Development of Healthy Snacks from Finger Millet (Eleusine Coracana) Malt: An Alternative Approach to Functional Foods

Karnika Prakash
Indian institute of Technology - Delhi

Dr. Rajni Chopra
Institute of Home Economics, University of Delhi

Abstract

Food is a most essential surviving tool fulfilling the basic requirement of hunger and also preserves essential nutrients for good health. Finger millet (ragi) (Eleusine coracana) grains were given various processing treatments like malting, germination, blanching, pressure cooking and roasting to reduce the anti-nutritional factors. The most efficacious processing treatment variant is then further used for development of muffins. In the present study, malting resulted in 54.6 % reduction in Phytic acid and 51.2 % reduction in tannic acid respectively. Therefore finger millets were malted by optimizing the sprouting time for 120 h, at ambient temperature and the flour was obtained for development products. Functional muffins were developed and standardized from finger millet malt. The raw materials traditionally referred to as essential in muffin manufacturing, i.e. and refined flour, was targeted for removal or reduction. Proximate analysis and chemical composition of wheat flour, finger millet flour, finger millet malted flour as well muffins developed from these flours respectively reveled that malting increases the bio accessibility of micronutrients. Muffins were prepared and standardized for two variations i.e. 60 % and 90 %. The mean scores, textural and proximate analysis for control and two experimental variations for muffins were analyzed statistically at 5% significance level.

Keywords: Finger millet, Antinational factors, Functional muffins, Sensory evaluation, Texture, Nutrient content

I. 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), mudde (dumpling) and ambali (thin porridge). 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.

Finger millet grain is a potential source of carbohydrate 81.5 %, protein 9.8 %, crude fiber 4.3 %, and mineral 2.7 %. It's a rich source of crude fiber and mineral which remarkably higher than those of wheat (1.2 % fiber, 1.5 % minerals) and rice (0.2 % fiber, 0.6 % minerals); moreover its protein profile is comparatively well balanced; as it contains more lysine, threonine, and valine than other millets (Ravindran 1991; Sripriya et al. 1996). Studies revealed that finger millet contains 11.5 % dietary fiber which is considerably higher than the fiber content of brown rice or polished rice. On comparing nutritionally finger millet with other popularly consumed cereals and millets, it has a substantial amount of calcium (0.38 %), fiber (18 %), phenolic compounds (0.3 %–3 %), and Sulphur containing amino acids (Shobana et al. 2013).

Phytic acid has a strong binding capacity and readily forms complexes with multivalent cations and proteins. These Phytate mineral complexes are generally insoluble at physiological pH and hence render the mineral bioavailability unavailable to monogastrics (Ravindran et al. 1994). The tannins reduce the nutritional quality of food as they can bind both exogenous and endogenous proteins including enzymes in the digestive tract, affecting the utilization of proteins. Tannic acid/ tannins are polyphenolic compounds. They are present on the seed coat; therefore removal of seed coat reduces the tannins. Anti-nutritional effect of tannins is the binding capacity with iron, proteins and hampering unavailability for absorption. It was reported that 0.91 % of tannins is present in ungerminated millet which decreased by about 72 % on 72 h germination (Rao and Deosthale 1982).

Five major low cost techniques which can be used for the reduction in antinutronal factors includes malting, germination, blanching, roasting and pressure cooking. According to Potter 1995, 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. Similarly germination has been documented as an effective treatment to remove some anti-nutritional factors in legumes by mobilizing secondary metabolic compounds which are thought to function as reserve nutrients and initiates three main types of chemical changes in the seed which include the breakdown of certain materials, transport of materials from one part of the seed to another especially from the endosperm to the embryo or from the cotyledons to the growing parts and the synthesis of new materials from the breakdown product formed (Esonu et al. 1998).Blanching is also a low cost technique with moist thermal process for enhancing the shelf life of the plant by creating isothermal temperature variations. Pressure cooking is a high pressure technique which allows increase in temperature and then sterilizes products above their boiling point (Padhke and Sohonie 1962). Roasting is a heat processing which is widely accepted as an effective means of inactivating the thermo- labile antinutritional factors of legume grains (Sathe et al. 1984). Because limited publications have considered the effect of low cost processing treatments on reduction of antinutrional factors millets; therefore the objective of this study as to conclude the influence of malting, germination, pressure cooking, blanching and roasting on antinutrional factor of finger millet and hence the paramount treatment can be used in developing muffins from finger millet.

