CHEMICAL PROPERTIES OF SELECTED FINGER MILLET CULTIVARS (ELEUSINE COROCANA L) FOR DEVELOPMENT OF VALUE ADDED PRODUCTS IN THREE DIFFERENT FORMS OF FRESH, COOKED AND MALTED CONDITION

P. HEMASANKARI, B. DAYAKAR RAO1, A. SRINIVAS2, K.N. GANAPATHI3 AND C. TARA SATHYAVATHI4

1,2,3,4ICAR-IIMR, Telangana, Hyderabad 500 030, Telangana, India


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Key words : Finger millet, Value added, Cooked and malted

Abstract – Finger millets one of the major millet has rich amount of dietary fibre and protein. It is a poor man’s crop and it satisfies the hunger of the physically active people of low income. This study of estimation of minerals is done with selected 7 finger millet cultivars of freshly harvested PR-202, Dhalamandia, Bhalumandia, Suvarnamukhi, Vegavathi, KMR-204 and CFMV-2 from ICAR-IIMR field. The selected finger millet cultivars were tested for its protein, fat, ash, crude fibre, carbohydrates, energy value iron, zinc and calcium content in all 3 forms of raw, cooked and sprouted form. The mc, %wb ranged between 11.96 to 37.86%±3.91 in raw selected finger millet cultivars and in cooked millets, the mc ranged between 16.27 to 58.48%±5.59 and in sprouted millet, 17.74-34.26%. Raw finger millet cultivars range in protein content from 5.58% to 9.48%±1.32, in cooked it is 7.76% to 9.80%±0.82, in sprouted it is 6.34 to 9.11±1.09. Sprouted protein is less from cooked by 18.3%, cooked protein is highest among all three forms of protein being tested in the selected varieties of finger millet and is 28.09% higher than the raw millets from raw to sprouted the protein increase is 11.99%. The raw millet fat content is more than cooked by 21.43%, cooked is more in fat than sprouted by 54.55% increase in raw to sprouted is 64.29%. The fat calorific value of the selected 7 cultivars ranges between in raw, 12.6-25.2 kcal/ kg ±4.08, cooked, 9.90-18.90± 3.12 kcal/kg and sprouted 4.50-19.80± 5.02 kcal/kg. The fat calorific value is less followed by cooked and then raw. This may be due to either leaching of fat soluble or due to complex ion formations with other macro molecules. The decrease in ash content is in 2.92%, this may be due to decrease in organic matter in the cooked millet sample. The increase in ash content of raw to cooked is 53.28%, raw to sprouted is 35.04%, cooked to sprouted the decrease is 28.09%. The decrease in carbohydrate is 10.16%±6.28. Raw millet carbohydrate is 35.07-69.32%± 15.41, cooked millet ranges between 38.41-62.28%±8.75, sprouted millet ranges between 29.05-45.04 %±6.14, raw to cooked is 8.70%, raw to sprouted is 17.16%, cooked to sprouted increase is 24.37%. Raw to cooked millets energy values decrease is 6.4%, cooked to sprouted increase is 8.05% and raw to sprouted is 1.78%. The percentage iron leaching is least in Dhalamandia variety and more in Suvarnamukhi variety. In sprouted form, the iron content had increased by 36.40% in Dhalamandia variety, Zinc content is increased by 13.58% in PR-202 variety. The average zinc content is highest in raw,1.48mg/g (KMR-204)±0.11 followed by sprouted 1.36 mg/g (KMR-204)±0.13 and then in cooked, 1.04 mg/g(KMR-204)± 0.10. Calcium content in raw grain ranges from 242.1 mg/g (Bhalumandia)±6.56-288.96 mg/g (Vegavathi)±6.56, in sprouted condition ranges from 237.75 mg/g ±11.06, (KMR-204) to 320.84 mg/g, (PR-202)±11.06 and in cooked condition ranges from 207.88 mg/g±9.17, (CFMV-2) to 267.74 mg/g±9.17, (PR-202).

