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Original Research Article

Impact of Processing Methods on Bio Availability of Iron and Calcium in Selected White Finger Millet Varieties

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A B S T R A C T

Finger millet (*Eleusine coracana*) is one of the important minor cereals and constitutes a staple food for a large segment of the population in the Indian subcontinent as well as of many in the African countries. In preset study white finger millet varieties (GE 6834-1, KMR-344 and DHWFM 11-3) procured from AICSMIP Bengaluru were analysed in raw and processed form for the iron and calcium bio availability. The results from the study indicated that the mean bioavailable iron content in selected raw samples was 1 mg, in soaked 1.30 mg, while in malted 3.50 mg and in popped 2.97 mg /100 g. Among the selected white finger millet varieties DHWFM 11-3 recorded highest bioavailable iron content in all the four processing methods employed. Increment trend of bio available iron was in the following order Malted (mean 3.50 mg/100 g) >Popped (mean 2.97 mg /100 g)>Soaked (mean 1.30 mg/ 100 g)>Raw (mean 1.00 mg/100 g). Significant difference was also observed in all the processing methods for calcium bio availability. In raw as well as soaked, malted and popped samples where it ranged with a mean value of 79.48 mg/100 g in raw samples 110.36 mg/ 100 g in soaked sample, 187.43 mg/100 g in malted samples and 143.11 mg / 100 g in popped samples. Among the selected varieties, KMR 344 showed significantly higher per cent age of bio available calcium in all the processing methods.

Keywords

Variety, White finger millet, bioavailability, malting, popping, soaking

Introduction

Finger millet (*Eleusine coracana* L.) is an annual plant widely grown as a cereal in many parts of the world. Because of their short growing seasons, they are cultivated in a wide range of soils, climatic conditions and are of specific importance in semi-arid regions. It is cheap and abundantly available millet in India being less expensive compared to cereals and the staple for the poorer sections of population. Nutritionally its importance is well recognised because of its high content of calcium (0.38%) and dietary fiber (18%) compared to the cereals such as barley, rice, maize and wheat (Kamat & Belavady, 1980; Ravindran, 1991). Hence, could be the choice for nutritional contents. Being an excellent source of micronutrients, which could alleviate the wide spread micronutrient malnutrition in the developing countries. The importance of trace element bioavailability in the etiology of nutritional deficiencies, for example in the etiology of iron deficiency and iron deficiency anaemia, can be expected to be most pronounced in individuals with high requirements. Of special concern is the situation in poor communities where infants and young children are consuming monotonous, cereal-based diets. Lestienne *et al.,* (2005) defined bio availability of a nutrient as the proportion of the total nutrient content in a food, meal or diet that is utilized for normal metabolic functions. Hence in this study bio availability of Fe and Ca are analysed so that varieties with better bioavialable iron and calcium can be produced and popularized to masses to combat with micro nutrient deficiency disorders.

Materials and Methods

White finger millet varieties (WFM) [GE 6834-1, KMR 344, DHWFM 11-3], were procured from AICSMIP, PC unit, GKVK, Bengaluru.

Grains were sorted to remove stones, dirt and any other foreign particles. They were stored in an air tight polythene pouches until ready for processing.

Milling

Raw clean and moisture free grains of white finger millet varieties were powdered in flour mill and stored in air tight polythene cover for further analysis.

Soaking

In soaking treatment the raw and clean grains of three selected white finger millet varieties were soaked in distilled water in a conical flask at different intervals of 12 hour, 24 hour and 48 hour at room temperature. The soaking water was discarded and then the soaked grains were dried at 60 °C till it attains constant moisture content. The dried seeds were ground to fine powder and stored in air tight polythene cover for further analysis.

Malting

In malting treatment the raw and clean grains of three selected white finger millet varieties were steeped in distilled water over night in a conical flask at room temperature and germinated under controlled conditions on moist muslin cloth at 25 ºC in a B.O.D. incubator at intervals of 12 hour, 24 hour and 48 hour. Germinated seeds were taken out and dried at 60 ºC in a hot air-oven for 6 h till it attains constant moisture content; growth portions were removed by gentle rubbing manually. Devegetated seeds were weighed, powdered and used for the further experiments.