Thus, with an objective to develop value added product from processed finger millet the present study was aimed at the reduction of antinutritional factors of finger millets by different processing treatments and incorporation of best processed finger millet flour into snack product such as muffins. The refined wheat flour (RWF) were replaced by processed finger millet for the development of muffins and the physical properties, nutrients and texture of muffins were examined and compared with commonly consumed RWF muffins.

II. MATERIALS AND METHODS

A. *Materials*

Dehusked Finger Millet (ragi) (Eleusine coracana) was procured from local market, Delhi. Standards of Tannic acid and Phytic acid and other reagents were procured from MERCK. Ingredients for the preparation of muffins were also procured from local market of Delhi.

B. *Preparation of Processed Finger Millet Flour*

Malting 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.

Germination Germinated finger millet was prepared by the method given by Srilakshmi (2003). Grains were steeped for 24 h at room temperature allow it to sprout for 48 h. Grains were dehydrated for 60 mins at 60 °C. Grains were powdered to obtain flour for later usage.

Blanching Finger millet was prepared according to the method given by Sharma (2006).Grains were steeped in boiling water for 2-5 mins, and then immediately transferred in cold water for 2-5 mins. Grains were removed and dehydrated for 60 mins at 60 °C. Grains were powdered to obtain flour for later usage.

Pressure cooking Finger millet was pressure cooked according to the method given by Sharma (2006). Grains were steeped for 24 h at room temperature, pressure cooked for 5 mins. Grains were removed and dehydrated for 60 mins at 60 °C. Grains were powdered to obtain flour for later usage.

Roasting Finger millet was prepared according to the method given by Sharma (2006).Grains were dehydrated for 60 mins at 60 °C. Grains were powdered to obtain flour for later usage.

C. *Biochemical Analysis of Processed Finger Millet Flour*

Tannic acid estimation in processed finger millet flour Processed finger millet flours (0.5 g) obtained after different processing treatments were extracted in 70 mL distilled water for 30 mins at 70-75 °C. Tannic acid was determined calorimetrically given by Folins – Denis with slight modifications (AOAC 1970). During the reaction, tannins like compounds reduce phosphotungstomolybdic acid in alkaline solution to produce a highly colored blue solution, the intensity of which is proportional to the amount of tannins. The intensity of which was measured in a spectrophotometer at 700 nm (Sadasivam and Manickam 1996).

Phytic acid estimation in different processed finger millet flour Processed finger millet flours (0.5 g) obtained after different processing treatments were extracted with 30ml of 0.2 N Hydrochloric acid on magnetic stirrer. The extracts are then centrifuged at 2000 rpm for 20 mins. Supernatants were collected and utilized for the analysis. Phytic acid was determined calorimetrically given by Haug and Lantzsch with slight modification. It is an indirect method hereby the sample extracts were reacted with an acidic iron-3- solution along with known iron content. The decrease in iron content was determined calorimetrically with 2, 2'-bipyridine in the supernatant which was a measure for the phytic acid content (Sadasivam and Manickam 1996; Haug and Lantzsch 1983).

