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Assessment of Finger Millet Germplasm in Relation to Nutritional Perspective

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ABSTRACT

Background: Finger millets serve as a major food in resource-poor countries of Asia and Africa by providing 75% of total calorie intake next to fine cereal grains and gluten-free cereal products. Finger millet an ideal crop for use as a staple food and for famine reserve. The crop has dual importance as source of food grain as well as straw for fodder.

Methods: Thirty one finger millet germplasm with four checks obtained from AICRP on Small Millets, Zonal Agricultural Research Station, Kolhapur and used in this investigation.

Result: Proximate composition and mineral content analyses revealed significant variations in crude protein (6.23-7.76%), crude fiber (2.30-3.55%) and ash ranging from (1.83-2.77%). calcium content ranged from (273-380 mg/100 g), magnesium content observed (142-193 mg/100 g). Highest iron content observed in KFMG 2266 with 4.33 mg/100 g, zinc content ranged from (2.13-2.98 mg/100 g) and highest phosphorus content recorded in KFMG 2261 with 268 mg/100 g.

Key words: Finger millet, Germplasm, Mineral, Nutritional content, Proximate composition.

INTRODUCTION

Finger millet (*Eleusine coracana* L.) is commonly known as “ragi” in India. The ragi word is originated from a Sanskrit *raga* meaning red (Gull *et al.*, 2016). It is well adapted in where rainfall is high about (600-1200 mm) and particularly in southern part of Indian states(Chowdary and Bisarya, 2020). This can be grown in almost all types of soils and climatic conditions.The major finger millet growing states in India are Karnataka, Uttarkhand, Tamil Nadu, Andhra Pradesh, Odhisha, Jharkhand and Maharashtra (MOA and FW 2024). Finger millet cultivated area in India is 10.37 lakh ha. Production of finger millet in India is 13.86 lakh tones and yield 1335 kg/ha. In Maharashtra cultivated area of finger millet 0.70 lakh ha. Production of finger millet in Maharashtra is 0.88 lakh tones and yield 1251 kg/ha (APEDA 2023-2024).

Finger millet was found to be a rich source of nutritional components. It contains 9.70% of moisture, 9.10% of crude protein, 1.20% of crude fat, 3.10% of ash content (Jan *et al.*, 2022). Finger millet is an ideal crop for use as a staple food and famine reserve. The crop has dual importance as source of food grain as well as straw for fodder. Finger millet is a rich source of calcium (344 mg/100 g) which is 5 to 30 times more than in most cereals, making it the richest plant source (Gupta *et al.*, 2017). Calcium helps in keeping bones and teeth healthy. It has higher dietary fiber, minerals and sulphur containing amino acids compared to white rice, the current major staple in India (Shobana *et al.*, 2013). Finger millet is rich source of micronutrients like iron, magnesium, sodium, phosphorus, copper and potassium. Phosphorus, present in finger millet contributes to the development of body tissue and energy metabolism (Vanithasri *et al.*, 2012; Ramashia *et al.*, 2018) with concentration of Phosphorus in finger millet ranging from 130.0-283.0 mg/100 g. Other minerals present in finger millet grains include iron with a concentration of 3-20% (Rajiv *et al.*, 2011; Shukla and Srivastava, 2014) and magnesium implicated for the reduction of high blood pressure, severity of asthma, frequency of migraines and the risk of heart attack (Saleh *et al.*, 2013; Verma and Patel, 2013; Prashantha and Muralikrishna, 2014). In comparison with other millet species, finger millet grains are more nutritious (Devi *et al.*, 2014; Dlamini and Siwela, 2015) with higher mineral content and proximate composition. Finger millet also contains vitamins which are required by the human body for regular functioning and self-maintenance. Finger millet grain possesses water and fat soluble vitamins and rich in thiamine, niacin, riboflavin and tocopherol (Purma and Soni, 2024).

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MATERIALS AND METHODS

Germplasm collection

Finger millet germplasm included 31 germplasms with four checks in the investigation were obtained from AICRP on Small Millets, Zonal Agricultural Research Station, Kolhapur.

Proximate composition

Proximate composition of finger millet germplasm such as crude protein, crude fiber, ash, crude fat and moisture were estimated by using standard method AOAC (2000).

