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RESEARCH ARTICLE

ENHANCEMENT OF NUTRITIONAL AND SENSORIAL ATTRIBUTES OF *MURUKKUS* BY ACCOMPANIMENT OF MALTED FINGER MILLET *(ELEUSINE CORACANA)*

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ABSTRACT

Food is a most essential surviving tool fulfilling the basic requirement of hunger and also preserves essential nutrients for good health. Market is flooded with variety of Ready to eat products which are calorie dense foods as well as poor nutrient source. Malting process awakens/activates the enzymes, resulting in the conversion of starch to fermentable sugars, partial hydrolysis of proteins other macromolecules hereby increasing the bioavailability of nutrients. In the present study, finger *milletgrains* were malted by providing favorable time and temperature and were analyzed for proximate and chemical composition. The raw materials traditionally referred to as essential in *murukkus* manufacturing, i.e. rice flour, and was targeted for reduction by replacing finger millet malt to obtain murukkus. *Murukkus* were tried in both forms (fried/baked), thus standardized for two variations i.e. 40 % and 60 %. The mean scores for control and experimental variations for *murukkus* were analyzed statistically at 5 % significance level. Sensory evaluation and consumers preference data reveals that *murukkus* (fried) with 60 % and *murukkus* (baked) with 40 % of finger millet malt incorporation respectively, were most acceptable and preferred products.

INTRODUCTION

In ancient India, finger millet (*ragi*) *(Eleusine coracana)* was a well-domesticated plant in various states. It was traditionally referred as *nachni* (meaning dancer) in Maharashtra, *umi* in Bihar, etc. (Achaya, 2009). It complement as a fundamental food for a large division of the population in these countries. It ranks sixth in production after wheat, rice, maize, sorghum and *bajra* in India. It is generally used in the form of the whole meal for preparation of traditional foods, such as roti (unleavened breads or pancake), muddle (dumpling) and *ambali* (thin porridge). Finger millet contains about 5–8 % protein, 1–2 % ether extractives, 65–75 % carbohydrates, 15–20 % dietary fiber and 2.5–3.5% minerals (Chethan and Malleshi, 2007).It has the highest Calcium content among all cereals (344 mg/100 g), contains Phosphorous 283 mg/100g and Iron 3.9 mg/100g. Studies revealed that finger millet contains 11.5 % dietary fiber which is considerably higher than the fiber content of brown rice or polished rice (Gopalan, Ramasastri and Balasubramanian, 2004).

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Lamently besides so many advantages allied with this traditional millet still this millet is extensively consumed by only poor farmers or as an animal feed in major part of the country Malting is a controlled germination process which activates the enzymes of the resting grain resulting in the conversion of starch to fermentable sugars, partial hydrolysis of proteins and other macromolecules (Potter, 1995). Malting serves the purpose of converting insoluble starch to soluble starch, reducing complex proteins, generating nutrients for yeast development, and the development of enzymes (Goldammer, 2008). According to many studies malting has been the active and expedient way for value addition of cereals (Adeyemo, Olayode and Odutuga, 1992; Akpapunam, Igbedioh and Aremo, 1996). Presently there is a good fortune in developing food products by blending composite malted cereals and legumes as a pathway towards refining the nutritional quality of the product suitable for improving children's health (Agu and Aluva, 2004). Snacks contribute an important part of many consumers in daily nutrients and calories intake (Detweiler, 1991). The nutritional awareness amongst the consumers has warranted the production of low calorie food products with an increased fiber content that can be readily included in the balanced diet. *Murukkus* are