INTRODUCTION

Finger millets one of the major millets has rich amount of dietary fibre and protein. It is a poor man’s crop and it satisfies the hunger of the physically active people of low income. Chemical constituents including protein, ash, fat, crude fibre and carbohydrates are rich in finger millet varieties.
Finger millet is very rich in micronutrient calcium though zinc and iron content are more in different varieties. Calcium is very much essential for bone development and teeth for growing children, pregnant mothers and age old people. With age the density of the bone decreases and osteoporesis occur for women of more than 45 years of age occurs. Hence intake of this finger millet in the form of value added products like porridge, health mix, biscuits, cake, bread, rusk, puffed, flaked, semolina and kurkurae is a must and recommended practice followed in villages. A thorough knowledge of the amount of the constituents like protein, ash, fat, crude fibre and carbohydrates, minerals like calcium, iron and zinc is very much needed and hence this study was undertaken at ICAR-IIMR, Hyderabad. Germination is a traditional process, that is used to soften the kernel structure and increase the nutritional composition of finger millet grains (Pushparaj and Urooj, 2011). The analysis was done using SPSS-16.0 version. The values were the result of two replications. The values were significant at 5% level of significance (p ≤ 0.05). Three dimensional graphs were drawn using Design Expert Software version 12.0.

MATERIALS AND METHODS

This study is done with selected 7 finger millet cultivars of freshly harvested PR-202, Dhala-mandia, Bhalumandia, Suvarnamukhi, Vegavathi, KMR-204 and CFMV-2 obtained from ICAR-IIMR field. Raw finger millets labeled were stored under refrigerated conditions till the completion of the study. The finger millet cultivars are rich in calcium and iron and hence the proximates including protein, fat, crude fibre and carbohydrates, minerals like calcium, iron and zinc is very much needed and hence this study was undertaken at ICAR-IIMR, Hyderabad. Germination is a traditional process, that is used to soften the kernel structure and increase the nutritional composition of finger millet grains (Pushparaj and Urooj, 2011). The analysis was done using SPSS-16.0 version. The values were the result of two replications. The values were significant at 5% level of significance (p ≤ 0.05). Three dimensional graphs were drawn using Design Expert Software version 12.0.

RESULTS AND DISCUSSION

The moisture content present is estimated using infrared moisture meter. The moisture content is an indication of the keeping quality of the grain. The mc, %wb ranged between 11.96 to 37.86% ± 3.91 in raw selected finger millet cultivars and in cooked millets, the mc ranged between 16.27 to 58.48% ± 5.59 and in sprouted millet, 17.74-34.26%. The percentage increase in mc in cooked is 26.49% than that of raw millets, the percentage increase in sprouted to cooked millets is 8.29%, the percentage increase in sprouted to raw millet is 32.58%.

Cooking was done taking 10g of the sample and cooking in the water bath at controlled conditions of temperature and time. The malting of grains were done with cleaned, sorted and immersed grains in distilled water for 6h. The grains were later spread on stainless trays lined with muslin wet cloth. The malted grains were dried in the oven dryer at 50°C for 1h. Dried grains were kept in airtight polythene bags for further usage (Olamiti et al., 2020). All analyses were conducted in triplicates, and mean ± standard deviation (SD) was used to present the results. A one-way analysis of variance (ANOVA) was employed to analyze the data using SPSS software 16.0 (SPSS Chicago, Illinois, USA). The Duncan multiple range test was used to compare mean values with a significance level of p ≤ .05. Three dimensional graphs were drawn using Design Expert Software version 12.0.
absorbed moisture from the soaking water during germination, and more cells within the grains were moistened.

Protein are building blocks of human body and hence it's estimation is essential. Protein is estimated using kjelettech apparatus. Raw finger millets protein varies in between 5.56% to 9.48 %±0.50 and in cooked protein ranges between 7.76% to 9.80%±0.31 and in sprouted protein ranges between 6.34-9.11±1.09. The percentage increase in protein is 3.27% to 28.35%. Raw finger millet cultivars ranges in protein content from 5.58% to 9.48%±1.32, in cooked it is 7.76% to 9.80%±0.82, in sprouted it is 6.34 to 9.11±1.09. Sprouted protein is less from cooked by 18.3%, Fig. 12 represents comparative study of proximate composition of sprouted finger millet, cooked protein is highest among all three forms of protein being tested in the selected varieties of finger millet and is 28.09% higher than the raw millets from raw to sprouted the protein increase is 11.99%. Protein calorific value is more in cooked followed by sprouted and raw form. The percentage increase in cooked to raw form is 28.35%, cooked to sprouted form is 18.29%, sprouted to raw form is 12.30%.

