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Effect of processing on the nutritional composition of ragi (*Eleusine coracana*)

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Ragi is millet, packed with fibre and calcium, is extremely beneficial due to its enormous health benefits. The millet is wholesome and recommended for all age groups. This study was planned to analyse the effect of processing on the nutritional composition of ragi. Raw and malted form of ragi were nutritionally analysed. Significant changes in nutritional composition of ragi were observed during processing. The raw ragi flour had good amounts of crude protein (4.6%), crude fat (3.06%) and crude fibre (14.8%). Amounts of amino acids were on the higher side *i.e.* tryptophan (116.77mg/100g protein), methionine (181.56mg/100g protein) and lysine (195.67mg/100g protein), as well as total sugars (5.32g/100g) and starch (0.82g/100g). Malting of ragi enhanced the crude protein (7.11%), ash (4.13%), tryptophan (250.13mg/100g protein) and methionine (351.1mg/100g protein) content. The antinutritional components reduced after the process of malting. The results revealed that malting of ragi should be done to enhance its nutritional profile and to maximize health benefits.

Key Words : Malted ragi, Processing, Proximate composition, Amino acids, Anti nutritional components

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INTRODUCTION

Finger millet or ragi (*Eleusine coracana*) was native of Ethiopia but spread out to Asia few thousand years ago. Now-a-days, there is a sudden increase in the demand of minor millets due to their health benefits and ragi is one of them. It is the most familiar millet in different regions of India commonly known as *Koracan* in Srilanka and *Nrttakondaka* in the Sanskrit literature of India.

There is higher consumption of ragi in Karnataka, Gujarat and Maharashtra. Ragi ranks fourth in the world after sorghum, pearl millet and foxtail millet and grown extensively in Africa and South Asia. The total production of millets around the world was 762,712 metric tons in the year 2013 with the top production in India, contributing with 43.85 per cent (Chandra *et al.,* 2016). It was estimated that ragi shares ten per cent of the thirty million tons of world's millet production (Dida *et al.,* 2008). In some countries this crop is referred as "poor people's crop". Different grades of ragi are available with yellow, white and brown colour grains but the most cultivated is red coloured ragi. Most commonly ragi is milled into fine powdered flour along with the seed coat which is the excellent source of fibre and micronutrients. This flour is further utilised in various product development.

Ragi is a treasure trove of nutrients. The low cost millet, is a rich source of dietary fibre, calcium and phytochemicals with nutraceutical potential. The total dietary fibre (22%) of ragi grains were reported relatively higher than that of many other cereal grains e.g. 12.6%, 4.6% and 12.8%, respectively for wheat, rice and maize. Ragi is a rich source of calcium which is thirty times more than that of rice and wheat (Srivastava and Sharma

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2012). Also, ragi contain good amounts of thiamine, riboflavin, iron, methionine, isoleucine, leucine, phenylalanine and other essential amino acids. Ragi is also known for its beneficial effects such as anti-diabetic, anti-tumorigenic, antioxidant, atherosclerogenic and antimicrobial properties (Mathanghi and Sudha, 2012).

Ragi can be processed by using different techniques like milling, malting, fermentation, popping and decortication. It can be incorporated among vermicelli, noodles, Indian sweet (*Halwa*) mixes, *Papads*, pasta, soups and bakery products (Shobana *et al.*, 2013). The importance of ragi as a nutraceutical crop was highlighted by (Gupta *et al.*, 2017) providing minerals, calories and protein which make it an ideal model for nutrition-agriculture research.

Karki and Kharel (2012) reported that germination increased the (P< 0.05) total reducing sugar and glucose contents in all millet varieties. By the process of germination the content of tannin and phytic acid also reduced by 20-38 per cent and 18-21 per cent, respectively (Ghavidel and Prakash, 2007). The grains after the treatment of malting can be incorporated in geriatric and weaning foods (Platel *et al.*, 2010). In the other study, Desai *et al.* (2010) prepared cakes incorporated with various blends of wheat flour and malted ragi flour. Rajiv *et al.* (2011) reported that muffins incorporated with ragi flour can increase the mineral content in muffins (Krishnan and Prabhasankar, 2010) developed pasta by using sprouted ragi flour. So, keeping the above properties in view, the present study was planned with the objective to determine the effect of processing on the nutritional composition of ragi.

METHODOLOGY

Sample selection and preparation :

The samples of ragi were procured from the local market. Two forms of ragi *i.e.* raw (whole grain) and malted ragi were nutritionally evaluated.

Proximate analysis :

Raw and malted samples of ragi were analysed for their proximate composition namely moisture, crude protein, crude fat, crude fibre and ash using AOAC (2000) method. Carbohydrate content was calculated by difference of total contents from 100. The energy content was calculated by factorial method.