Popping (Malleshi *et al.*, 1986)

After determining the moisture in the sample by hot air oven drying method, water was sprinkled on the grain to raise the moisture content to 19 per cent and grains were equilibrated in a closed airtight container for a period of 1hr, 4hrs and 8 hrs prior to popping. After that, the equilibrated grains were added in an iron frying pan, the temperature of which was maintained at 175-200 ^{0} C. When popping sound was stopped the pan was removed from the flame and popped millets were powdered and used for further analysis

Bioavailability of iron and calcium (Rao and Prabhavati, 1978)

Two g of the sample was mixed with 25 ml of pepsin HCl. The pH of the mixture was adjusted to 1.35 with distilled HCl and incubated in a 100 ml conical flask at 37 ^{0} C in a metallic shaker water bath for 90 min. At the end of the incubation, the contents of the flask were centrifuged at 3000 rpm for 45 min and supernatant filtered through whatman No.44 filter paper. Soluble and Ionizable iron and calcium were determined in aliquots of the filtrate at pH 1.35. In the other aliquot pH was adjusted to 7.5 with NaOH and incubated in a 100 ml conical flask at 37^0 C in a metallic shaker water bath for 90 min. At the end of the incubation, the contents of the flask were centrifuged at 3000 rpm for 45 min and supernatant filtered through whatman No.44 filter paper and the filtrate was used for the determination of soluble and ionizable iron and calcium.

$$\text{Per cent bio availability of Fe/ Ca} = \frac{\text{Bio availability of Fe / Ca}}{\text{Weight of sample}} \times 100$$

Statistical analysis

Three samples for each parameter were prepared, each sample was analyzed in triplicate and the values were then averaged. Data were assessed by analysis of variance (ANOVA)

Results and Discussion

Iron (Fe) and Calcium (Ca) are essential elements in human nutrition and their deficiencies are major public health threats worldwide. Among the micronutrient malnutrition situations afflicting the human population, Fe and Ca deficiencies are of major concern not only because of the serious health consequences they may have, but also because of the number of people affected worldwide particularly in Africa and India (Afify *et al.*, 2011).

The importance of trace element bioavailability in the etiology of nutritional deficiencies, for example in the etiology of iron deficiency and iron deficiency anaemia, can be expected to be most pronounced in individuals with high requirements. Of special concern is the situation in poor communities where infants and young children are consuming monotonous, cereal-based diets. Lestienne *et al.*, (2005) defined bio availability of a nutrient as the proportion of the total nutrient content in a food, meal or diet that is utilized for normal metabolic functions.

The iron and calcium bio availability in the selected white finger millet varieties was analysed in raw and processed form. Significant difference was found between the treatments [Table 1 & Fig.1]. In the raw sample, the iron bioavailability was ranged from 0.82 to 1.20 mg /100 gm. Where as in processed samples the iron bio availability was increased.

Increment trend of bio available iron was in the following order Malted (mean 3.50 mg/100 g) >Popped (mean 2.97 mg /100 g)>Soaked (mean 1.30 mg/ 100 g)>Raw (mean 1.00 mg/100 g). The values by other workers were 0.53, 0.54, 0.55 and 0.59 mg/100 g in fox tail millet (Kulkarni and Naik, 1999), 0.64 and 2.70mg/100g in raw and malted pearl millet and 0.29 and 2.98 in raw and malted ragi respectively (Rao and Deoosthale, 1988). The bio availability of iron was increased after processing due to reduction in phytic acid and other anti-nutritional factors.

Suma and Urooj, (2012) also reported that simple processing methods like soaking and cooking significantly reduced antinutrients in millet and brought an improvement in the bio availability of iron.

Significant difference was observed in all the processing methods for calcium bio availability. In raw as well as soaked, malted and popped samples where it ranged with a mean value of 79.48 mg/100 g in raw samples 110.36 mg/ 100 g in soaked sample, 187.43 mg/100 g in malted samples and 143.11 mg / 100 g in popped samples.

Table.1 Impact of processing methods on bio availability of iron mg/100g in selected white finger millet varieties

Varieties	Iron (mg /100g)	Raw	Soaked		Malted		Popped	
		Bio available iron	Bio available iron	Per cent increase over raw	Bio available iron	Per cent increase over raw	Bio available iron	Per cent increase over raw
GE 6834-1	5.18	0.97^{bA}	1.24^{bB}	21.77	3.39^{bD}	71.38	2.90^{bC}	66.55
KMR 344	4.61	0.82^{aA}	1.04^{aB}	21.15	2.81^{aD}	70.81	2.40^{aC}	65.83
DHWFM 11-3	7.42	1.20^{cA}	1.62^{cB}	25.92	4.30^{cD}	72.10	3.62^{cC}	66.85
Mean	**5.73**	**1.00**	**1.30**	**22.94**	**3.50**	**71.43**	**2.97**	**66.41**
CD ($P \leq 0.05$) means between varieties and between methods: 0.028					**SEm±(0.05) : 0.012**			

