Germinated Millets based Healthy Crackers: An Effective, Efficient and Sustainable Approach to Prevent Malnutrition

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Abstract—*Millets are observed as nutritious and health beneficial food grains and help in management of malnutrition. This study concentrates on the further enhancement of nutritional qualities and benefits of finger and pearl millets by household processing technique called germination. It is noted that germination process has increased the nutrients significantly such as fat increased by 35% and 15.25%, protein (18.39% and 22.91%), calcium (4.78% and 19.53%) and iron (17.77% and 10.11%) in GFMF (Germinated Finger Millet Flour) and GPMF (Germinated Pearl Millet Food) respectively. Germination also led to the reduction in anti-nutrients in both the samples of GFMF and GPMF as tannin reduced by 31.44 % and 58.60%, phytic acid (42.06% and 71.98%), oxalic acid (28.77% and 34.93%) and trypsin inhibitors (20.27% and 52.22%). Food product named as healthy crackers are developed in four variants, variant A incorporating 4%, B incorporating 8%, C incorporating 16% and D incorporating 32% of GFMF and GPMF each. Sensory evaluation of the samples revealed that variant D has good overall acceptability with the score of 7.05±1.14. It is an excellent source of protein (10.98 g/100g), fat (28.3 g/100g), calcium (152.95 mg/100g) and iron (4.8 mg/100g). Hence, it can be wisely concluded that the food products developed from germinated millets contain less anti-nutrients, are rich in nutrients and have good sensory characteristics. It can prove to be very beneficial for children for their physical and mental growth and to overcome malnutrition.*

1. INTRODUCTION

Malnutrition is considered as a big hindrance in national development. For the sake of overcoming the intense problems of malnutrition, the quality and quantity of diet should be given significant weightage. In developing countries, children develop malnutrition when introducing nutritionally inadequate complementary foods. This time food must be formulated nutritionally energy- rich, easily digestible and functional food with easy availability and low cost to promote optimization of the body for future prospective. To obtain this aim, we must be use local, seasonal, low cost raw food ingredients having rich nutritional and functional properties such as cereals and millets, pulses, dairy materials. Millets also have potential for using as human food and beverages and 'words of wisdom' for research and investigation. India is considered as hub of minor crops like millets. Millets have great potential to broadening genetic diversity of food basket and facilitating to boost food and nutritional security [5].

Millets are generic term used for small sized annual grasses family (**Poaceae**) from heterogeneous group that cultivated as grain crops in hard environmental conditions [12] referred 'coarse cereals'. Millets constitute a cheap source of major and minor nutrients for poorest people whom they need vital nutrients but their utilization is limited due to the presence of anti-nutrients, poor digestibility and low palatability occurs decrease its uses. Food processing methods helps to make meal more attractive in appearance, consistency, flavor, taste, verities as well as making the food safe and increase shelf life with qualitatively changes the nutritive value of the food due to decreasing anti-nutrients and enhance the availability of nutrients. Germination not only improves the taste but also enriches the nutritive value with increasing protein digestibility, fiber, vitamin B and decreasing the anti-nutrients [13].

Finger millet (Eleusine coracana) or 'Ragi' belongs to minor cereal and mostly consumed in India and Africa. It is third ranked millet crop in India. It can crop easily, have excellent storage properties, rich and cheap source of nutrients, which is higher than rice and equal to wheat. Finger millet is a very good source of micronutrient such as calcium, iron, phosphorous, zinc and potassium, which could be alleviate malnutrition in the developing countries [11].

Pearl millet (Pennisetum glaucum) or 'Bajra' is a staple food in Asia and Africa produce in arid and semi arid land. It is fourth ranked most tropical crop in world. It is good source of nutrient and micronutrient especially rich in iron among all cereals [1]. Pearl millet has high level of calcium, iron, zinc, lipids, and amino acids [9] such as lysine, tryptophan, threonine and fatty acid like omega-9, omega-6 and omega-3 fatty acids.

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The objective of this study is effect of germination on nutritional profile of finger and pearl millets and development of food products to combat malnutrition.

2. MATERIAL AND METHODS

Whole raw finger millet flour (WRFMF) and Whole raw pearl millet flour (WRPMF)

Finger and pearl millets were thoroughly cleaned, remove foreign material and dirt. Thereafter, they were sundried and ground into fine flour or powder in a mixer and stored separately.