Fat is the indicator of storage stability of the grain product. Fat is estimated using soxhlet apparatus. Fat in raw finger millets ranged between 1.40 to 2.80%, fat in cooked finger millets is in between 1.10 to 2.30% and in sprouted finger millets is in between 0.50-2.20%. The percentage decrease in fat content 21.43%. Raw finger millet cultivars fat content ranges from 1.40-2.8 %±1.32, cooked millet fat content ranges from 1.10-2.30±0.40, Fig.11 represents comparative study of proximate composition of cooked finger millet, sprouted millet fat content ranges from 0.50-2.20±0.50. The raw millet fat content is more than cooked by 21.43%, cooked is more in fat than sprouted by 54.55% increase in raw to sprouted is 64.29%. Table 3 represents the proximate composition of different sprouted finger millet cultivars The fat calorific value of the selected 7 cultivars ranges between in raw, 12.6-25.2 kcal/kg ±4.08, cooked,9.90-18.90± 3.12 kcal/kg and sprouted 4.50-19.80± 5.02 kcal/kg. The fat calorific value is less followed by cooked and then raw. This may be due to either leaching of fat soluble or due to complex ion formations with other macro molecules.

The ash content indicates the organic content in the grain product. The ash is estimated using muffle furnace. The ash in raw finger millet ranged between 2.43 to 2.74% ± 0.12, the ash in cooked finger millet ranged between 1.28% to 2.66%±0.49, the ash in sprouted finger millet ranged between 1.78-2.23%±0.15. The decrease in ash content is in 2.92%, this may be due to decrease in organic matter in the cooked millet sample. Table 1 represents the proximate composition of different raw finger millet cultivars. The increase in ash content of raw to cooked is 53.28%, raw to sprouted is 35.04%, cooked to sprouted the decrease is 28.09%. The percentage increase in ash varies between 12.35%-28.23% from raw finger millet cultivars to sprouted finger millet cultivars. Iron ranges between 0.32 to 3.87mg/100g, CFMV-2, 0.32 mg/ 100g and PR-202, 3.87mg/100g.

The crude fibre is estimated using AOAC method. Crude fibre ranges from 15.64 to 33.03 % ±1.98, minimum is in KMR-204, maximum in Suvarnamukhi. The crude fibre estimation is much needed for the body since it indicates the indigestible cellulose that prevents the absorption of other nutrients. The crude fibre ranged between 7.83 to 28.51±2.77 in raw millet sample and in cooked millet sample ranged between 5.52% to 22.12%±2.60, in sprouted millet sample ranged between 22.96-33.03±5.25. The percentage decrease in crude fibre is 22.41%. The proportion of dietary fibre in finger millet is higher than in many other kinds of cereal (Abioye et al., 2022). Millets possesses hypoglycemic effect that is attributed to the high fibre content in it. The health benefits associated with high fibre foods are delayed nutrient absorption, increased fecal bulk, lowering of blood lipids, prevention of colon cancer, barriers of digestion, mobility of intestinal contents, increased faecal transit time and fermentability characteristics (Aisoni et al., 2018). The increase is 29.50% from raw to cooked, in cooked decrease is 75.96% decrease in raw to sprouted is 65.90%. The crude fibre calorific value is more in sprouted followed by raw and then cooked. The percentage increase in sprouted crude fibre calorific value is 65.89% compared to raw, from raw to cooked is 29.50%, sprouted to cooked is 7.96%. Fig.10 represents comparative study of proximate composition of raw finger millet. The percentage increase in crude fibre from sprouted to raw finger millet is 29.40 to 71.26%, least in PR-204 followed by KMR-204.CFMV-2, Dhalamandia, Suvarnamukhi, Bhalamandia and Vegavathi.