D. *Proximate and Chemical Composition of Wheat Flour, Finger Millet Flour and Finger Millet Malt Flour*

The wheat flour, finger millet flour, finger millet malt flour was subjected to proximate analysis such as moisture, protein, fat, crude fiber and ash content. The total carbohydrate was calculated by difference. Along with this in all the three flours iron, calcium, phosphorus content was estimated. The standard procedures given by Ranganna (1986) were used for all the above determinations

E. *Preparation of muffin batter and muffins*

The refined wheat flour and finger millet malt were mixed in the required proportions for muffins preparation. The various blends were sieved thrice to ascertain through mixing. The process adopted for muffins was as per the method elaborated in 'The art and science of cooking' by Khaana (1998). The muffins were developed using the basic recipe given in Table 1.

Table - 1
Muffin formulation

Ingredients	Amounts (g)
Refined flour	55
Butter	35
Castor sugar	55
Egg	1
Milk	15 ml
Baking powder	½ t
Cocoa powder	10
Choco chips	10
Chocolate essence	2 drops

Source: The art and science of cooking by Khaana (1998)

The basic recipes given in Table 1 were used to develop and standardize muffins by incorporating processed flour at different flours. Muffins were tried at different variations 20 %, 30 %, 50 %, 90 %, 100 % levels.

F. Analysis of Muffin Batter Characteristics

Batter viscosity Viscosities of muffin batter with different variations were measured according to the procedure given by Ebeler et al. (1986) with slight modification. The funnel was filled with the batter and allowed to flow for 15 secs with funnel specifications as 10 cm from top and 1.6 cm from inside bottom diameter. The amount of batter flowed down was collected, weighed and viscosity value are reported in g/s and hence higher value indicates lower viscosity.

Batter specific gravity Specific gravity of muffin batter was calculated using in specific gravity bottle. The specific gravity of muffin batter was measured by dividing weight of a certain volume of muffin batter by the weight of an equal volume of water at 25 ^{0}C.

$$\text{Specific gravity } (g/cm^3) = \frac{\text{(Weight of filled container – weight of container)}}{\text{(Weight of water filled container- weight of container)}}$$

Cake moisture loss during baking and after 5 days of storage Moisture loss of the muffin was calculated by the equation:

- % ML (Moisture loss) = $W_1 - W_2 / W_1 \times 100$

Where W_1 is the weight of the muffin batter transferred into each muffin mould (35 g) and W2 is the weight of the baked muffin after 30 min cooling at room temperature. Similarly muffin samples were weighed after 5 days of storage.

Sensory analysis Sensory evaluation was done on freshly made muffins. Fifty panel members of Institute of Home Economics including faculty and Masters Students were randomly chosen for evaluating sensory attributes of freshly prepared muffins. The attributes evaluated were appearance, color, texture, after taste, overall acceptability. For each sample of both muffins, panelists scored their liking of these characteristics using the five point hedonic scale (1= unsatisfactory, 2= satisfactory, 3= good, 4= very good, 5= excellent)

G. Texture Analysis

Texture characteristics of muffin crumb (firmness, cohesiveness, hardness, springiness and chewiness) were evaluated using a TA-XT2 texture analyzer (Stable Microsystems, UK). The compression test was done to evaluate the textural attributes of muffin samples. The test consists of compressing the sample two times in a reciprocating motion that imitates the action of the jaw and extracting from the resulting force-time curve a number of textural parameters that correlate well with sensory evaluation of those parameters. Crumb of the muffins were placed on the aluminum plate and were compressed to 60 % of their original height with a pre speed of 1mm/sec, test speed of 5mm/sec and post - test speed of 5mm/sec using a cylinder probe 5 kg of trigger force.

H. Proximate Analysis of Muffins Supplemented with Finger Millet Malt Flour

Similarly, as above mentioned the proximate analysis of muffins with different variations were also carried out.

I. Statistical Analysis

Nutritional, functional and textural analysis was done in replicates and their statistical significance was analyzed by ANOVA followed by Tukey's HSD test for significant differences ($p< 0.05$).

