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Research Article

DEVELOPMENT OF MILK BASED MALTED FINGER MILLET (RAGI) PORRIDGE: EFFECTS OF MALTING OF FINGER MILLET ON COMPOSITIONAL ATTRIBUTES

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ABSTRACT

Finger millet (*Eleusine coracana*) is also known as Ragi in India. Malting of finger millet improves its digestibility, sensory and nutritional quality as well as has pronounced effect on lowering the anti-nutrients. Milk can act as a potent carrier for the development of value added products based on ragi. The objective of this study was to develop milk based malted ragi porridge as well as to study the effect of malting on the composition of milk based ragi porridge. Inclusion level of malted ragi flour (4%, 5% and 6%) in milk was optimized for the preparation of milk based malted ragi porridge. Based on the results of sensory evaluation, it was found that 5% malted ragi flour in milk was the optimum level to develop porridge. Malting was observed to have significant ($P<0.05$) positive influence on protein, ash, crude fiber and acidity levels when compared with control (porridge containing unmalted ragi flour). Malting also resulted in increased content of calcium, phosphorus and vitamin C in porridge in comparison to control.

Key words: Eleusine Coracana, Finger millet, malting, porridge, ragi

Milk and dairy foods are nutrient-dense foods supplying energy and significant amounts of protein and micronutrients. The inclusion of dairy products adds diversity to plant-based diets. Milk driven value added products make a significant contribution to meet the body's needs for minerals and vitamins. Milk proteins are outstanding sources of essential amino acids. Milk has always been a choice of innovation for food researchers to meet the ever changing consumer's preferences. The processing of milk and milk products leads to generation of many functional compounds beneficial to human health but most of these foods are rich in fat and deficient in dietary fiber and may pose danger of cardiovascular diseases, colon cancer, obesity including diabetes mellitus. So, the incorporation of dietary fibers from different sources would enhance the desirability of milk products.

Ragi (Finger Millet; *Eleusine coracana*) is in use since time immemorial, and a large number of its traditional food preparations are in practice in the rural areas. It contains high levels of fibre, minerals and vitamins and has eight times more calcium (344 mg/100 gm) than other cereals (Verma and Patel, 2013). It contains important amino acids viz., isoleucine, leucine, methionine and phenylalanine which are deficient in other starchy meals. It is comparable to rice with regards to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to minerals and micronutrient contents (Verma and Patel, 2013). Ragi has gained importance because of its slowly digestible and resistant starch (Wadikar *et al*., 2007) and has low glycemic index which makes it suitable for diabetic patients (Pradhan *et al.*, 2010).

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Malting of ragi improves its digestibility, sensory and nutritional quality as well as pronounced effect in the lowering the anti nutrients. There are various benefits of malting such as vitamin-C is elaborated, phosphorus availability is increased and lysine and tryptophan are synthesized (Desai *et al*., 2010). The malted and fermented ragi flour are extensively used in preparation of weaning food, instant mixes, beverages and pharmaceutical products (Rao and Muralikrishna, 2001). Ragi porridge serves as an ideal low calorie diet for all age groups especially growing infants, pregnant women and old age people. Hence this study was undertaken with the objective to develop milk based porridge by incorporation of malted ragi and to assess the influence of malting on organoleptic, physicochemical and nutritional qualities of milk based ragi porridge.

MATERIALS AND METHODS

The present study was carried out in the Department of Livestock Products Technology, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar. The study was carried out in multiple steps. First the control (milk based unmalted ragi porridge, MBURP) was prepared by incorporation of unmalted ragi flour (URF) (5%) in homogenized toned

milk (200 ml) along with the addition of sugar (6%) and flavor (a pinch of cardamom powder he second step, unmalted ragi grains were germinated, malted and milled to obtain malted ragi flour (MRF). In the third step, milk based malted ragi porridge (MBMRP) was developed using different levels of MRF in homogenized toned milk along with the addition of sugar and flavour (cardamom). Finally, experiments were conducted to assess the influence of malting on organoleptic, physicochemical and nutritional attributes of milk based ragi porridge. There were three replicates for control and nine for experimental product.