Germinated finger millet flour (GFMF) and Germinated pearl millet flour (GPMF)

One portion of finger and pearl millets was soaked overnight separately. Next day, water was drained and wrapped of seeds in a muslin cloth and hung in a humid atmosphere for germination. This germination process was conducted for 48 hours and both millets were sundried properly to make moisture free. Germinated seeds were ground in a mixer and stored separately in container for analysis.

Then nutrient and anti-nutrient analyses of various versions of samples.

Nutrient analyses: Moisture [2], Ash, fat, Crude fibre and total carbohydrate [8], Protein [7], Calcium [10] and Iron [8] were estimated.

Anti-nutrient analyses: Tannins [6], Phytic acid [3], Oxalic acid [7] and Trypsin inhibitor [4] estimated of all versions of finger and pearl millet flour. Trypsin inhibitor is defined as the number of trypsin units inhibited (TIU).

Food product development for malnourished children

This recipe was improvised with best effort by incorporating finger and pearl millets in processed (germinated) forms like GFMF and GPMF in different ratio and adopted standardization trials.

Healthy cracker (Mathari)

Mathari is prepared with maida and oil. It is a salted crispy snack taken mostly with tea. It is popular in North India. It can be stored for few weeks in air tight container and can be consumed any time. Healthy crackers is prepared with maida, semolina, ground nuts, carrot leaves powder, carom seeds, oil and incorporated with GFMF and GPMF to enrich protein, calcium, iron, vitamins and immune boosting phytonutrients. Carrot leaves are highly nutritive; provide vitamins (vitamin A, B6, C, K, niacin) and minerals (folate, potassium) and phytonutrients. Soyabean oil contains omega-3 fatty acid which has shown to reduce the risk of chronic diseases.

3. RESULT AND DISCUSSION

Proximate analyses of all versions of finger and pearl millets have been done and result shows in Fig 1. It is found that the moisture content for WRFMF and GFMF are 13.1±0.10 and 16.2±0.25 (g/100g) and for WRPMF and GPMF are 12.4±0.40 and 15.0±0.50 (g/100g) respectively. Significant difference is found in moisture content of GFMF when compare with WRFMF and also in GPMF compare with WRPMF. Total ash content for WRFMF and GFMF are 2.8±0.17 and 2.7±0.10. For WRPMF and GPMF are 2.3±0.10 and 2.2±0.20. After processing, no significant difference is found in ash content for GFMF and GPMF when compare with WRFMF and WRPMF respectively. Fat content for all versions are WRFMF; 1.3±0.20, GFMF; 2.0±0.20, WRPMF; 5.0±1.0, GPMF; 5.9±0.20. It is found that fat content in germination increase significantly. For WRFMF, GFMF, WRPMF and GPMF, the crude fiber contents are 3.5±0.10, 4.5±0.10, 2.1±0.05 and 2.8±0.10. The crude fiber content increased significantly in germinated samples. Millets are good source of protein and in the same line protein content is 7.1±0.20 (g/100g) in WRFMF, 8.7±0.26 (g/100g), in GFMF, 11.1±1.10 (g/100g) in WRPMF, 14.4±1.08 (g/100g) in GPMF. It has been seen that significant increase is found in protein content of all germinated samples compared to native samples. Carbohydrate content for all samples (WRFMF, GFMF, WRPMF and GPMF) is 71.8±0.20, 69.2±0.40, 67.5±0.36 and 64.7±0.35 (g/100g). It is registered a significantly decrease in germination.

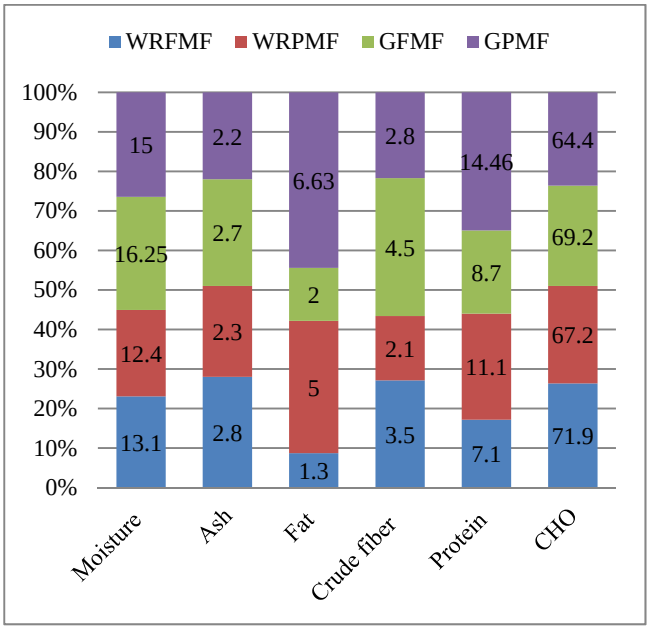

Figure 1: Proximate analyses of all version of finger and pearl millets, WRFMF- whole raw finger millet flour, WRPMF- whole raw pearl millet flour, GFMF- germinated finger millet flour, GPMF- germinated pearl millet flour.