The carbohydrate represents the starch that is present and it indicates the energy of the produce. The carbohydrate content is found out by detecting the cumulative amount of protein, fat, fibre and ash from 100. The carbohydrate content in raw finger
millets ranged between 22.20 to 69.32%±5.82 and in cooked millets it ranged between 8.41 to 62.28%±6.78, carbohydrate ranges from 29.05 to 45.04%±2.32, minimum is in Vegavathi and maximum is in KMR-204, 45.04%±2.32. Crude fibre is least in KMR-204 followed by CFMV-2, Bhalumandia, PR-202, Dhalamandia, Vegavathi and Suvarnamukhi. The decrease in carbohydrate is 10.16%±6.28. Raw millet carbohydrate is 35.07-69.32%±15.41, cooked millet ranges between 38.41-62.28%± 8.75, Table 2 represents the proximate composition of different cooked finger millet cultivars. Sprouted millet ranges between 29.05-45.04%± 6.14, raw to cooked is 8.70%, raw to sprouted is 17.16%, cooked to sprouted is 24.37%. Fig. 1 Proximates of selected 7 cultivars in 3 different form, raw, cooked and sprouted form. The carbohydrate calorific value is highest in raw form.

Fig. 1. Proximates of selected 7 cultivars in 3 different form, raw, cooked and sprouted form.
followed by cooked and then sprouted form. The percentage increase in carbohydrate cooked from raw is 8.71, raw to sprouted is 17.17% and cooked to sprouted is 24.37%.

Raw millet energy values between 217.97-337.68±17.36, Fig. 7 represents energy value of raw finger millet cooked ranges 232.88-319.9 ±24.26, Fig.8 represents energy value of cooked finger millet and sprouted ranges between 214.14 to 284.06±29.27kcal/kg, Fig.9 represents energy value of sprouted finger millet. Raw to cooked millets energy values decrease is 6.4%, cooked to sprouted increase is 8.05% and raw to sprouted is 1.78%. Fig.3 represents calorific value of selected 7 cultivars in 3 different forms, raw, cooked and sprouted form.

Iron is an important mineral that is needed for haemoglobin content in the human body, zinc for immune development and calcium in development of bones and teeth. Reduction of the antinutrient factors, phytic acid and enhancement of bioavailability of micronutrients in millet grains can be made by estimation of zinc and iron. The calcium content present gives more mechanical strength to the grain and hence estimation of this element becomes important. The selected finger millet cultivars were tested for its iron, zinc and calcium content in all 3 forms of raw, cooked and sprouted form using standard procedure in Atomic Absorption spectro photometer. Iron is an important mineral that is needed for haemoglobin content in the human body, zinc for muscle development and calcium in development of bones and teeth. Reduction of the antinutrient factor, phytic acid and enhancement of bioavailability of micro nutrients in millet grains can be made by estimation of zinc and iron. The calcium content present gives more mechanical strength to the grain and hence estimation of this element becomes important. The raw finger millet iron content ranges between 1.47(CFMV-2)-4.35 mg/g (Bhalumandia)±0.44. Some minerals are leached due to cooking in the water used for cooking. In cooked form of finger millets, the iron content ranged between 0.23 (Suvarnamukhi)-4.07 mg/g (KMR-204)±0.46. Fig.5 represents relationship between iron, zinc and calcium and protein of cooked selected cultivars of finger millet grain.

The iron content in sprouted form of finger millet ranged between 0.32 mg/g (Vegavathi)-3.87mg/g(PR-202)±0.51. The percentage iron leaching is least in Dhalamandia variety and more in Suvarnamukhi variety. In sprouted form, the iron content had

