a domesticated cereal of African origin which spread in prehistory to Asia, also sometimes referred to as ragi (in India). It is a tetraploid species with a chromosome number of 2n = 36. The domestication of finger millet traces back to approximately 5000 years ago in the highlands of western Uganda and Ethiopia. From there, it spread to India nearly 3000 years ago, where it has since become an integral part of the agricultural and dietary systems (Raizada and Goron, 2015; Upadhyay *et al.*, 2007) [18, 19]. Millets are the backbone for dry land agriculture. They are hardy, resilient crops that have a low carbon and water footprint, can withstand high temperatures, grow on poor soils with little or no external inputs and are thus termed as the ‘miracle grains’ or ‘crops of the future’.It is an excellent source of protein (5-8%), minerals (2.5-3.5%) like calcium (344 mg 100 g^{-1}, which is 8-10 times higher calcium than wheat or rice). It has iron and amino acid (methionine, an amino acid lacking in the diets of hundreds of millions 4 of the poor who live on starchy foods such as cassava, plantain, polished rice and maize meal) ether extractives (1-2%), dietary fiber (15-20%) and carbohydrates (65-75%). The year 2023 has been earmarked by the United Nations as the "International Year of Millets" and presents a unique opportunity to highlight the importance of millets as a nutritious and climate-resilient food.

Finger millet carbohydrates are reported to have the unique property of slower digestibility. The excellent malting qualities have added to the uniqueness of the grain in expanding its utility range in food processing and value addition. Adapted predominantly to tropical, rainfed conditions, finger millet is highly suitable for dryland farming due to its exceptional tolerance to drought and adverse environmental conditions. It thrives in a wide range of altitudes, particularly performing better at higher elevations than most other tropical cereals. This resilience is attributed to its diverse set of morpho-physiological, molecular and biochemical traits that confer enhanced tolerance to both biotic and abiotic stresses, making it a crucial crop for food security in marginal environments. Its consumption has been linked to improved management of blood glucose levels, reduction of cholesterol and prevention of constipation due to its high soluble fiber content and low-fat levels (Hittalmani, 2004) [10]. The presence of tryptophan, an essential amino acid, contributes to appetite control by promoting satiety, thereby aiding in weight management (Mall and Tripathi, 2016) [14]. Its slow digestibility also helps regulate calorie intake and maintain a steady release of glucose, offering significant health benefits over more rapidly digestible cereals.

Materials and Methods

The experiment was conducted on the 15 genotypes of finger millet, which were collected from Hill Millet Research Station (HMRS), Navsari Agricultural University, Waghai, Dangs. Biochemical parameters like moisture, carbohydrate, protein, fat, fiber and ash content were recorded from seed samples with three repetitions for each genotype (50g x 3). Moisture analysis was done from mature seeds after harvesting according to the method described by Association of Official Analytical Chemists (AOAC) (1999) [5]. Total carbohydrate was analysed spectrophotometrically by anthrone method as described by Hedge and Hofreiter (1962) [9]. Protein analysis was done by micro-Kjeldahl method as described by Kundgol *et al.* (2014) [13] with minor modifications.Total fat content of the sample was determined as per the procedure laid by AOAC (1984) [4]. Fibre estimation was carried out according to the method described by Maynard (1970) [15]. Ash analysis was carried out following the method described by Dangeti *et al.* (2013) [7].

Mineral analysis: Micronutrients (Fe and Zn) were estimated by the modified method described by Jackson (1967) [11]. Determination of calcium from finger millet seed samples were done by using Versanate (EDTA) titration method as described by Cheng and Bray (1951) [6]. Phosphorus estimation was done by using spectrophotometer following the method described by Jackson (1967) [11].

Following 15 genotypes of finger millet (Photo.1) were used in this experiment

Sr. No.	Genotypes	Sr. No.	Genotypes
1.	WN-583	9.	WN-665
2.	WN-586	10.	DN-6
3.	WN-587	11.	CFMV-1 (NC)
4.	WN-599	12.	CFMV-2 (NC)
5.	WN-601	13.	GNN-6 (LC)
6.	WN-609	14.	GN-8 (LC)
7.	WN-657	15.	GN-9 (LC)
8.	WN-664		