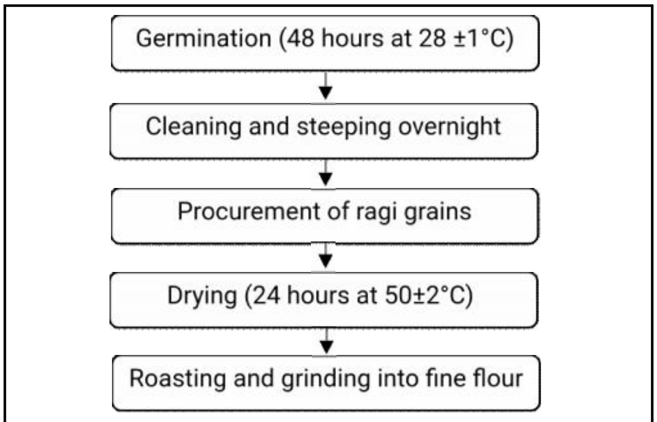

Fig. A : Schematic presentation of malting process of ragi

Amino acid content :

The amino acid content of ragi samples was evaluated. Tryptophan and methionine were estimated by the procedure used by Concon (1975) and Horn *et al.* (1946), respectively. The estimation of available lysine was carried out by the method giver by Carpenter (1960).

Available carbohydrates :

The available carbohydrate content like total sugars (Dubois *et al.*, 1956), reducing sugars (Nelson, 1944), non-reducing sugars and starch (Clegg, 1956) were estimated spectrophotometrically.

Anti-nutritional factors :

The anti-nutritional factors such as phytates and total phenols were estimated by the procedure used by Haug and Lantzsch (1983) and AOAC (1985), respectively. The estimation of trypsin inhibitor activity was carried out by the method giver by Roy and Rao (1971).

Statistical analysis :

All determinations were carried out in triplets and the results were expressed as mean ± standard deviation. The data were analysed with the help of standard statistical tools. To test the significant difference between raw and malted ragi samples t-test was applied. The significant difference was checked at 5% level of significance.

OBSERVATIONS AND ASSESSMENT

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Proximate composition (dry weight basis) :

The proximate composition of raw and malted ragi has been given in the Table 1. Moisture content of raw and malted ragi was 7.76 and 7.28 per cent, respectively. The protein content of malted ragi was significantly higher (P≤0.05) *i.e.* 7.11 per cent than the raw ragi *i.e.* 4.6 per cent. Chandra *et al.* (2016) reported that ragi is a treasure trove of calcium (0.34%), dietary fibre (18%), phytates (0.48%), protein (6%-13%), minerals (2.5%-3.5%) and phenolics (0.3%-3%). Mwikya *et al.* (2000) revealed that changes in proximate composition and *in vitro* protein digestibility were significant. Also, 13.3 per cent of the seed's dry matter was lost after 96 hours of sprouting. The fat content of raw ragi was observed to be 3.06 per cent which was significantly higher (P≤0.05) than malted ragi *i.e.* 2.31 per cent. Fat in ragi is composed of oleic acid, linoleic acid, palmitic acid and traces of linolenic acid as reported by (Singh and Sarita, 2016). In the similar study, Begum *et al.* (2016) reported that ragi malt had adequate protein content (8.9 g/100 g), low fat (1.5 g/100 g) with fair amount of carbohydrate (79.0) and energy (365 Kcal). However, crude fibre content of raw ragi was significantly higher *i.e.* 14.8 per cent than malted ragi *i.e.* 11.74 per cent. Archna (2014) evaluated ragi for its nutritional profile and revealed that 100 g of millet flour has 336 Kcal of energy, 5.8-12.8 per cent of protein, 71.3- 89.5 per cent of carbohydrates, 3.5- 3.9 per cent of fibre and 1.3- 2.7 per cent of fat. In the present study, significant increase was observed in ash content of malted ragi *i.e.* 4.13 per cent as compared to raw ragi *i.e.* 2.85 per cent, respectively. The carbohydrate content of raw ragi was found to be 66.93 g and that of malted ragi was 67.43 g. The energy content of raw and malted ragi was 314 and 319 Kcal, respectively. Begum *et al.* (2016) observed that ragi malt had high calcium content (193 mg) and phosphorus (268 mg). Abubakar *et al.* (2015) analysed the nutritional composition of unprocessed finger millet (*Eleusine coracana*) that showed moisture, ash, fibre, protein levels being (11.75% ± 0.06, 2.2% ± 0.02, 1.20% ± 0.05 and 2.92% ± 0.03), respectively. Singh and Raghuvanshi (2012) reported the ash content of ragi varies from 1.7- 4.13 per cent with the protein content of nearly 7 per cent protein. Wide variations were reported in protein content from 5.6- 12.70 per cent in some studies. Calcium content ranges from 162 to 487 mg %.