Minerals content

Micronutrients such as Mg, Ca, Zn and Fe in the digested sample were estimated by using the atomic absorption spectrophotometer. For determination of phosphorus 1.0 g of defatted sample was digested with di-acid mixture (HNO_3+ HCl) in the ratio of 9:4 and acid extract were used for determination of other micronutrients. Phosphorus was determined by using a known quantity of di-acid extract as mentioned above and the yellow color was developed with combined HNO_3 vanadomalayaite reagent. Phosphorus was determined calorimetrically by using a spectrophotometer at 420 nm wavelength.

Phenolic compounds

Phenol content was estimated by the method suggested by Bray and Thorpe (1954). Phenols react with phosphomolybdic acid in Folin-Ciocalteau's reagent in alkaline medium and produce blue colored complex (molybdenum blue). Tannin content in defatted finger millet was estimated by the Folin-Denis method. This is based on the non-stoichiometric oxidation of molecules containing a phenolic hydroxyl group.

All nutritional and proximate analysis was carried out at Laboratory, Department of Biochemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri during the period March 2024 to July 2024.

RESULTS AND DISCUSSION

Proximate composition

Crude protein content (%)

Finger millet, with its protein content, can support these functions, contributing to better health and well-being.Crude protein content variation of thirty- five finger millet germplasm were evaluated and presented crude protein content ranged from 6.23% to 7.76% with a mean value of 7.11% (Table 1). Highest crude protein content recorded in germplasm KFMG 2236 (7.76%) followed by KFMG 2262 (7.69%).

Crude fiber content (%)

The fiber in finger millet can help in the slower absorption of carbohydrates, leading to more stable blood sugar levels. This can be particularly advantageous for people with diabetes or those at risk of developing diabetes.Crude fiber content of thirty-five finger milletgermplasm ranged from 2.30% to 3.55% with a mean value of 2.95%. Highest crude fiber content was observed in germplasm KFMG 2261 (3.55 %) followed by germplasm KFMG 2264 (3.50%). Lowest crude fiber content was recorded in germplasm KFMG 2231 (2.30 %).

Crude fat (%)

While finger millet is not extremely high in fat, the fat it does contain contributes to the overall energy content of the grain. Crude fat content of thirty -five finger millet germplasms are revealed that crude fat content ranged from 1.74 to 2.13% with an average value of 1.92%. Highest crude fat content recorded in KFMG 2270 (2.13%) and lowest in KFMG 2262 (1.74%) (Table 1).

Ash (%)

The ash content can be an indicator of the quality of the grain. Ash content reflects the total mineral content of the grain, including essential minerals such as calcium, iron, magnesium, potassium and phosphorus. These minerals are vital for various bodily functions, including bone health, oxygen transport, muscle function and electrolyte balance. Ash content of thirty-five finger millet germplasm ranged from 1.83% to 2.77% with the mean value of 2.34%. Highest ash content was recorded in KFMG 2233 (2.77%)followed by KFMG 2237 (2.73%) and KFMG 2272 (2.73%). The lowest ash content was observed in KFMG 2251 (1.83%) (Table 1).

Moisture (%)

Moisture content is one of the critical factors determines the shelf life of germplasm. The moisture content of thirty-five finger millet germplasm ranged from 8.05 to 10.64 per cent with a mean value of 9.66 per cent. Among finger millet germplasm highest moisture content was observed in KFMG 2232 (10.64%) while lowest moisture content was observed in KFMG 2251 (8.50%) (Table 1).

Mineral content

Calcium content (mg/100 g)

Calcium is essential for muscle contraction and overall muscle function. Adequate calcium intake helps maintain normal muscle function and prevents issues like muscle cramps and spasms.The calcium content of thirty -five finger millet germplasm was ranged from 273 to 383 mg/100 g with a mean value of 345.85 mg/100 g. Among all thirty- five finger millet germplasm highest calcium content was observed in KFMG 2233 (383 mg/100 g). Lowest calcium content was observed in the germplasm KFMG 2258 (273 mg/100 g). Among the check varieties Phule Kasari and Dapoli-3 recorded 375 and 374 mg/100 g grain calcium content respectively.