III. RESULTS AND DISCUSSIONS

A. Tannic Acid and Phytic Acid Estimation

Results of the present study indicate the most efficient processing treatment for the reduction of tannic acid and phytic acid was malting followed by germination. The reduction of tannic acid content during malting was 51.2 %, whereas phytic acid was reduced by 54.6 % as shown in figure 1.

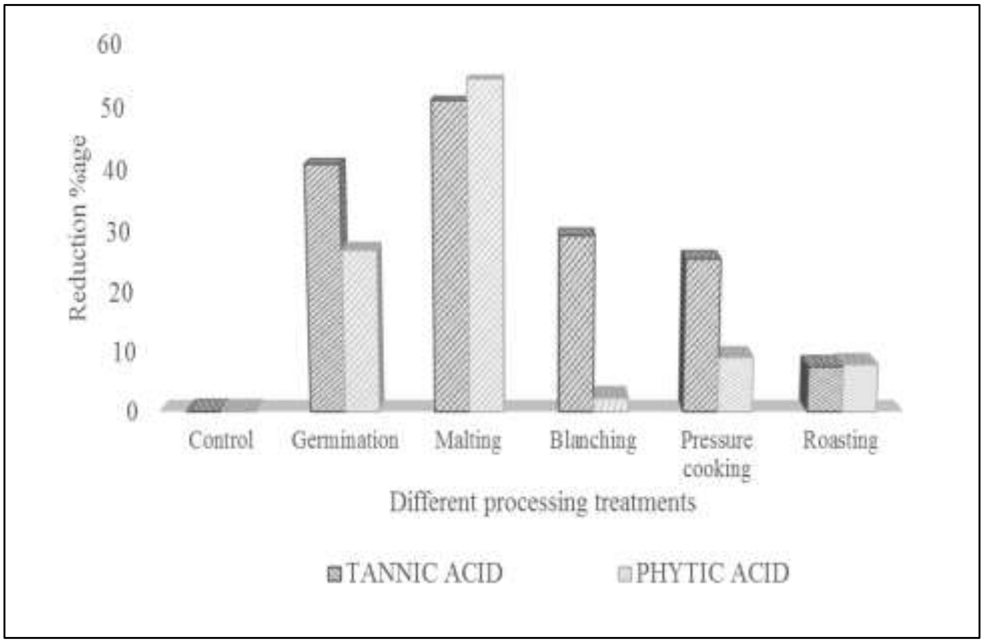

Fig. 1: Graphical representation of reduction percentage in Tannic acid and Phytic acid content in processed finger millet flour

The destruction of tannic acid content was by almost all the processing treatments. Malting and germination were found to be most effective treatment for reduction of antinutritional factors like tannic acid and phytic acid. Among both the treatments, malting was most effective in decreasing the tannic acid content. Loss of tannic acid content during malting may be attributed to the presence of polyphenol oxidase and to the hydrolysis of tannin- protein and tannin enzyme complexes which results in the removal of tannins. Similarly a study conducted by Rao and Deosthale (1982), reported that of tannic acid was destroyed during malting in pearl millet. According to Karki and Kharel (2012), maximum tannin content reduction was reported in GE 5016 malt i.e. 46.7 % whereas a minimum reduction of 27.5 % was reported in Dalle malt. A reduction of 25 % in tannic acid after malting was also noted by Reichert et al. (1980) in barley, moreover he also illustrate that this decline in tannic acid is due to the partial polymerization of tannins in water. Larger tannin polymers or complexes of tannin with other biopolymers would be insoluble and thus not extractable.