Amino acid content (dry weight basis) :

The amino acid content of raw and malted ragi has been given in the Fig. 1. Raw and malted ragi were evaluated for tryptophan, methionine and lysine content. Banusha and Vasantharuba (2013) revealed that there was a significant increase (p< 0.05) in free amino acid content and a significant decrease (p< 0.05) was observed in total protein during malting of both finger millet and mung bean for 36 hours. Tryptophan content of raw and

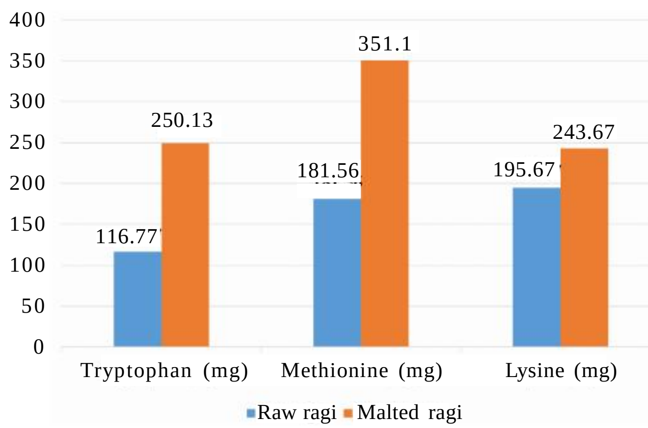

Fig. 1 : Amino acid content of raw and malted ragi (mg per 100 g dry weight basis)

Table 1 : Proximate composition of raw and malted ragi (dry weight basis)

Proximate composition	Raw ragi	Malted ragi	t-test
Moisture (%)	7.76±0.10	7.28±0.59	1.38 NS
Crude Protein (%)	4.6±0.58	7.11±0.95	3.91*
Crude Fat (%)	3.06±0.45	2.31±0.72	1.53 NS
Crude Fibre (%)	14.8±1.10	11.74±1.48	2.88*
Ash (%)	2.85±0.87	4.13±0.50	2.22*
CHO (g)	66.93±4.71	67.43±2.08	0.16 NS
Energy (Kcal/100g)	314±5.75	319±8.05	0.91 NS

Values are Mean ± S.D.
* indicates significance of value at P=0.05
NS – Non significant

malted ragi were found to be 116.77 mg and 250.11 mg per 100 g, respectively. Methionine content was found to be significantly higher ($P \leq 0.05$) in malted ragi i.e. 351 mg as compared to raw ragi *i.e.* 181.56 mg per 100 g. Lysine content of raw ragi was found to be 195.67 mg and that of malted ragi was 243.67 mg per 100 g. Chandra *et al.* (2016) revealed that ragi has 0.3 g/100 g of arginine, 0.13 g/100 g of histidine, 0.22 g/100 g of lysine, 0.10 g/100 g of tryptophan, 0.31g/100 g of phenylalanine, 0.22 g/100 g of tyrosine and 0.21 g/100 g of methionine.

Anti- nutritional components (dry weight basis) :

The anti- nutritional components of raw and malted ragi has been given in the Table 2. Raw and malted ragi were evaluated for phytate, total phenols and trypsin inhibitor activity content. Phytate content of raw and malted ragi were found to be 175 mg and 72.67 mg per 100 g, respectively. Chaudhary and Vyas (2014) reported that phytic acid content in the premixes prepared from pulse, oilseed and millet was decreased from 1.88 mg/100 g (non-germinated sample) to 0.33 mg/100 g in 48 hours (germinated sample). Oxalic acid also reduced from 25.63 mg/100 g (control) to 6.73 mg/100 g in 48 hours (germinated sample). Abubakar *et al.* (2015) revealed that in unprocessed finger millet (*Eleusine coracana*), anti-nutritional composition showed cyanide, oxalate, tannin and phytic acid content (0.44 mg/kg, 0.27 mg/100 g, 0.989% and 0.348%), respectively. Total phenol content was found to be significantly higher ($P \leq 0.05$) in raw ragi *i.e.* 4.1 mg as compared to malted ragi *i.e.* 1.08 mg per 100 g. In a study, Rani and Antony (2014) analysed the polyphenol content in four different varieties of ragi and revealed that after 0, 6, 12, 18, 24, 36 and 48 hour of germination the polyphenol content was significantly decreased. The trypsin content of raw ragi was found to be 0.39 mg and that of malted ragi was 0.28 mg per 100 g. Mwikya *et al.* (2000) revealed that the antinutritional factors along with phytates and tannins decreased multifolds, trypsin inhibitor activity decreased threefold. After 48 hours of germination, the viscosity and starch content also decreased with the increase in sugar content. Mamiro *et al.* (2001) reported that after the process of soaking, germination, autoclaving and fermentation among ragi (*Eleusine coracana*) and kidney beans (*Phaseolus vulgaris*) phytic acid content was reduced by 85 per cent in ragi and 66 per cent in kidney beans by the overall processing.