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Fig. 2. Minerals of selected 7 cultivars in 3 different form, raw, cooked and sprouted form.
increased by 36.40% in Dhalamandia variety. Zinc content is increased by 13.58% in PR-202 variety. The average zinc content is highest in raw, 1.48 mg/g (KMR-204) ± 0.11 followed by sprouted 1.36 mg/g (KMR-204) ± 0.13 and then in cooked, 1.04 mg/g (KMR-204) ± 0.10. Calcium content in raw grain ranges from 242.1 mg/g (Bhalumandia) ± 6.56-288.96 mg/g (Vegavathi) ± 6.56, in sprouted condition ranges from 237.75 mg/g±11.06, (KMR-204) to 320.84 mg/g, (PR-202) ± 11.06 and in cooked condition ranges from 207.88 mg/g±9.17, (CFMV-2) to 267.74 mg/g± 9.17, (PR-202). The mineral composition of the malted greengram coincided with the earlier findings of Poorni Sandupama and Jagath Wansapala, 2024. The percentage increase in calcium from raw to sprouted is 20.47%, the highest in sprouted and cooked form comparison is in Suvarnamukhi, 22.78%. In cooked form all the minerals, calcium, iron and zinc are less compared to raw form. Fig. 6 represents relationship between iron, zinc and calcium and protein of sprouted selected cultivars of finger millet grain.

Fig. 3. Calorific value of selected 7 cultivars in 3 different forms, raw, cooked and sprouted form
The iron content is the indication of the haemoglobin content of the body and the estimation is essential. The iron content in raw finger millet cultivars ranged between 1.47 mg / 100 g to 4.35 mg/100g±0.44, in cooked millet it ranged between 0.23 mg/100g to 4.07 mg/100g ± 0.46. The percentage decrease in iron content is 6.44%. The zinc content gives more immune to the human body and hence it's estimation is important. The zinc content in raw finger millet cultivars ranged between 1.48 mg/100g to 2.24 mg/100g±0.01, in cooked finger millet cultivars ranged between 1.04 mg/100 g to 1.90 mg/100g±0.11. The percentage decrease is 15.18% in zinc content. The calcium content is essential for bone and teeth development and is essential for estimation. The calcium content in raw finger millet cultivars ranged between 242.15 mg/100g to 288.96 mg/100g±6.56 in cooked millet cultivars ranged between 207.88 mg/ 100g to 267.74 mg/ 100g± 9.17. The decrease in calcium content is 7.34%. Sprouted finger millet is considered to be more nutritious than raw and cooked millet especially in calcium content. Fig. 2 represents minerals of selected 7 cultivars in 3 different form, raw, cooked and sprouted form.

Iron varies from 0.32 to 3.87 %± 0.51, zinc ranges between KMR-204, 1.36% to PR-202, 2.5%± 0.13 and calcium ranges between 237.75%, CFMV-2 to PR-202, 320.84%±11.06. Iron ranges between 0.32 to 3.87mg/100g, CFMV-2, 0.32mg/ 100g and PR-202, 3.87 mg/100g. Zinc ranges from 1.36 to 2.5mg/100g, KMR-204, 1.36 mg/ 100g and PR-202 it is 2.5 mg/ 100g. Calcium ranges between 237.75 mg/ 100g to 320.84 mg/100g. Least calcium is in KMR-204 and most in PR-202, 320.84 mg/100g. Fig. 4 represents relationship between calcium, zinc, iron and with protein of raw selected cultivars of finger millet grain.

The raw finger millet iron content ranges between 1.47(CFMV-2)-4.35 mg/100g (Bhalumandia) ± 0.44. Some minerals are leached due to cooking in the water used for cooking. In cooked form of finger millets, the iron content ranged between 0.23 (Suvarnamukhi)-4.07 mg/100g (KMR-204) ±0.46. The iron content in sprouted form of finger millet ranged between 0.32 (Vegavathi)-3.87 mg/100g (PR-202) ± 0.51. The percentage iron leaching is least in Dhalamandia variety and more in Suvarnamukhi variety. In sprouted form, the iron content had increased by 36.40% in Dhalamandia variety and in Suvarnamukhi variety. In cooked form all the minerals, calcium, iron and zinc are less compared to raw form. Among all the three forms,
Table 1. Proximate composition of different raw finger millet cultivars

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<th>ash</th>
<th>cr.fib.</th>
<th>carb</th>
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<th>zn</th>
<th>cal</th>
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Table 2. Proximate composition of different cooked finger millet cultivars