Magnesium content (mg/100 g)

Magnesium content of thirty- five finger millet germplasm were ranged from 142 to 193 mg/100 g with a mean value of 159.34 mg/100 g. Lowest magnesium content was recorded in germplasm KFMG 2239 (142 mg/100 g) and highest magnesium content observed in germplasm KFMG 2262 (193 mg/100 g). Phule Nachani and Phule Kasari check finger millet varieties recorded 167 and 156 mg/100 gm magnesium content respectively (Table 2).

Phosphorus content (mg/100 g)

Phosphorus content of thirty -five finger millet germplasm were ranged from 141 to 303 mg/100 g with a mean value of 220.51 mg/100 g. Highest phosphorus content was recorded

Table 1: Proximate composition of finger millet germplasm.

Name of germplasm	Moisture (%)	Ash (%)	Crude Fat (%)	Crude fiber(%)	Crude protein(%)
KFMG 2231	10.22	2.50	2.00	2.30	6.89
KFMG 2232	10.64	2.18	1.85	2.55	7.44
KFMG 2233	9.76	2.77	1.96	3.20	7.22
KFMG 2234	9.40	2.20	1.74	3.10	6.78
KFMG 2235	10.45	2.47	1.90	3.05	7.26
KFMG 2236	10.30	2.68	2.05	3.30	7.76
KFMG 2237	10.28	2.73	1.92	2.45	6.56
KFMG 2239	10.20	2.43	2.10	3.15	7.30
KFMG 2247	10.41	2.27	1.89	2.35	7.28
KFMG 2251	8.50	1.83	1.80	2.90	7.66
KFMG 2252	9.86	2.47	2.02	2.45	6.78
KFMG 2253	9.61	2.00	1.79	3.45	6.99
KFMG 2259	10.02	1.86	1.94	3.20	7.00
KFMG 2260	9.63	2.33	1.88	3.25	6.81
KFMG 2261	10.15	2.40	2.08	3.55	6.23
KFMG 2262	10.23	2.66	1.78	3.05	7.69
KFMG 2263	10.16	2.53	1.90	3.45	6.80
KFMG 2264	9.26	2.00	1.76	3.50	7.03
KFMG 2265	9.65	2.37	2.08	2.55	6.34
KFMG 2266	9.73	2.33	1.76	3.15	7.05
KFMG 2267	8.95	2.53	2.00	2.95	6.59
KFMG 2268	8.91	2.07	1.94	3.35	6.78
KFMG 2269	10.00	2.33	1.98	2.45	6.75
KFMG 2270	10.43	2.43	2.13	2.60	7.64
KFMG 2271	9.29	2.37	2.03	2.30	7.22
KFMG 2272	9.94	2.73	2.00	2.55	7.63
KFMG 2273	9.44	2.43	1.84	2.40	6.80
KFMG 2274	9.01	2.67	1.80	3.45	7.00
KFMG 2275	8.88	2.23	1.92	3.35	7.68
KFMG 2276	8.94	1.87	1.82	3.30	7.46
KFMG 2258	9.12	1.93	2.00	3.40	7.66
Phule Nachani (ch)	9.36	2.17	1.92	3.30	7.19
Phule Kasari (ch)	8.91	2.33	1.84	2.65	7.62
Dapoli - 3 (ch)	9.20	2.43	1.80	2.85	7.01
GPU 67 (ch)	9.24	2.35	2.06	2.45	6.89
Range	8.5-10.64	1.83-2.77	1.74-2.13	2.30-3.55	6.23-7.76
Mean	9.66	2.34	1.92	2.95	7.11
SE ±	1.15	0.08	0.10	0.13	0.10
CD at 5 %	3.24	0.22	0.30	0.38	0.29

in germplasm KFMG 2261 (268 mg/100 g) followed by KFMG 2236 (260 mg/100 g). Lowest phosphorus content was recorded in germplasm GPU 67 (141 mg/100 g). Among the check varieties Phule Nachani and Phule Kasari recorded 230 and 202 mg/100 gm phosphorus content respectively (Table 2).