Similar trends were also seen in phytic acid content by almost all the processing treatments. A destruction of phytic acid was produced by almost all the processing treatments. Among all the processing treatments, malting was most effective in decreasing the phytic acid content. Loss of phytic acid content during malting may be attributed due to leaching of phytate ions into the soaking medium under the influence of concentration gradient. Such losses may be a function of the changed permeability of the seed coat. Reduction may also be attributed to the increased activity of phytase enzyme during sprouting. Malting stemmed to enhance total carbohydrate and soluble sugars from 73.7 to 83.1 % and 2.9 to 9.9 mg/100g, respectively simultaneously the total and reducing sugar content increased from 1.5 to 16.0 and 1.44 to 8.36 % respectively (Shukla et al. 1986). A marked decrease in phytic acid content in pearl millet by malting has been reported by Opoku et al (1981). According to Rao and Deosthale 1988; Malleshi and Desikachar 1986; Deosthale 2002 malting condenses the phytin phosphorus content of finger millet. In another study by Rao (1994) also testified that during malting phytin phosphorus content reduced by 58 % to 65 % in brown and white varieties, respectively.

B. Proximate and Chemical Composition of Wheat Flour, Finger Millet Flour and Finger Millet Malt Flour

The proximate composition of wheat flour is given in Table 2. The data showed that wheat flour is a good source of protein and minerals. The proximate and chemical compositions of finger millet flour and finger millet malt flour were also illustrated in Table 2. It was apparent from the observation that the malting technique is a valuable, advantageous and a low cost process to escalate calcium and phosphorus content of finger millet flour. 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.

Table - 2
Proximate and chemical composition of wheat flour, finger millet flour and finger millet malt flour

Parameters	*Wheat flour*	*Finger millet flour*	*Finger millet malt flour*
Moisture (%)	*12.15±0.23*	*11.6±0.35*	*11.95±0.37*
Protein (%)	*10.09±0.19*	*7.30±0.18*	*7.83±0.14*
Fat (%)	*0.54±0.17*	*1.07±0.05*	*1.15±0.14*

Crude fiber (%)	0.52±0.02	3.21±0.05	3.91±0.06
Total carbohydrate (%)	74.46±0.74	74.47±0.41	73.28±0.63
Ash (%)	0.82±0.04	1.48±0.20	1.88±0.16
Calcium (mg/100g)	53.66±2.51	370.46±1.55	412.6±1.73
Iron (mg/100g)	4.13±0.06	13.2±0.3	11.6±0.8
Phosphorous (mg/100g)	351±3	244.06±0.6	298.4±0.9

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

C. Standardization and Development of Muffins Using Finger Millet Malt Flour

In Table 3, different levels of malted finger millet were tried to replace the maximum amount of refined wheat flour in standardized recipe. It is important to incorporate maximum amount of malt powder to make muffins more nutritious containing nutrients with high bioavailability, easy digestibility and quick and easy utilization by the body. Therefore, an attempt was made to incorporate malted finger millet at five different levels.

Table - 3
Incorporation levels of finger millet malt flour in muffin preparation

Incorporation levels of FMM flour	Ingredients							Remarks
	Refined wheat flour (g)	Finger millet flour (g)	Butter (g)	Castor sugar (g)	Egg	Baking powder (g)	Cocoa powder (g)	
I. (20%)	44	11	35	55	1	¼ t	3	Taste – Good Texture – Good
II. (30%)	38.5	16.5	35	55	1	¼ t	3	Taste – Good Texture - Good
III. (50%)	27.5	27.5	35	55	1	¼ t	3	Taste – Good Texture – Good
IV. (90%)	10	45	35	55	1	¼ t	3	Taste- acceptable after taste Texture – Good, soft
V. (100%)	0	55	35	55	1	¼ t	3	Taste - bitter

*FMM: Finger millet malt

Results in table 3 indicates that variation I and II had good taste and texture with no after taste whereas sub variations III apart from having good taste and texture, had significant amount of finger millet malt flour i.e. 50 %. On the other hand, variation IV also had a good taste and the slight after taste of finger millet was liked by all and acceptable. Variation V had bitter taste and sticky texture and was unacceptable. Therefore, out of all the variations the two variations were selected i.e. variation III and variation IV 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, Delhi University who analyzed the product. Hence, optimum incorporation level of finger millet malt in muffins for final recipe was 50 % and 90 % given in Table 4.