Note: values are mean triplicates of samples
Superscript in capital letters (A, B & C) indicates the significant difference between the processing methods within the variety
Superscript in small letters (a, b & c) indicates significant difference between the varieties, within the processing method

Table.2 Effect of processing methods on bio availability of calcium mg/100g in selected white finger millet varieties

Varieties	Calcium (mg /100g)	Raw	Soaked		Malted		Popped	
		Bio available calcium	Bio available calcium	Per cent increase over raw	Bio available calcium	Per cent increase over raw	Bio available calcium	Per cent increase over raw
GE 6834-1	259	83.92^{bA}	113.96^{bB}	26.36	193.47^{bD}	56.62	150.22^{bC}	44.13
KMR 344	299	86.70^{cA}	125.58^{cB}	30.96	214.15^{cD}	59.51	164.21^{cC}	47.20
DHWFM 11-3	244	67.83^{aA}	91.55^{aB}	25.90	154.68^{cD}	56.15	114.90^{aC}	40.96
Mean	**267**	**79.48**	**110.36**	**27.74**	**187.43**	**57.42**	**143.11**	**44.10**
CD ($P \leq 0.05$) means between varieties and between methods: 0.018					**SEm±(0.05) : 0.01**			

Note: values are mean triplicates of samples
Superscript in capital letters (A, B & C) indicates the significant difference between the processing methods within the variety
Superscript in small letters (a, b & c) indicates significant difference between the varieties, within the processing method