Raw Materials: Adequate quantity of brown ragi (Indaf-15cultivar), homogenized toned milk (Amul Taaza; composition per 100 gm as energy (58.20kcal), moisture (88.50g), carbohydrate (4.80g), protein (3.00g), fat (3.00g), ash (0.70g) and crude fiber (0.00g). Sugar and flavour (cardamom) were procured from local market. Chemicals used in the study were of analytical grade.

Preparation of Control Porridge (MBURP): Cleaning and washing of ragi seeds was done. Seeds were soaked in water for 12-14 h, drained, dried in sun and roasted on low flame and then milled to obtain fine URF. Homogenized toned milk (200 ml) was heated in a pan and 10 g (5%) of URF was added to it with continuous stirring to avoid lump formation. Temperature was raised to boiling. After a boil, cooking was done at low flame until it gained porridge like consistency. Sugar (12 gm; 6%) was added at the end of cooking and a pinch of cardamom powder was added to the slightly cooled product for flavour. The product was presented to the judging panel at lukewarm temperature for sensory evaluation. After cooling, product was packed in polystyrene cups and stored at refrigerated temperature.

Malting of Whole Ragi Grains: Cleaned and washed ragi seeds were soaked in water and kept at 25-30^{0}C for 12 h, drained and were allowed to germinate for about 36-48 h by keeping at 25-30^{0}C in a muslin cloth to obtain germinated ragi seeds. These germinated seeds were mechanically dried in a hot air oven at 50$\pm$2^{0}C for 2-3 h to stop the germination. Kilning/roasting was done in a conventional toasting pan at a temperature of 73$\pm$2^{0}C to develop characteristic aroma and desirable quality of product. Finally, malted ragi seeds were milled to obtain fine MRF.

Preparation of Experimental Porridge (MBMRP): Homogenized toned milk (200 ml) was heated in three separate pans and three different levels (MBMRP1, 4%; MBMRP2, 5% and MBMRP3, 6%) of MRF were added separately to each pan while continuous stirring to avoid lump formation. Contents in each pan were made to boil. Remaining procedure was same as adopted for the preparation of MBURP.

Selection of Level of Ragi for Experimental Porridge (MBMRP): Sensory evaluation was carried out in terms of color and appearance, flavour, consistency and overall acceptability for selection of experimental porridge. Malted ragi porridges having different levels of MRF(MBMRP1, MBMRP2 and MBMRP3) were put on trial along with control (MBURP) having URF. Nine point hedonic scale was employed for the evaluation of samples. Based on sensory evaluation conducted by a panel of semi trained judges on this scale, milk based ragi porridge containing 5% MRF (MBMRP2) was selected as final experimental product for further studies.

Nutritional Composition of URF and MRF: URF and MRF were subjected to proximate analysis such as moisture, protein, fat, crude fiber and ash content. The total carbohydrate was calculated by difference. The standard procedures given by AOAC (2007) were used for all the above determinations.

Proximate Composition of Milk Based Ragi Porridge (MBRP): Both MBURP and MBMRP were analyzed for proximate, nutritional and physico-chemical parameters. Proximate composition, moisture and total solids contents were determined following the standard methods of AOAC (2007). Protein estimation was done by Kjeldahl method using Kjel-plus digestion system and semiautomatic distillation system (Pelican Equipments, Chennai). Fat extraction was done by Roese-Gottlieb method using Mojonnier tube following the methods of AOAC (2007). Ash content was determined by gravimetric method as described by AOAC (2007) using muffle furnace.

Physicochemical Analysis of MBRP: The titratable acidity of samples was determined by the method described by AOAC (2007).

Nutritional Composition of MBRP: Total carbohydrates were calculated by difference of other

Table 1
Proximate composition of ragi grain flour

Parameters (%)	Ragi flour	
	Unmalted	Malted
Moisture	12.68±0.01	12.69±0.17
Carbohydrate	77.42±0.02	76.85±0.02
Protein	7.30±0.03	7.50±0.05
Fat	1.08±0.02	1.10±0.04
Crude fiber	3.60±0.07	3.90±0.03
Ash	1.60±0.01	1.85±0.02

Results are mean ±SD of three determinations. Mean ±SD

components viz., fat, protein, ash and moisture content. Total energy was calculated by considering that 1 g of fat contributes 9.3 calorie of energy while 1 g of protein and carbohydrates contribute 4.1 calorie of energy. Crude fibre of the samples was assessed as per the non–enzymatic method of AOAC (2007). Samples were defatted by using SOCSPLUS extraction apparatus.