predominately based on rice flour and the blending of rice flour with millet can upgrade the nutritional quality of such products. Moreover traditionally the murukkus were prepared by frying hence baking murukkus can make them less calorie dense product. The use of composite flours in the production of baked products especially baked products especially in bread, cookies, crackers that are targeted at consumers who are gluten sensitive or diabetic is becoming a very normal practice (Pathriana and Sivayogasundaram and Jayatissa, 1983). Millets are rich source of dietary fiber, phytochemicals, micronutrients, nutraceuticals, and hence now a days they are rightly termed as nutricereals *Murukkus* may be regarded as relatively simple cereal based food products commonly consumed as snack food to answer the occasional pangs of hunger. *Murukku* is a savory snack popular in India and Sri Lanka, originating in the cuisine of the Indian state of Tamil Nadu. It is also popular in places with large Tamil populations, such as Fiji and Malaysia. Because of its taste and easy preparation, it is now a widely available snack. *Murukku* is typically made from a mixture of split black gram dal and rice flour, salt, and flavorings such as chili, asafoetida, *ajawain,*cumin seeds and other spices (The Hindu, 2010).

MATERIALS AND METHODS

Raw material: Dehusked finger millet, rice flour, salt, cumin seeds, asafoetida and vegetable oil were procured from local market, Delhi.

Preparation of finger millet malt flour

Finger millet malt (FMM) was prepared according to the method given by Pathirana et al, 1983 with slight modifications. Finger millet grains were steeped for 18 h at room temperature and allowed to sprout for 120 h. Grains were dehydrated for 60 mins at 60 °C. Further rootlets of grains were removed and powdered to obtain flour for later usage.

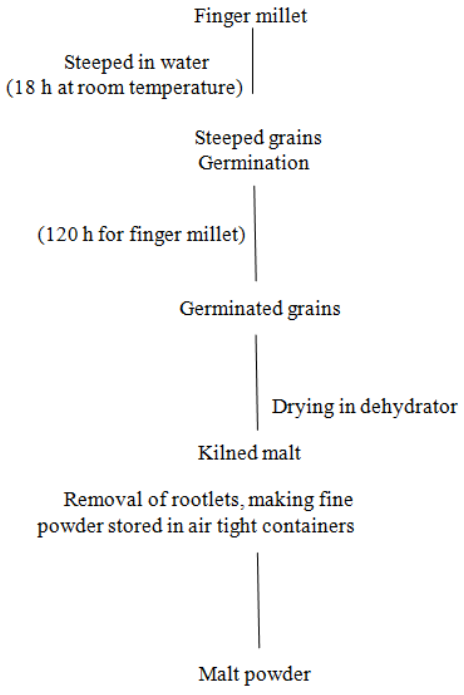

Fig. 1. Preparation of finger millet malt flour

The wheat flour, finger millet flour, finger millet malt flour were subjected to proximate analysis such as moisture, protein, fat, crude fiber and ash content. Moisture, ash and fat contents were assayed by the Association of the Official Analytical Chemists (AOAC, 1984) methods 14004 (1984), 14009 (1984) and 14006 (1984) respectively. Nitrogen was determined using the CHN analyzer (Elementar CHN analyzer). The quantity of protein was calculated as 6.25×N. Crude fiber and ash content were analyzed by the standard procedure given by Ranganna, 1986. The total carbohydrate was calculated by difference. Along with this in all the three flours Iron, calcium, phosphorus content were estimated. Metal ions (Iron, Calcium and Phosphorous) concentration in different flour samples were determined after digestion. 0.3 g of samples were digested with 6 mL of nitric acid along with 1 mL of hydrogen peroxide in microwave digester (Anton Paar Multiwave Pro) using standard method by Agilent Technologies. The digested solution was filtered through Whatman no.1 filter paper, and filtrate was further diluted accordingly and quantified through Microwave plasma- atomic absorption spectroscopy (4100 MP-AES Agilent Technologies).