Table - 4
Different levels of finger millet malt used for final sensory evaluation of muffins

Ingredients	Amounts (g)	
	50%	90%
Refined wheat flour	27.5	10
Finger millet malt	27.5	45
Butter	35	35
Castor sugar	55	55
Egg	1	1
Cocoa powder	3	3
Baking powder	¼ t	¼ t
Milk	50 ml	50 ml
Chocolate essence	Few drops	Few drops
Chocó chips	3	3

Source: The art and science of cooking by Khaana (1998)

D. Physical Characteristics of Muffin Batter

Alterations in muffin batter characteristics with supplementation of finger millet malted flour are shown in Table 5. It was observed form the data that the moisture content of the muffin batter was not ominously unalike from each other. On the other hand the batter viscosity increased significantly with the increase in finger millet malted flour. It was reported by Lu et al. (2010) that the viscosities of the cake batter increase with the substitution of higher percentage of green tea powder. A manifest result in increase in batter viscosity was noticed by De Fouw et al (1982) when the batter was supplemented with unheated or roasted navy bean hulls by replacing 15% of flour. Similar increase in batter viscosity was observed by increase in apple pomace level (Masood et al. 2002). There was a slight increase in the batter density of muffin batter with increase in finger millet malted flour. The increase in batter density of muffin batter due to the increase in the crude fiber content of the finger millet malt flour. Similar results were also reported by Lu et al. (2010) with significant increase in specific gravity of cake batter with increasing green tea powder level. Escalation in specific gravity of cake batter with increasing levels of microcrystalline cellulose was also observed (Brys and Zabik 1976).

Table - 5
Effect of malting on finger millet flour on batter parameters of muffins

Samples	*Batter viscosity (g/s)*	*Batter density (g/cm^3)*	*Moisture loss (%)*
Control	*1.51±0.17*	*1.067±0.64*	*17.11±0.44*
50% FMM	*3.63±0.21*	*2.012±0.03*	*17.69±0.16*
90% FMM	*6.75±0.24*	*2.091±0.84*	*18.04±1.01*

*Values are mean ± standard deviation of triplicate independent determinations (dry weight basis).
*FMM= Finger millet malt

E. Sensory Characteristics of Malted Finger Millet Flour Muffins

Muffins were prepared by replacing refined flour with malted finger millet flour with two variations i.e. at 50 % and 90 % incorporation level along with control as indicated in Table 6. A comparison of mean score of sensory attributes namely appearance, color, texture, after taste and overall acceptability has been done.

Table - 6
Sensory characteristics of muffins prepared using finger millet malt flour

Characteristics		*Mean ± SD*		*F- Test*
Malted Finger Millet Muffins				
	Control	*50% FMM*	*90% FMM*	
Appearance	*4.10±0.71^c*	*3.17±0.72^a*	*3.61±0.78^b*	*15.153**
Color	*4.17±0.75^b*	*3.43±0.78^a*	*3.79±0.69^{ab}*	*9.653**
Texture	*3.82±0.82^b*	*3.10±0.82^a*	*3.33±0.95^a*	*6.943**
Taste	*4.07±0.70^b*	*3.25± 0.81^a*	*3.61±0.90^a*	*9.978**
After taste	*3.97±0.74^b*	*3.33±0.83^a*	*3.61±0.96^{ab}*	*5.532**
Overall acceptability	*4.035±0.72^b*	*3.23±0.87^a*	*3.69±0.73^b*	*10.882**