Minerals and Vitamin C Content of MBRP: Reference for calcium, phosphorus, iron and vitamin C contents of URF and MRF were taken from the reports of Desai *et al*. (2010). Mineral composition of milk and sugar in terms of calcium, phosphorus and iron were referred from the work done by Gopalan *et al.* (2009) and reference for vitamin C content in milk was taken from the work done by Cremin and Power (1982). Based upon the above mentioned reports, minerals and vitamin C values for porridge samples were calculated.

Statistical Analysis: Data obtained were subjected to statistical analysis using Duncans Multiple Range Test by using SPSS software for finding out the significant difference in the mean values (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Proximate Composition of Ragi Grain Flours (URF and MRF): Proximate composition of ragi grain flours is depicted in Table 2. The compositional analysis of unmalted ragi flour and malted ragi flour revealed that upon malting, there was an increase in protein ash, fat and crude fiber contents. However, the carbohydrate content decreased upon malting. Moisture content remained almost same. The results of the present study are in close agreement with WHO (1998) which reported that the increase in protein could be attributed to a net synthesis of enzymic protein by germinating seeds. The results are also in close proximity with the average composition of unmalted and malted ragi flour reported by Desai *et al.* (2010).

Sensory Evaluation for Selection of Ragi Level for Experimental Porridge: Sensory scores of milk based ragi porridge are depicted in Table 3. For colour and appearance, MBMRP2 was scored significantly ($P \leq 0.05$) higher than MBMRP1 and non-significantly higher than MBURP and MBMRP3 by the judges. For flavour, judges preferred MBMRP2 significantly higher as compared to MBURP, MBMRP1 and MBMRP3. The consistency of MBMRP2 was evaluated significantly higher in comparison to MBMRP1 and non-significantly higher than MBURP and MBMRP3 by the judges. With respect to overall acceptability scores, MBMRP2 was scored significantly higher as compared to MBURP, MBMRP1 and MBMRP3 samples.

It was evident from the results that MBMRP prepared by combination of 5% MRF with milk was organoleptically the most acceptable to the panelists within the ratios studied. Therefore MBMRP with 5% MRF was selected for further study. The results are in close agreement with Malleshi and Desikachar (1986) and Pawar and Dhanvijay (2007) who reported that malting of finger millet improves the sensory and nutritional qualities.

Proximate Composition of Milk Based Ragi Porridge: The results of proximate composition (Table 3) revealed that there was a non-significant ($P>0.05$) difference in moisture and total solids contents of MBURP and MBMRP2. Fat content of both MBURP and MBMRP2 showed no difference at all. However, protein and ash contents as well as % acidity were found significantly higher in MBMRP2 in comparison to MBURP. The results pertaining to protein contents in this study are in a close agreement with Hassan *et al*. (2006) who reported that the augmentation in the protein content of germinated grains of pearl millet cultivars might be due to quantitative reduction in the anti- nutritional factors such as tannin, phytic acid, polyphenols which are known to interact with protein to form complexes.

The results pertaining to fat content are in agreement with the findings of Desai *et al.* (2010) who reported no significant differences in the fat content of unmalted

Table 2

Sensory scores of milk based ragi porridge prepared using different levels of malted ragi flour

Sensory attributes	Milk based ragi porridge			
	URF	MRF		
	MBURP	MBMRP1	MBMRP2	MBMRP3
Colour and appearance	$7.61^{ab}\pm0.12$	$7.28^{b}\pm0.14$	$7.89^{a}\pm0.08$	$7.61^{ab}\pm0.12$
Flavour	$7.72^{b}\pm0.11$	$7.50^{b}\pm0.12$	$7.89^{a}\pm0.10$	$7.55^{b}\pm0.12$
Consistency	$7.55^{ab}\pm0.12$	$7.22^{b}\pm0.15$	$7.66^{a}\pm0.11$	$7.50^{ab}\pm0.12$
Overall acceptability	$7.72^{b}\pm0.09$	$7.27^{b}\pm0.14$	$7.94^{a}\pm0.05$	$7.50^{b}\pm0.11$