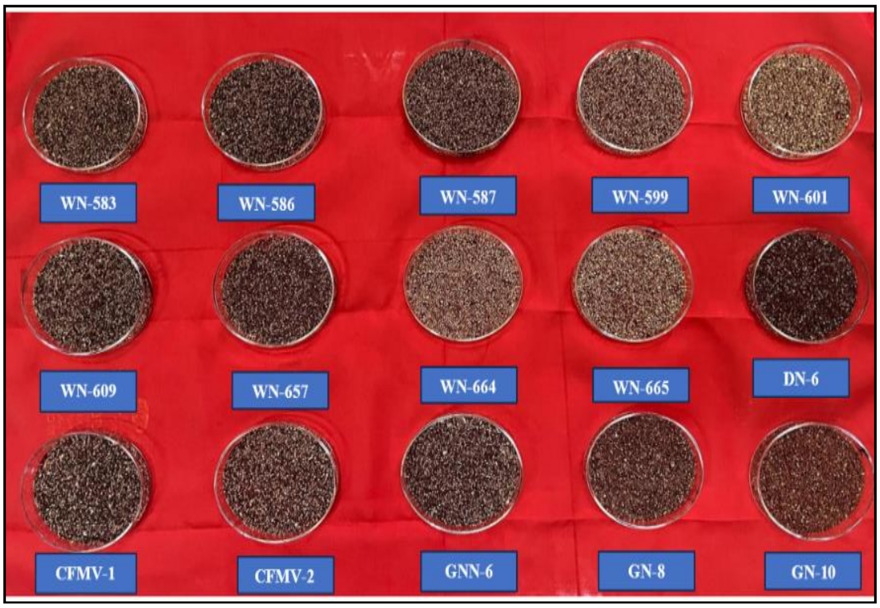

Photo 1: Seeds of finger millet genotypes

Photo 2: Overview of experimental field

Result and Discussion

Proximate a analysis of Finger Millet Genotypes

Moisture (%)

Moisture content was observed in the range of 7.08 to 11.08%, presenting a significant difference (Table 1). Maximum moisture content was observed in CFMV-2 (11.08%) and minimum moisture content was observed in WN-609 (7.08%). Moisture content determines the shelf life and milling characteristics of the grains. Lower the moisture content, higher the shelling percentage and length of shelf life of grains (Kamatar *et al.* 2015) [12].

Carbohydrate (%)

Carbohydrate content among the 15 finger millet genotypes ranged from 65.35% to 75.47% (Table 1). The highest carbohydrate content was recorded in WN-583 (75.47%), whereas the lowest was observed in WN-586 (65.35%). Carbohydrates serve as a primary source of quick energy for the human body. Although millets are rich in carbohydrates, their carbohydrate content is relatively lower compared to staple cereals like rice and wheat (Kamatar *et al.*, 2015) [12].

Protein (%)

Protein content was found in the range from 4.15 to 6.35% and it showed significant variation among the genotypes (Table 1). Highest protein content was recorded in CFMV-2 (6.35%) whereas lowest protein in WN-609 (4.15%). Similarly, Proximate analysis of finger millet genotypes revealed protein ranged 6.7-8.0% and the present findings are consistent with Nakarani *et al.* (2021) [16].

Fat (%)

Fat content among the finger millet genotypes ranged from 1.74% to 5.07% (Table 2). The highest fat content (5.07%) was recorded in CFMV-1 whereas the lowest fat content (1.74%) was observed in WN-586. Proximate composition of crude fat from 4.67 to 7.10%was similarly to observations of Njoku *et al.* (2025) [17].

Fiber (%)

Fiber content ranged between 2.74 and 3.97% (Table 2). The highest fiber content was recorded in WN-587 and CFMV-2 (3.97%). WN-599 (2.74%) recorded the lowest fiber among all the genotypes. This result corroborating the earlier findings of Njoku *et al.* (2025) [17].

Ash (%)

Ash content ranged from 2.25 to 4.53% (Table 2). The highest ash content was recorded in CFMV-2 (4.53%). WN-665 (2.25%) recorded the lowest ash content among all the genotypes. The ash content of a biological material provides an indication of the total inorganic matter present in the sample after the organic matter is completely burned off (Abubakar *et al.* 2015) [1]. It's an important source of minerals essential for all physiological functions (Anon. 2021) [2].

Mineral analysis of Finger-Millet Genotypes

Calcium (%)

Calcium content ranged from 0.25 to 0.38% (Table 3). The highest calcium content was recorded in GN-10 (0.38%). WN-601 (0.25%) has recorded the lowest calcium content among all the genotypes. Similar results were reported earlier by Njoku *et al.* (2025) [17] mineral compositions showed that calcium ranged from 351.65 to 366.17 mg/100g. Calcium is the most abundant mineral in the body, essential for building and maintaining strong bones and teeth, muscle movement, neural communication, blood circulation and hormone release. Vitamin D is crucial for calcium absorption in the body Anonymous (2023c) [2].

Phosphorus (%)

Phosphorus content among the finger millet genotypes ranged from 0.16% to 0.29% (Table 3). The highest phosphorus content (0.29%) was recorded in the genotype CFMV-2 and GN-8, while the lowest phosphorus content (0.16%) was observed in genotypesDN-6.Phosphorus is a vital mineral necessary for the formation and maintenance of bones, teeth, DNA and RNA. It plays essential roles in cell membrane formation, energy production (ATP), protein, sugar phosphorylation, gene transcription regulation, enzyme activation, pH balance, and intracellular energy storage **(**Anonymous, 2023c) [2].