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Average 8.73 1.76 2.25 12.22 50.05 2.03 1.47 229.98 34.46 24.98 34.94 15.12 24.45 200.22 274.72
Minimum 7.76 1.10 1.28 5.52 38.41 0.23 1.04 207.88 19.43 16.27 31.04 9.90 11.04 153.64 232.88
Maximum 9.80 2.30 2.66 22.12 62.28 4.07 1.90 267.74 55.69 35.77 39.20 18.90 44.24 249.12 319.90
Sem 0.50 0.17 0.05 2.77 1.04 0.23 0.28 21.09 31.46 21.40 15.20
Cd(5%) 11.43 12.71 6.01 21.63 14.81 7.15 21.97 19.18 11.43 12.81 10.80
the sprouted form had an increased iron, zinc and calcium content compared to other 2 forms. The correlation coefficient for raw, cooked and sprouted finger millet iron content is, between sprouted and cooked, positive correlation is $r=0.01$, raw and sprouted has negative correlation, $r=(-0.19)$ and raw and cooked $r=(-0.24)$. In zinc content, the positive correlation coefficient between raw and sprouted is $r=0.75$, raw and cooked, $r=0.80$, sprouted and cooked, $r=0.94$. In calcium content, the raw and sprouted correlation is $r=0.43$, raw and cooked, $r=0.45$, sprouted and cooked, $r=0.78$. The pearson correlation coefficient of raw protein with cooked is $r=0.64$ and with that of sprouted protein is $r=0.263$, cooked with sprouted is $r=0.724$. The correlation coefficient of raw fat with cooked is $r=(-0.151)$ and raw fat with sprouted fat is $r=(-0.032)$, cooked with

![Fig. 6. Relationship between iron, zinc and calcium and protein of sprouted selected cultivars of finger millet grain](image)

![Fig. 7. Energy value of raw finger millet](image)

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Average   7.61 | 1.20 | 2.07   | 25.71| 45.55| 3.87 | 2.50 | 320.84| 49.40 | 31.92| 28.00| 38.89| 116.20| 214.14

Minimum   6.34 | 0.50| 1.78   | 22.96| 32.89| 0.32 | 1.36| 257.75| 49.40 | 31.92| 28.00| 38.89| 116.20| 214.14

Maximum   9.11 | 1.80| 2.14   | 25.71| 45.55| 3.87 | 2.50 | 320.84| 49.40 | 31.92| 28.00| 38.89| 116.20| 214.14

SD       0.41 | 0.21 | 0.06   | 1.98 | 4.50 | 0.31 | 2.22 | 3.55 | 6.55 | 6.55 | 6.55 | 6.55 | 6.55 | 6.55 | 6.55


Fig. 8. Energy value of cooked finger millet

Fig. 9. Energy value of sprouted finger millet

Fig. 10. Comparative study of proximate composition of raw finger millet

sprouted fat is r=0.520. The Fig.13 represents comparision of three different forms of selected 7 finger millet varieties.

CONCLUSION

The protein content is less in sprouted (7.61%) than in cooked (8.73%) form. Crude fibre is more in sprouted (26.92%) form than in cooked (12.22%) form by 54.6%. The moisture is more in sprouted (26.94%) than in cooked (24.98%) and raw(21.58%) form and hence carbohydrate is much less in sprouted (37.03%) than in other 2 forms of raw (53.89%) and cooked (50.05%). The calorific value is much less in sprouted (243.93 kcal/kg) form than in raw (289.91kcal/kg) and cooked (274.74kcal/kg) form. The decrease in ash content of cooked millet from raw millet is 2.92%, this may be due to decrease in organic matter in the cooked millet.
Chemical Properties of Selected Finger Millet Cultivars (*Eleusine corocana* L) for Development
sample. The percentage increase in protein of cooked millet from raw millet is 3.27% to 28.35%. The percentage decrease in fat content of cooked millet from raw millet is 21.43%. The percentage decrease in crude fibre of cooked millet from raw millet is 22.41%. The decrease in carbohydrate is of cooked millet from raw millet 10.16%±6.28. This study is much needed for selection of better finger millet variety with better cooking qualities to reassure the nutritional security of both farmers and consumers for the crop to be grown in a particular area. The comparison between these three forms indicates a more healthy choice for nutritious finger millet rich diet for the future generation among the selected varieties and to make value added products.

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REFERENCES