Standardization and development of murukkus

Murukkus were prepared by moderately substituting rice flour with 40, 50, 60, and 75 % of finger millet malt flour (FMM). The percent escalation in substitution was done till they were acceptable and the murukkus can be easily fried/ baked without breakage (Table 1). Recipe of the standardized *murukkus* was as follows- rice flour mixture (100 %), washed black gram pulse (20 %) and fat (50 %). Preparation was as follows firstly, cereal + pulse mixture (rice flour, washed black gram pulse, finger millet malt flour), salt, cumin seeds, oil and asafoetida were mixed to develop a firm dough using warm water simultaneously. The dough was allowed to rest for some time after that dough is filled in the *Murukku presser* and *murukkus* were shaped and simultaneously fried in hot oil on slow flame. Along with it *murukkus* were baked at 180 C for 20 mins. After frying and baking *murukkus* were allowed to cool down and kept in air tight containers for further analysis.

Table 1. Basic recipe for making murukkus (fried/baked)

Ingredients	Amounts (g)
Rice flour	80
Washed black gram dal	20
Cumin seeds	¼ t
Asafoetida	¼ t
Salt	½ t
Refined oil (for dough)	35

Source: http://www.sanjeevkapoor.com/Recipe/Murukku.html

Standardization was done by replacing rice flour with finger millet malt flour at various levels i.e. 40, 50, 60 and 75 % respectively.

Sensory evaluation

Sensory evaluation was done on freshly made *murukkus*. Fifty panel members of Institute of Home Economics including faculty and Masters Students were randomly chosen for evaluating sensory attributes of freshly prepared *murukkus*. The attributes evaluated were appearance, color, texture, after taste, overall acceptability. For each sample of *murukkus*,

panelists scored their liking of these characteristics using the five point hedonic scale (1= unsatisfactory, 2= satisfactory, 3= good, 4= very good, 5= excellent)

Statistical analysis of data

The statistical analysis was conducted using the SPSS package. The sensory analysis was statistically analyzed. Analysis of variance and Tukey's HSD was used to assess significant differences between means at 5% level of probability. Each experiment (in triplicate) repeated at least twice and the values presented in terms of means ± standard deviation.

RESULTS AND DISCUSSION

Proximate composition of wheat flour and finger millet flour
The proximate composition of wheat flour is given in Table 2. The data showed that rice flour is a good source of protein and minerals. The proximate compositions of finger millet flour and finger millet malt flour were also illustrated in Table 2. Malting is an unpretentious biotechnological technique to bring about abundant proliferation in enzyme activities and causes predigestion of carbohydrates and protein in legumes (Ghavidel and Davoodi, 2011). Besides that malting brings no significant changes on protein and fat contents. According to Malleshi and Desikachar, 1986 malting of finger millet improves not only its digestibility but parallelly progresses the bioavailability of nutrients resulting in holistic enhancement of its sensory and nutritional quality. Results in Table 3, apparently indicates that the malting technique is a valuable, advantageous and a low cost process to escalate calcium and phosphorus content of finger millet flour. Results indicated increase in minerals from the untreated finger millet. This is could be due to the binding of minerals to the antinutritional factors such as phytate which are predominantly present in finger millet. Malting is one of the successful technique in reducing phytate content. Study conducted by Larsson et al. malting and soaking of oats reduces the phytate content and hereby increasing the Zinc and iron content in oats. Malting and soaking of oats condensed the phytate content by 77% and folded the amount of Zn absorbed in comparison to the with oat porridge prepared from untreated oats. Similar increase in iron absorption was observed i.e. around 47 % from oat porridge (Larson, Sandstrom and Sandberg, 1996). Similarly sprouting of finger millets resulted in increase in calcium, iron and Zinc from 76.9, 18.1 % and 65.3 % in the raw grain to 90.2 %, 37.3 % and 85.8 % respectively (Mwikya et al., 2000).