Iron (mg kg^{-1})

Iron content ranged between 41.2 to 47.63 mg kg^{-1}(Table 3).The highest iron content was recorded in CFMV-2 (47.63 mg kg^{-1}) while WN-586 (41.2 mg kg^{-1}) recorded lowest iron content among all the genotypes Iron is crucial for red blood cell production, cellular energy metabolism and proper functioning of immune system. Iron deficiency leading to anaemia remains the most prevalent nutrient disorder globally (Weyh *et al.* 2022) [20].

Zinc (mg kg^{-1})

Zinc content among the finger millet genotypes ranged from 11.96 to 17.63 mg/kg (Table 3). The highest zinc content (17.63 mg/kg)was recorded inCFMV-2, while the lowest zinc content (11.96 mg/kg) was observed in WN-586.Similar results were also observed zinc content (12.40-17.45 mg/kg) by Nakarani *et al.* (2021) [16].

Table 1: Moisture, Carbohydrate and Protein content of finger millet genotypes

Sr. No.	Genotypes	Moisture (%)	Carbohydrate (%)	Protein (%)
1.	WN-583	8.53	75.47	4.85
2.	WN-586	9.72	65.35	5.14
3.	WN-587	10.38	65.75	4.75
4.	WN-599	9.04	69.87	5.10
5.	WN-601	7.96	72.67	5.20
6.	WN-609	7.08	71.52	4.15
7.	WN-657	8.45	69.50	5.35
8.	WN-664	10.08	73.55	4.77
9.	WN-665	9.54	68.22	4.25
10.	DN-6	9.78	70.66	5.65
11.	CFMV-1	9.08	72.48	4.63
12.	CFMV-2	11.08	74.37	6.35
13.	GNN-6	9.06	70.32	4.83
14.	GN-8	7.76	70.67	4.74
15.	GN-10	9.39	74.04	5.80
	Mean	0.91	1.09	0.72
	S.Em. ±	0.17	1.32	0.24
	CD at 5%	0.49	3.81	0.35
	CV (%)	3.24	3.22	4.12

Table 2: Fat, Fiber and Ash content of finger millet genotypes

Sr. No.	Genotypes	Fat (%)	Fiber (%)	Ash (%)
1.	WN-583	4.11	3.90	2.93
2.	WN-586	1.74	3.06	2.34
3.	WN-587	3.34	3.97	4.15
4.	WN-599	4.78	2.74	3.55
5.	WN-601	2.46	3.84	3.73
6.	WN-609	4.71	3.76	4.06
7.	WN-657	3.91	3.84	2.34
8.	WN-664	2.57	3.76	3.13
9.	WN-665	1.91	3.84	2.25
10.	DN-6	2.94	3.65	3.12
11.	CFMV-1	5.07	3.9	2.45
12.	CFMV-2	3.96	3.97	4.53
13.	GNN-6	3.2	3.32	3.45
14.	GN-8	3.28	3.93	3.83
15.	GN-10	3.87	3.87	3.22
	Mean	1.06	1.00	0.91
	S.Em. ±	0.19	0.089	0.09
	CD at 5%	0.56	0.26	0.27
	CV (%)	9.74	4.41	5.03

Table 3: Mineral content of finger millet genotypes

Sr. No.	Genotypes	Calcium (%)	Phosphorus (%)	Iron (mg kg^{-1})	Zinc (mg kg^{-1})
1.	WN-583	0.33	0.18	45.48	14.20
2.	WN-586	0.31	0.17	41.20	11.96
3.	WN-587	0.32	0.28	45.04	12.87
4.	WN-599	0.35	0.23	45.08	12.45
5.	WN-601	0.25	0.22	43.73	15.55
6.	WN-609	0.27	0.23	43.61	15.38
7.	WN-657	0.27	0.27	45.18	16.32
8.	WN-664	0.35	0.17	46.17	16.16
9.	WN-665	0.30	0.28	44.65	17.24
10.	DN-6	0.28	0.16	43.78	13.57
11.	CFMV-1	0.33	0.17	45.86	15.89
12.	CFMV-2	0.37	0.29	47.63	17.63
13.	GNN-6	0.32	0.28	43.84	14.05
14.	GN-8	0.34	0.29	42.5	16.12
15.	GN-10	0.38	0.26	44.01	15.60
Mean		0.876	0.683	1.033	0.893
S.Em. ±		0.007	0.0092	0.522	0.720
CD at 5%		0.020	0.0266	1.508	2.080
CV (%)		3.94	6.87	2.03	8.31

Conclusion

The study revealed that the integration of biochemical and molecular markers can be effectively employed to characterize and study genetic diversity among finger millet genotypes. The combined use of proximate and mineral analysis further supports the nutritional superiority of finger millet. The findings of this study can be effectively utilized by finger millet breeders and researchers for the development of nutrient-rich varieties and for advancing genetic improvement programs aimed at enhancing both productivity and nutritional quality in finger millet.

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