Iron content (mg/100 g)

Iron content of thirty-five finger millet germplasm were ranged from 3.03 to 4.33 mg/100 g with a mean value of 3.84 mg/100 g. Highest iron content in germplasm KFMG 2266 (4.33 mg/100 g) and lowest iron content in germplasm KFMG 2268 (3.03 mg/100 g). Phule Kasari check variety recorded 4.23 mg/100g iron content (Table 2).

Zinc content (mg/100 g)

Zinc is essential for a healthy immune system. It supports the function of various immune cells and is involved in the body's defense against infections and inflammation. Zinc content of thirty-five finger millet germplasm with a mean value of 2.66 mg/100 g were ranged from 2.13 to 2.98 mg/100 g. Highest zinc content observed in germplasm KFMG 2251 (2.98 mg/100 g) followed by KFMG 2236 (2.95). Lowest zinc content recorded in germplasm KFMG 2271 (2.13 mg/100 g). Among the check varieties Phule Nachani and Dapoli-3 recorded 2.73 and 2.70 mg/100 g zinc content respectively (Table 2).

Phenolic compounds content

Phenol content

Among the thirty- five germplasm phenol content of KFMG 2266 and KFMG 2261 was found significantly higher than check varieties. A significant variation ranging from 162 to 281 mg/100 g and lower phenol content was found in

Table 2: Mineral content of finger millet germplasm.

Name of germplasm	Calcium (mg/100 g)	Magnesium (mg/100 g)	Phosphorus (mg/100 g)	Iron(mg/100 g)	Zinc(mg/100 g)
KFMG 2231	364	173	249	3.38	2.93
KFMG 2232	378	160	255	3.88	2.75
KFMG 2233	383	148	225	4.05	2.60
KFMG 2234	355	150	253	4.13	2.80
KFMG 2235	280	145	234	4.00	2.58
KFMG 2236	335	149	260	3.95	2.95
KFMG 2237	343	144	198	3.75	2.50
KFMG 2239	366	142	230	3.25	2.95
KFMG 2247	305	165	189	4.08	2.85
KFMG 2251	343	179	170	4.08	2.98
KFMG 2252	368	184	180	3.63	2.81
KFMG 2253	380	151	174	3.28	2.58
KFMG 2259	298	180	192	4.20	2.60
KFMG 2260	314	148	219	4.25	2.78
KFMG 2261	373	146	268	4.23	2.80
KFMG 2262	355	193	210	3.78	2.60
KFMG 2263	375	189	192	3.93	2.53
KFMG 2264	378	170	244	3.25	2.40
KFMG 2265	313	145	254	3.73	2.65
KFMG 2266	280	155	225	4.33	2.70
KFMG 2267	380	159	252	3.88	2.50
KFMG 2268	369	158	249	3.03	2.63
KFMG 2269	376	153	231	4.03	2.93
KFMG 2270	346	156	245	3.95	2.83
KFMG 2271	293	159	256	3.88	2.13
KFMG 2272	374	190	234	4.03	2.58
KFMG 2273	363	144	247	4.08	2.48
KFMG 2274	375	144	210	3.53	2.63
KFMG 2275	303	145	150	3.73	2.33
KFMG 2276	298	178	250	3.23	2.58
KFMG 2258	273	148	210	4.00	2.53
Phule Nachani (ch)	372	167	230	3.93	2.73
Phule Kasari (ch)	375	156	202	4.23	2.68
Dapoli - 3 (ch)	374	154	190	3.90	2.70
GPU 67 (ch)	348	150	141	3.95	2.65
Range	273-383	142-193	141-268	3.03-4.33	2.13-2.98
Mean	345.85	159.34	220.51	3.84	2.66
SE ±	0.22	0.40	1.14	0.22	0.27
CD at 5%	0.63	1.14	3.22	0.61	0.76

KFMG 2270. Average value of phenol content was 228.48 mg/100 g.

Tannin content

A wide range of tannin content from 240 to 413 mg/100 g. was found in finger millet germplasm with average tannin content of 317.34 mg/100 g. KFMG 2260 germplasm showed highest tannin content and lowest content was found in KFMG 2270 (Table 3).