Standardization and development of murukkus fried/baked with finger millet malt flour

In Table 4, different levels of finger millet malt flour were tried to replace the maximum amount of rice flour in standardized recipe. It is important to incorporate maximum amount of malt powder to make *murukkus* more nutritious containing nutrients with high bioavailability and easy digestibility by the body. Results in table 4 indicates that variation I and II had good taste and texture with no after taste whereas variations III had a slight after taste of malted finger millet baked and fried *murukkus* but was liked by all and acceptable. On the other hand, variation IV had bitter taste and was unacceptable. Therefore, out of all the variations the two variations were selected i.e. variation I and variation III were finalized for sensory evaluation by panelists (40) which included faculty members and students of Masters in Foods and Nutrition Department, Institute of Home Economics, University of Delhi who analyzed the product. Both the fried and baked *murukkus* were equally acceptable, when the incorporation levels of malted finger millet was 40 % and 60 %. Hence, optimum incorporation level of finger millet malt in fried/ baked *murukkus* for final product were 40 % and 60 % given in Table 5.

Sensory characteristics of finger millet malt flour murukkus (fried)

Murukkus were prepared by replacing rice flour with malted finger millet flour with two variations i.e. at 40% and 60% incorporation level along with control as indicated in Table 6. A comparison of means of sensory attributes namely appearance, color, texture, after taste and overall acceptability has been done. According to the data in table 6 revealed that mean scores for appearance, texture, taste, after taste, overall acceptability were comparable for all the three products and there was no significant difference between the three whereas for color the mean score of fried finger millet *murukkus* with 40 % malted finger millet flour was significantly different from control *murukkus* and was least acceptable of all. Mean score of 60 % malted finger millet flour was same as compared to control fried *murukkus* and the difference of 4.17 % was insignificant at 5 % level. Therefore, *murukkus* fried made with 60 % malted finger flour were similar to control *murukkus* and rating lies above good. Similarly a study by Vidyavati et al., 2004 on preparation of baked / fried *papad* by finger millet reported that finger millet flour can be blended up to 50 % with black gram dal flour to prepare *papad* of acceptable quality. Mean scores of *murukkus* made with 60 % malted finger millet flour were found to have no significant statistical difference from mean score of control *murukkus* at 5 % level. Though the *murukkus* made with 40 % malted finger millet flour have a significant difference from control *murukkus* but there was only a difference of 4.96 % between them. A study by Dharmaraj and Malleshi, 2010; Ushakumari, 2009 used seed coat matter from nger millet as an ingredient in composite our. It is one of the unique approaches to enhance the nutritional value of the biscuits. To improve the nutritional value further, the finger millet grains are processed by hydrothermal treatment which signi cantly alters the nutrient pro le and functional properties of nger millet in the product. Figure 1 depicts, that 45 % of subjects liked 60 % fried *murukkus,* nearly 10 % of subject liked the 40 % fried *murukkus*when consumers were asked how often they would like to have the product, 70.4 % responded occasionally and 9.6 % responded daily. When asked if consumers would buy if product is available in the market, 70.6 % responded positively while 25.8 % whereas not sure about it.

Sensory characteristics of finger millet malt flour baked murukkus: Baked *murukkus* were prepared by replacing rice flour with malted finger millet flour with two variations i.e. at 40 % and 60 % incorporation level along with control. As indicated in Table 6. A comparison of mean of sensory attributes namely appearance, color, texture, after taste and overall acceptability has been done.

Table 2. Proximate composition of rice flour, finger millet flour and finger millet malt flour

Parameters	Rice flour	Finger millet flour	Finger millet malt flour
Moisture (%)	12.15±0.23	11.6±0.35	11.95±0.37
Protein (%)	09.04±0.11	7.30±0.18	7.83±0.14
Fat (%)	1.42±0.17	1.07±0.05	1.15±0.14
Crude fiber (%)	2.52±0.02	3.21±0.05	3.91±0.06
Total carbohydrate (%)	80.46±0.74	74.47±0.41	73.28±0.63
Ash (%)	0.82±0.04	1.48±0.20	1.88±0.16

*Values are mean ± standard deviation of triplicate independent determinations (dry weight basis).