Mean±SE; n=18; Means bearing different superscripts in a row differ significantly ($P \leq 0.05$). MBURP=Milk based ragi porridge containing 5% URF; MBMRP1=Milk based malted ragi porridge containing 4% MRF; MBMRP2=Milk based malted ragi porridge containing 5% MRF; MBMRP3=Milk based malted ragi porridge containing 6% MRF

Table 3
Proximate composition of milk based ragi porridge

Parameters (%)	Proximate composition of	
	MBURP	MBMRP2
Moisture	73.68^{a}±0.11	73.70^{a}±0.09
Total solids	26.32^{a}±0.09	26.30^{a}±0.11
Protein	3.35^{b}±0.00	3.45^{a}±0.00
Fat	3.05^{a}±0.02	3.05^{a}±0.02
Ash	0.88^{b}±0.00	0.99^{a}±0.00
Acidity	0.31^{b}±0.00	0.41^{a}±0.00
Total carbohydrates (%)	19.00^{a}±0.06	18.81^{b}±0.05
Crude fiber (%)	0.20^{b}±0.00	0.32^{a}±0.00
Energy (cal/100g)	120.00^{a}±0.07	119.67^{b}±0.16
Calcium	138.69	142.21
Phosphorus	104.28	105.34
Iron	0.89	0.83
Vitamin C	2.11	2.30

Mean+SE, n=9, Means with different superscripts within a row differ significantly ($p \leq 0.05$). MBURP=Milk based ragi porridge containing 5% URF; MBMRP=Milk based malted ragi porridge containing 5% MRF. Minerals and vitamin C values are based upon calculations

(1.08%) and malted (1.14%) ragi flours. It could be the reason for same levels of fat content in both MBURP and MBMRP2 samples. The results with respect to ash content were in strong agreement with the findings of Subastri *et al*. (2015) who prepared *koozh* (water based finger millet porridge) by using germinated and non-germinated ragi flours. They observed that the germination of finger millet increased the mineral contents.

The results with respect to acidity levels are in accordance with Inyang and Zakari (2008) who reported that acids were produced during germination of pearl millet which helped to preserve the product.

Nutritional Composition of Milk Based Ragi Porridge: The results revealed that a significant ($P \leq 0.05$) decrease in total carbohydrates and energy contents whereas a significant increase in crude fiber content was noticed in MBMRP2 in comparison to MBURP (Table 3). This reflected that malting reduced the carbohydrate content of milk based ragi porridge Lasekan (1996) reported that the decrease in carbohydrate levels might be due to increase in alpha-amylase activity. The alpha-amylase breaks down complex carbohydrates to simpler and more absorbable sugars which are utilized by the growing seedlings during the early stages of germination.

The reason for the significant increase in crude fiber content in MBMRP2 as compared to MBURP might be the crude fiber levels in MRF (3.9%) and UMRF (3.6%). Inyang and Zakari (2008) reported significantly higher crude fiber content in germinated *fura* (2.38%) as compared to traditional *fura* (2.33%). The significant decrease in energy levels in MBMRP2 might be attributed to its significantly lower total carbohydrate levels as compared to MBURP sample.

Minerals and Vitamin C Composition: Results pertaining to minerals and vitamin C are depicted in Table 3. MBMRP2 was found to have higher levels of calcium, phosphorus and vitamin C in comparison to MBURP whereas iron content was lower in MBMRP2. Sangita and Sarita (2000) reported that during malting, calcium and phosphorus content increased whereas iron content decreased in malted finger millet flours. Taur *et al*. (1984) reported that the increase in vitamin C content after malting was attributed to the enzymatic hydrolysis of starch by amylases and diastases, which degraded starch and produced glucose. This increased amount of glucose became the precursor of vitamin C.

Based on the findings of this study, it was observed that milk based ragi porridge developed by using 5% MRF had higher sensory acceptance in terms of color and appearance, flavour, consistency and overall acceptability. Malting of ragi was found to increase the levels of protein, ash, crude fiber and titratable acidity in the porridge sample. The contents of calcium, phosphorus and vitamin C were higher in the milk based malted ragi porridge in comparison to unmalted ragi porridge. Hence, the study indicates that the development of malted ragi porridge by using optimum combination of milk and malted ragi can prove to be beneficial milk driven value added product.

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