Sireesha (2023) evaluated finger millet germplasm observed crude fat content with 1.3% and similar results were observed that crude protein content in was 7.3%. The results were in agreement with Dida and Kebero (2023) examined chemical composition of finger millet observed moisture content in the range of 7.15-13.1 per cent and crude protein content was recorded 7.7 g/100 g. Pandey *et al.* (2024) evaluated finger millet germplasm observed crude fat with 1.5%, crude protein with 7.7%, Iron with 3.9 mg/100 g, calcium with 350 mg/100 g and zinc with 2.3 mg/100 g. Karki *et al.* (2020) reported a similar result in finger millet with total ash content is in the range of 1.7 to 4.13 per cent which is higher than any other commonly consumed cereal grains. Similar results were stated by Jagati *et al.* (2021) in which ash content in finger millet was recorded 3 g/100 g. Gull *et al.* (2016) observed crude fiber in finger millet with 3.6 %. Similar results were reported that crude fiber content in finger millet germplasm was 3.6% (Kumar *et al.*, 2016). As reported by Patil *et al.* (2019) it was observed narrow range of crude fiber content in finger millet germplasm and recorded with range from 3.68 per cent to 4.15 per cent.

Kumar *et al*. (2016) reported calcium content 360 mg/ 100 g in finger millet germplasm. As documented earlier finger millet is the richest source of calcium contains about 0.34% as compared with 0.01-0.06% in most other cereals (Kumar *et al*., 2018; Gupta *et al*., 2017). The results were in agreement with those obtained by Hiremath*et al*.(2018) that the finger millet has the highest calcium content among all cereals (344 mg/100 g). Similar results observed that calcium content in finger millet was 398 mg/100 g by Jagati *et al*. (2021). The values found similar trend of calcium content in finger millet germplasm was 137.33 mg/100 g by Sireesha Y., (2023). These results are close conformity with observation obtained by Pandey *et al*. (2024) with calcium content in finger millet was 350 mg/100 g.

Similar results were reported regarding magnesium content of finger millet germplasm in the study ranged from 143.24 to 192.94 mg/100 g with little variation by Hiremath *et al*.(2018). The magnesium content in finger millet germplasm ranged from 0.55 to 0.90 per cent recorded by Patil*et al*.(2019). These results are close conformity with observation obtained by Jagati *et al*. (2021) found that magnesium content in finger millet was 137 mg/100g. The results were in the accordance with magnesium content highest in finger millet with 287 mg/100gobtained by Shahi and Singh (2022). As documented earlier different minerals present in finger millet among which magnesium content recorded 137 mg/100 g by Pandey *et al.* (2024).

Kumar *et al*. (2016) highlighted from their study that phosphorus content in finger millet was 283 mg/100g. Similar results obtained that phosphorus content in finger millet was ranged from 130-250 mg/100 g (USDA 2016). Similar trends in the results were observed in phosphorus content to 250 mg/100 g in finger millet and in rice 160 mg/ 100 g by Gull *et al.* (2016). These results are close conformity with observation obtained by Patil *et al.* (2019) concluded that narrow range of phosphorus content was observed in thirtyseven genotypes of finger millet. The phosphorus content ranged from 2.69 to 2.77 per cent among all the genotypes and highest value of phosphorus content observed 2.77 percent. The results were in agreement with Jagati *et al.* (2021) obtained phosphorus content in finger millet with 320 mg/100 g. Indian farming (2023) reported phosphorus content in finger millet 210 mg/100 g. As documented earlier by Sireesha Y., (2023) phosphorus content in finger millet was 158.43 mg/100 g. Similar trends in the results were reported with phosphorus content in finger millet was 283 mg/100 g by Pandey *et al.* (2024).