Table 3. Content of certain minerals in rice flour, finger millet flour and finger millet malt flour (mg/100g)

Parameters	Rice flour	Finger millet flour	Finger millet malt flour
Calcium (mg/100g)	10.66±2.51	370.46±1.55	412.6±1.73
Iron (mg/100g)	0.35±0.06	13.2±0.3	11.6±0.8
Phosphorous(mg/100g)	98.47±0.3	244.06±0.6	298.4±0.9

*Values are mean ± standard deviation of triplicate independent determinations (dry weight basis).

Table 4. *Murukkus* (fried/baked) prepared with finger millet malt flour incorporated at different levels

Variations	Ingredients						Remarks
	Rice flour (g)	Finger millet malt (g)	Washed black gram dal (g)	Oil for dough (g)	Salt (g)	Cumin seeds (g)	
I. (40%)	48	32	20	35	½ t	1 t	Taste- Good (B/F) Texture- Good (B/F)
II. (50%)	40	40	20	35	½ t	1 t	Taste – Good (B/F) Texture- Good(B/F)
III. (60%)	32	48	20	35	½ t	1 t	Taste- Acceptable after taste (F) Acceptable bitterness (B) Texture – Good (B/F)
IV. (75%)	20	60	20	35	½ t	1 t	Taste- Bitter (B/F)

B = Baked F= Fried

Table 5. Different levels of malted finger millet used for final sensory evaluation of fried/baked *murukkus*

Ingredients	Amounts (g)	
	40 %	60 %
Rice flour	48	32
Finger millet malt flour	32	48
Washed black gram dal	20	20
Cumin seeds	¼ t	¼ t
Asafoetida	¼ t	¼ t
Salt	½ t	½ t
Refined oil (for dough)	35	35

Table 6. Effect of finger millet malt flour on sensory characteristics of fried *murukkus*

Characteristics	Mean ± SD			F- Test
	Finger Millet Malt Fried *Murukkus*			
	Control	40% finger millet malt	60% finger millet malt	
Appearance	3.90±0.78^{a}	3.41±0.99^{a}	3.54±1.02^{a}	2.199
Color	3.90±0.87^{b}	3.22±0.84^{a}	3.35±1.01^{ab}	4.798*
Texture	3.77±0.84^{a}	3.70±0.86^{a}	3.67±0.87^{a}	0.102
Taste	3.77±0.84^{a}	3.64±0.79^{a}	3.54±0.88^{a}	0.558
After taste	3.67±0.97^{a}	3.48±0.85^{a}	3.51±0.92^{a}	0.393
Overall acceptability	3.83±0.82^{a}	3.64±0.87^{a}	3.67±0.90^{a}	0.441

Rating on 5-point rating scale. Means scores with different superscripts are significantly different as tested by Tukey's HSD *Significant at $p<0.05$

Table 7. Effect of finger millet malt flour on sensory characteristics of baked *murukkus*

Characteristics	Mean ± SD			F- Test
	Finger millet malt Baked *Murukkus*			
	Control	40% finger millet malt	60% finger millet malt	
Appearance	3.27±1.01^{a}	3.25±0.84^{a}	2.95±0.90^{a}	1.551
Color	3.30±1.04^{a}	3.30±0.97^{a}	2.80±0.79^{a}	2.748
Texture	3.00±1.10^{a}	3.40±0.78^{a}	2.90±1.01^{a}	2.614
Taste	3.00±0.93^{a}	3.10±0.98^{a}	2.90±0.93^{a}	0.491
After taste	2.70±0.99^{a}	2.80±0.95^{a}	2.80±0.89^{a}	0.114
Overall acceptability	2.90±0.95^{a}	3.30±0.89^{a}	3.10±0.92^{a}	2.157

Rating on 5-point rating scale. Means scores with different superscripts are significantly different as tested by Tukey's HSD.