Available carbohydrates (dry weight basis) :

The available carbohydrates of raw and malted ragi has been given in Fig. 2 and 3. Raw and malted ragi were evaluated for total soluble sugars, reducing sugars, non-reducing sugars and starch. The total soluble sugar content of raw and malted ragi were found to be 5.32 g and 5.60 g per 100 g, respectively. Reducing sugars were found to be significantly higher ($P \leq 0.05$) in malted ragi *i.e.* 2.83g as compared to raw ragi *i.e.* 2.49 g per 100 g. Non reducing sugars of raw ragi were found to be 2.82 g and that of malted ragi was 2.76 g per 100 g. The starch content of malted ragi was 0.86 g and that of raw ragi was 0.82 g. Thippeswamy *et al.* (2016) reported that the resistant starch in ragi flour was found to be less than 0.2

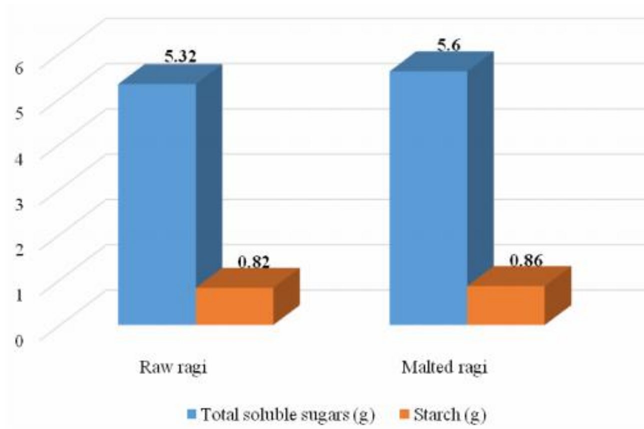

Fig. 2 : Total sugar and starch content of raw and malted ragi (g per 100 g dry weight basis)

Table 2 : Anti- nutritional components of raw and malted ragi (mg per 100 g dry weight basis)

Anti-nutritional factors	Raw ragi	Malted ragi	t-test
Phytates (mg)	175.1±3.2	72.67±4.5	32.1*
Total Phenols (mg)	4.1±0.4	1.08±0.03	14.4*
Trypsin inhibitor activity (mg)	0.39±0.2	0.28±0.02	1.06 NS

Values are Mean ± S.D.
* indicates significance of value at P=0.05
NS=Non-significant

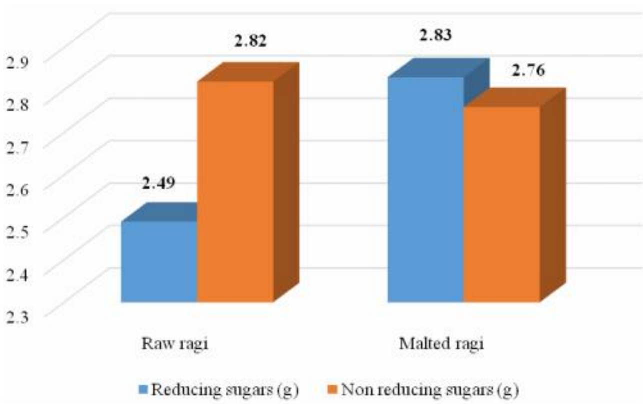

Fig. 3 : Reducing and non-reducing sugars in raw and malted ragi (g per 100 g dry weight basis)

per cent. However, dietary fibre: insoluble dietary fibre, soluble dietary fibre and total dietary fibre were estimated to 10.56, 1.06, 11.62 per cent and 12.22, 1.23, 13.44 per cent on as is basis and dry basis, respectively. Abubakar *et al.* (2015) analysed the nutritional composition of unprocessed finger millet (*Eleusine coracana*) which showed large volume of carbohydrate and lipid (79.53% ± 0.03, 2.4% ± 0.02), respectively. The total carbohydrate content of ragi was reported to be in the range of 72 to 79.5 per cent (Singh and Raghuvanshi, 2012).

Nutritional composition of different forms of ragi revealed that raw form contained less amount of nutrients as compared to the malted form. Amino acid content of malted ragi was found to be higher than raw form and it can be a good compliment to millets which are limiting in these amino acids. Malting leads to considerable decrease in the amount of antinutritional factors. The malted form of ragi can be included in the diets of patients suffering from osteoporosis. It can also be incorporated among vermicilli, noodles, Indian sweet (*Halwa*) mixes, papads, pasta, soups and bakery products. Ragi has wound healing, anti- ulcerative, cholesterol lowering and blood glucose lowering properties in it. The study revealed that processing of magi into malted form should be done in order to enhance nutrient content.

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