Gull *et al.* (2016) recorded similar trends in the finger millet results and observed iron content 6.3 mg/100 g. These results are close conformity with observation reported by Muthamilarasan *et al*.(2016) with iron content in finger millet ranged from 2.12 to 3.19 mg/100 g. Iron content in finger millet germplasm was recorded with 3.9 mg/100g by Kumar *et al*. (2016). The results were in agreement with those obtained by Patil *et al*. (2019) that iron content was observed in thirty seven genotypes of finger millet and ranged from 46.10 ppm to 105.03 ppm among all the genotypes. Similar results were previously reported with finger millet germplasm for mineral contents observed iron content in white colour grains 5.17 mg/100 g and in light brown colour grains 7.65 mg/100 g by Ojulong *et al.* (2021). As documented earlier finger millet recorded zinc content 2.3 mg/100 g by Kumar *et al.* (2016). Zinc content in finger millet was ranged from 1.44 to 2.31 mg/100 g recorded by Muthamilarasan *et al.* (2016). Similar results were previously reported by Patil *et al*. (2019) with zinc content observed in thirty seven genotypes of finger millet and ranged from 43.33 ppm to 64.32 ppm among the genotypes. The results were in agreement with those observed by Jagati *et al.* (2021) with zinc content in finger millet was 2.3 mg/100 g. These results are close conformity

Table 3: Phenol and tannin content in finger millet germplasm.

Name of germplasm	Phenol content (mg/100 g)	Tannin content (mg/100 g)
KFMG 2231	270	378
KFMG 2232	267	362
KFMG 2233	263	347
KFMG 2234	263	349
KFMG 2235	260	344
KFMG 2236	265	353
KFMG 2237	240	308
KFMG 2239	262	345
KFMG 2247	243	309
KFMG 2251	227	290
KFMG 2252	257	335
KFMG 2253	273	386
KFMG 2259	274	389
KFMG 2260	281	413
KFMG 2261	277	398
KFMG 2262	201	287
KFMG 2263	177	273
KFMG 2264	177	271
KFMG 2265	188	275
KFMG 2266	198	281
KFMG 2267	169	261
KFMG 2268	255	321
KFMG 2269	256	332
KFMG 2270	162	240
KFMG 2271	206	294
KFMG 2272	204	289
KFMG 2273	213	299
KFMG 2274	183	275
KFMG 2275	196	277
KFMG 2276	274	390
KFMG 2258	191	278
Phule Nachani (ch)	208	297
Phule Kasari (ch)	183	307
Dapoli - 3 (ch)	224	284
GPU 67 (ch)	210	270
Range	162-281	240-413
Mean	228.48	317.34
SE ±	1.41	1.32
CD at 5 %	3.98	3.72

with observation reported by Shahi *et al.* (2023) that zinc content was in finger millet 2.7 mg/100 g. Similar trends in the results were observed by Pandey *et al.* (2024) with 2.3 mg/100 g zinc content in finger millet.

Ramachandra *et al.* (1977) observed white grain varieties have very low phenol levels as compared with the brown and dark brown varieties (white, 0.05%; brown, 0.61%). Similar results were previously reported by Kazi *et al*. (2022), phenolic content was in finger millet landraces ranged from 355.33 mg/100 g. T_2 landraces being white showed fewer amounts (355.33 mg/100 g) while red to brown colour landraces possess high phenolic content. Kazi *et al*. (2024) Obtained results revealed that T1, T19 and T29 have the highest fractionations of phenol compounds in finger millet.

These results are close conformity with by Parida *et al*. (1989) reported that the white grain varieties of ragi had very low phenol and tannin levels when compared with brown varieties and investigated the tannin content of ragi from 0.04 to 3.47 per cent also highest amount of tannins (3.42% - 3.47%) was found in two African varieties.These results are similar to the values reported by Panwar *et al*. (2016) in finger millet germplasm tannin content ranged from 2.05 to 2.62 mg TAE/g.

CONCLUSION

Based on above results it can be concluded that KFMG 2236, KFMG 2272, KFMG 2270 and KFMG 2233 found superior for ash, crude protein, crude fiber and low-fat content. In case of mineral composition germplasm KFMG 2232, KFMG 2233, KFMG 2266 and KFMG 2274 recorded maximum mineral content which are good for health perspective. Out of thirty-five finger millet germplasm studied KFMG 2236, KFMG 2272, KFMG 2270, KFMG 2232, KFMG 2233 and KFMG 2266 showed overall superiority for nutritional and health perspective. Among the finger millet check varieties Phule Kasari and Dapoli-3 recorded superior proximate composition, mineral content and phenol compounds. Assessing the proximate composition and mineral composition in enhanced finger millet germplasm is crucial for understanding their nutritional value, agronomic potential and suitability for various uses.

Conflict of interest

The authors declare that there are noo conflict of interest.

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