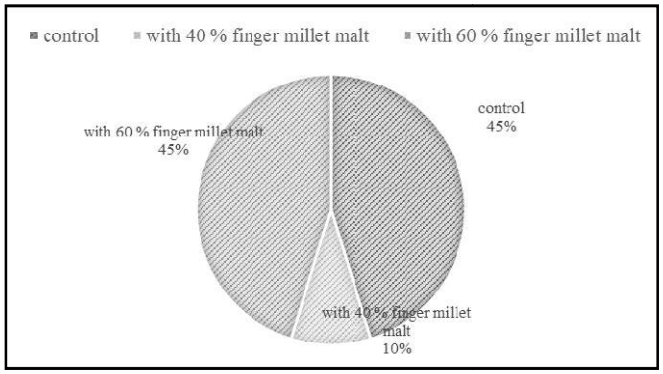

Fig. 1. Consumer preferences for finger millet malt fried murukkus

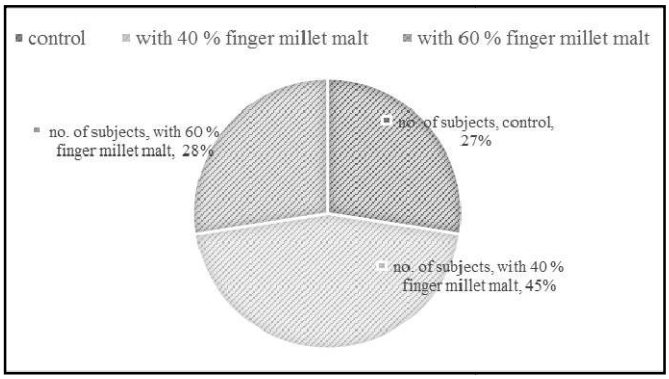

Fig. 2. Consumer preferences for finger millet malt baked murukkus

Rating on 5-point rating scale. Means scores with different superscripts are significantly different as tested by Tukey's HSD. Data in the above table 7 revealed that mean scores for appearance, color, texture, taste, after taste, overall acceptability were same for all the three products. Mean score of *murukkus* made with 40 % malted finger millet flour was same as compared to control *murukkus* and the difference of 13.7 % was insignificant at 5 % level. Therefore, baked *murukkus* made with 40 % malted finger millet flour were similar to control *murukkus* and the rating lies above good. Mean scores of *murukkus* made with 40 % malted finger millet flour were found to have no significant statistical difference from mean score of control *murukkus* at 5 % level. Though the *murukkus* made with 60 % malted finger millet flour were significantly different from control *murukkus* but there was only a difference of 6.89 % between them. Many studies have been done by using composite our based on wheat and other cereals including minor millets in bakery products. It is becoming popular because of the economic and nutritional advantages of these products (Dasappa, Manohar, Jyotsna and Venkateshwara, 2004; Eneche, 1999). There are several more studies on usage of nger millet for preparation of composite our and biscuits (Jisha and Padmaja, 2011; Saha et al., 2011) The study done by Krishnan et al., 2011 also showed that wheat our could be substituted by nger millet seed coat matter up to 20 % level for the preparation of glucose type biscuits. The biscuits from the composite ours contained higher levels of protein, dietary bre, calcium, iron and zinc and may offer the inherent health bene ts of nger millet namely the antioxidants to the consumer. Figure 2 depicts, that 28 % of subjects liked 60 % of baked *murukkus* and 45 % of subjects liked 40 % of baked *murukkus*. When consumers were asked how often they would like to have the product, 57.5 % responded occasionally and 3.75 % responded daily. When asked if consumers would buy if product is available in the market, 50 % responded positively whereas 32.5 % were not sure about it.

Conclusion

Snacking is becoming a common practice especially in children and adults therefore an attempt was made to develop some healthy snacks from processed finger millet malt flour to get the maximum advantage of their nutrient content in terms of bioavailability. All the products with different variations were acceptable to the panel members. Finally 60 % finger millet malt fried *murukkus* and40 %finger millet malt baked *murukkus* replacement were acceptable in *murukkus*. Therefore, malting holds a good potential for improving the nutritional value of finger millet by reduction in antinutrient and thereby enhancing its utilization by developing a specific malt flavor and odor.

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