Fig.1 Bio availability of iron in selected white finger millet varieties

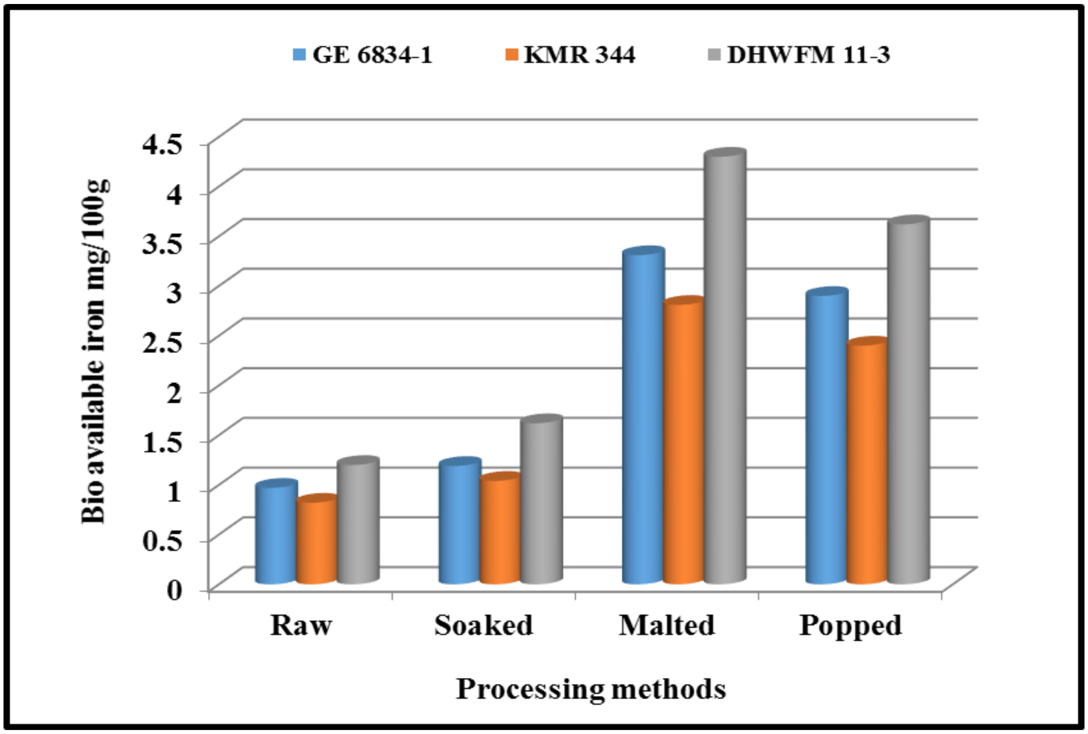
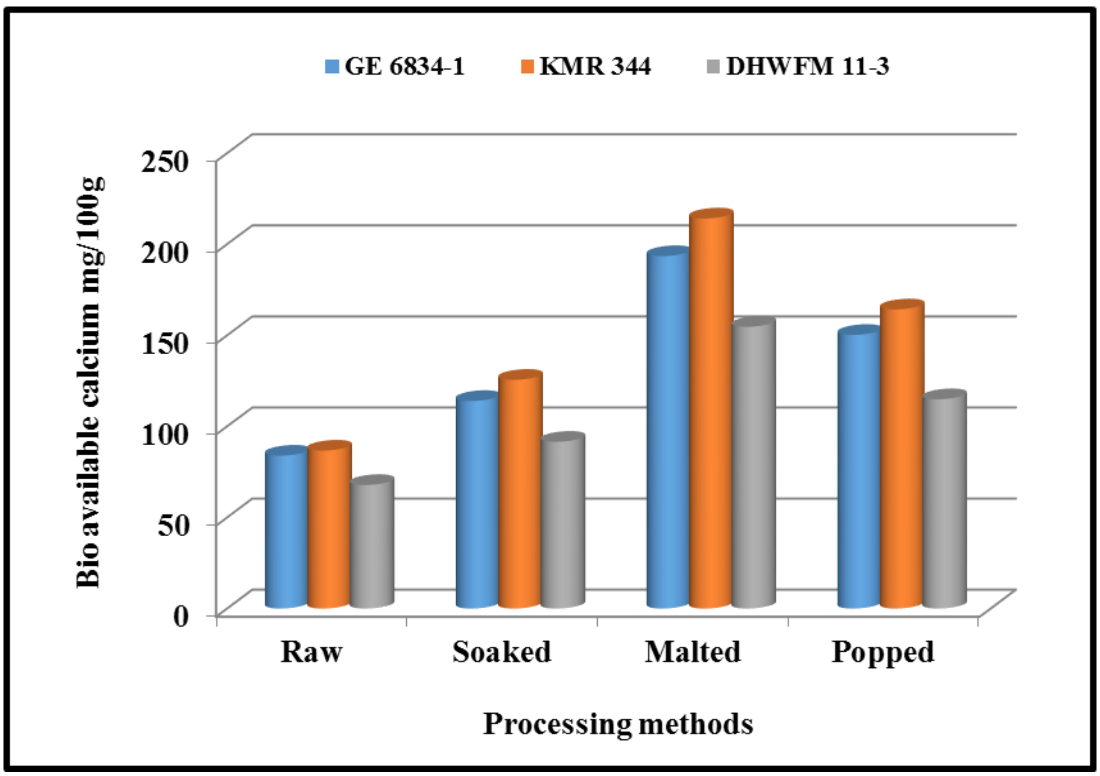


Fig.2 Bio availability of calcium in selected white finger millet varieties



Among the selected varieties, KMR 344 showed significantly higher per centage of bio available calcium in all the processing methods followed by the GE 6834-1 [Table 2 & Fig.2]. Increase of calcium bioavailability after malting, popping and soaking of white finger millet samples could be contributed to simultaneous reduction of phytic acid and fiber and even the absence of oxalates in the varieties. Several reports show the negative correlation of phytic acid and dietary fiber contents of foods with per cent of calcium bioavailability (Allen, 1982; Cheryan, 1980; Kamchan *et al.*, 2004). Similar results were observed from the Ghavidel and Prakash (2007) on legumes.

Processing methods significantly enhanced the bio availability of iron and calcium among selected varieties under study. The mean bioavialable iron in raw, soaked malted and popped samples ranged from 1, 1.30, 3.50 and 2.97 mg /100 g respectively. Among the varieties DHWFM11-3 had significantly higher per centage of bio available iron and among all the processing methods employed. The higher bio available iron among processing method followed in the order malting > popping > soaking > raw samples. Similarly high bio available calcium was found higher in varieties KMR 344 followed by GE 6834-1 and least was observed in the variety DHWFM 11-3. Processing methods significantly enhanced the bio available calcium. With a mean of 79.48, 110.36, 187.43 and 143.11 mg/100 g. In raw, soaked, malted and popped samples respectively. The higher per centage of bio available calcium among processing method found in the order malting > popping > soaking > raw samples. Hence processing methods showed significant difference for bio availability of iron and calcium among the selected varieties. Among processing methods malting significantly increased the bio availability of iron and calcium.

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