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Mineral analyses

Fig 2 demonstrates the mineral content of all versions. The calcium content of WRFMF, GFMF, WRPMF and GPMF are found as 342.4±1.36, 359.6±2.05, 41.2±0.57 and 51.2±2.90 (mg/100g) respectively. Mineral analysis of processed forms of all versions reveals that calcium content increased significantly during germination. Iron content for WRFMF, GFMF, WRPMF and GPMF are 3.7±0.06, 4.5±0.05, 8.0±1.20, 8.9±0.50 (mg/100g) respectively. Significant different of iron content is found in all versions; GFMF and GPMF.

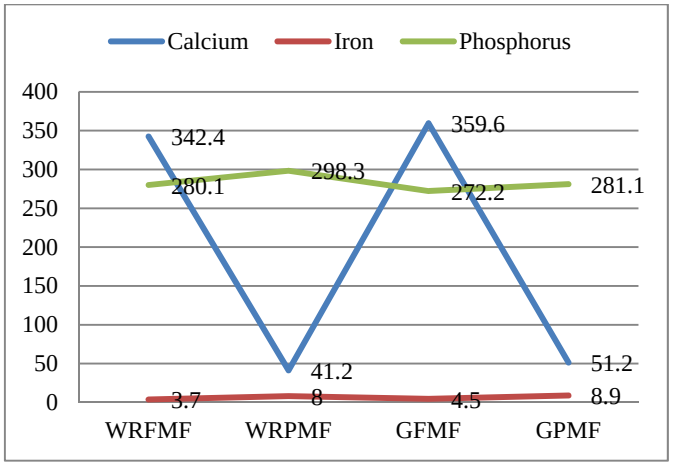

Figure 2: Mineral analyses of WRFMF, WRPMF, GFMF and GPMF.

Anti-nutrients analyses

Fig 3 shows the anti-nutrients content of finger and pearl millet versions. Tannin of WRFMF, GFMF, WRPMF and GPMF are found as 870.8±1.05, 360.5±0.10, 217.2±1.03, 148.9±2.04 mg/100g respectively. Tannin is significantly decreases during germination as well as popping process. Phytic acid for WRFMF and WRPMF are 851.4±1.60 and 858.6±2.60 (mg/100g), in germination, it is found as 238.5±1.30 (mg/100g) in GFMF and 497.4±1.54 (mg/100g) in GPMF are noticed. Phytic acid is significantly decreases in germination. Whereas, oxalic acid content for all version are WRFMF; 45.8±3.50, WRPMF; 21.2±1.05, GFMF; 29.8±2.06 and GPMF; 15.1±3.90 (mg/100g). Oxalic acid is significantly decreases during germination also. While, in context of trypsin inhibitor activity resulted of processing in decreasing trends, WRFMF, GFMF, WRPMF and GPMF are stood at 4188±8.00, 2001±5.10, 7190±3.40 and 5732±3.30 (U/g), indicating decreased significantly in the level of trypsin inhibitor activity.

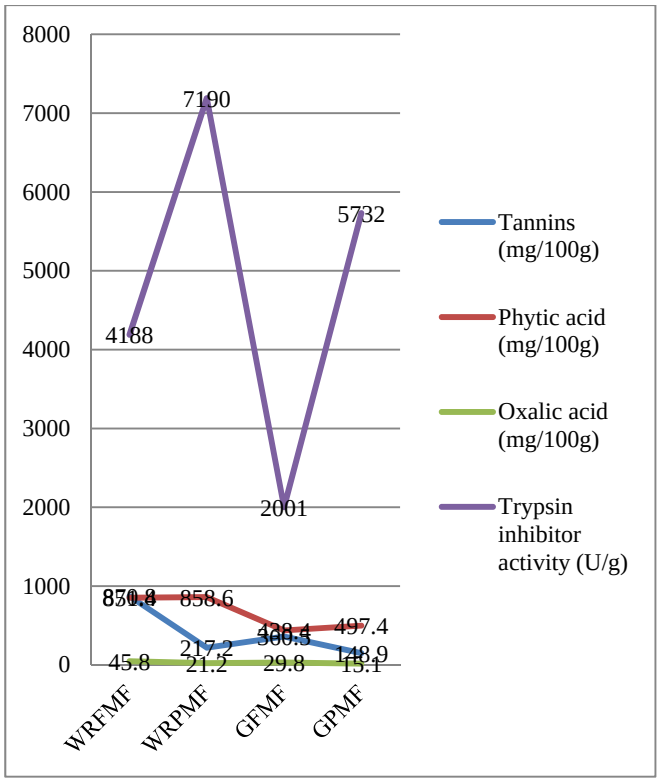

Figure 3: Anti-nutrients analyses of all WRFMF, WRPMF, GFMF and GPMF.

Food product for malnourished children

Healthy cracker (Mathari)

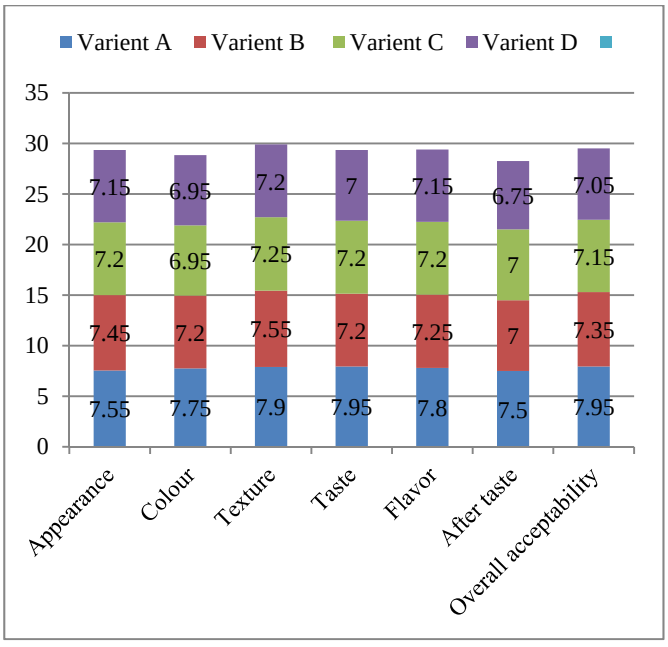

Figure 4: Sensory evaluation of healthy crackers

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Table 1: S- without incorporation of GFMF and GPMF, variant A- 4% (GFMF) + 4% (GPMF), variant B- 8% (GFMF) + 8% (GPMF), variant C- 16% (GFMF) + 16% (GPMF), variant D- 32% (GFMF) + 32% (GPMF).

Attribute	Standard	Variant A	Variant B	Variant C	Variant D
Appearance	7.95±0.88	7.55±0.94	7.45±1.09	7.2±1.32	7.15±1.38
Colour	8.05±0.88	7.75±0.78	7.2±0.89	6.95±0.94	6.95±1.05
Texture	7.95±0.99	7.9±0.78	7.55±1.09	7.25±1.25	7.2±1.32
Taste	8.25±0.78	7.95±0.94	7.2±1.19	7.2±1.15	7.0±1.07
Flavor	8.05±0.94	7.8±1.20	7.25±1.16	7.2±1.20	7.15±1.14
After taste	7.8±1.20	7.5±1.28	7.0±1.38	7.0±1.30	6.75±1.16
Overall acceptability	8.1±0.85	7.95±0.88	7.35±0.81	7.15±1.22	7.05±1.14

Table 2: Nutritive values of healthy crackers.

variants	Energy (Kcal.)	Carbohydrate (g/100g)	Protein (g/100 g)	Fat (g/100 g)	Calcium (mg/100 g)	Iron (mg/100 g)
standard	477.8	51.01	9.61	26.34	35.5	2.13
variant A	477.54	50.46	9.78	26.61	50.11	2.45
variant B	477.26	49.91	9.94	26.82	64.71	2.77
variant C	476.7	48.79	10.26	27.31	93.89	3.4
variant D	475.58	46.47	10.98	28.3	152.95	4.8

Four variants of healthy crackers were prepared by incorporation of finger and pearl millet flour at 4%, 8%, 16% and 32% respectively. Standard has no incorporation of GFMF and GPMF.

Figure 5. All versions of healthy crackers.

4. CONCLUSION

It is observed that protein, calcium, iron content increased significantly and anti-nutrients such as tannin, phytic acid, oxalic acid and trypsin inhibitor activity decreases significantly during germination process. Developed healthy crackers as food product have good overall acceptability and contain high protein, fat, calcium as well as iron content compare to standard.

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