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

According to essentials in table 6, revealed that mean scores for appearance was not same for all the three products and there was a significant difference between the three, whereas for texture and taste the mean score of muffins with 50 % and 90 % were comparable. Mean scores of color of control muffins and muffins with 90 % malted finger millet flour were insignificant at 5 % level. Similarly mean scores of aftertaste of control muffins and muffins with 90 % malted finger millet flour were also insignificant at 5 % level. Mean scores of overall acceptability of 50 % malted finger millet flour was significantly different from control muffins and was least acceptable of all. Mean score of muffins made with 90 % malted finger millet flour was comparable to control muffins and it is significantly different when compared to control muffins. The differences of 8.43 % were not worth mentioning at 5 % level. Therefore, muffins made with 90 % malted finger millet flour were similar to control muffins and rating lies above good. The graphical representations of mean scores of finger millet muffins have been shown in Figure 2. Earlier malted finger millet has been also utilized for the development of burfi by Kumari and Srivastava (2000), for commercially increasing the utility of finger millet as well as the cost of the burfi was kept low so that the large population of young poor malnourished children can also consume it and thereby meeting their nutrient adequacies.

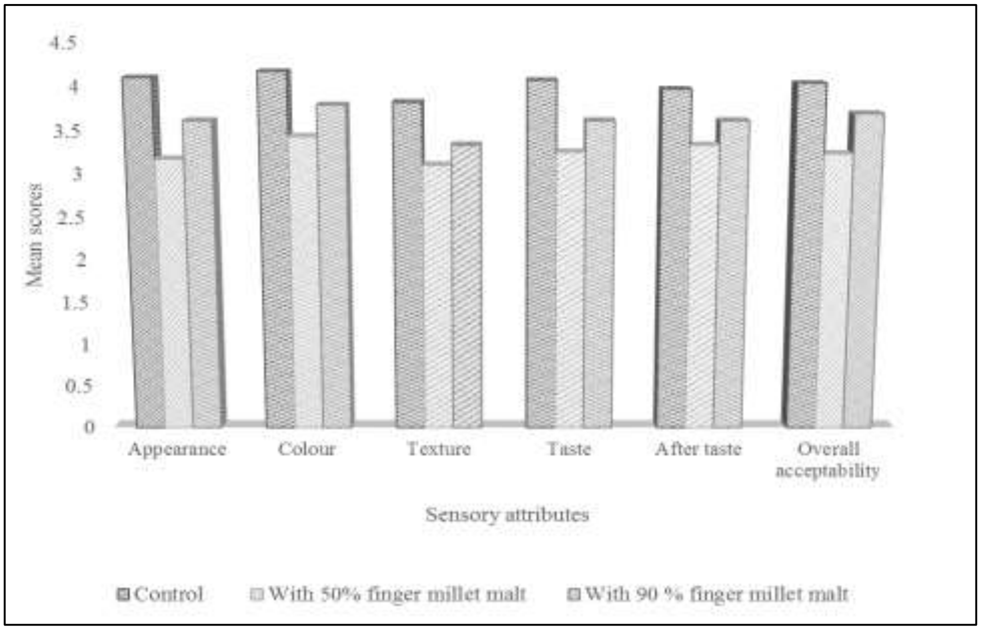

Fig. 2: Graphical representations of mean scores of muffins prepared from finger millet malt muffins

Figure 2 represents the mean scores of all the attributes. Mean scores of muffins made with 90 % malted finger millet flour were found to have no considerable statistical difference from mean score of control muffins at 5 % level. Though the muffins made with 50 % malted finger millet flour have a significant difference from control muffins but there was only a difference of 19.95 % between them. Similarly, a study done by Sudha et al. (2007), revealed that biscuits made from higher level of fiber 30 % from sources of wheat, oat and barley are more acceptable then lower levels. As finger millet also serves as a source of fiber which helps in improving texture, therefore higher level of malted finger millet flour were more acceptable as compared to 50 %. Finger Millet has been also used as a source of amylases in improving the nutrient density and texture of weaning food formulations. Although there were reports on the inhibitory activity of the polyphenols on the cereal amylases (Rohn et al. 2002), there were no reports on the inhibition of malted finger millet amylases by its polyphenols.

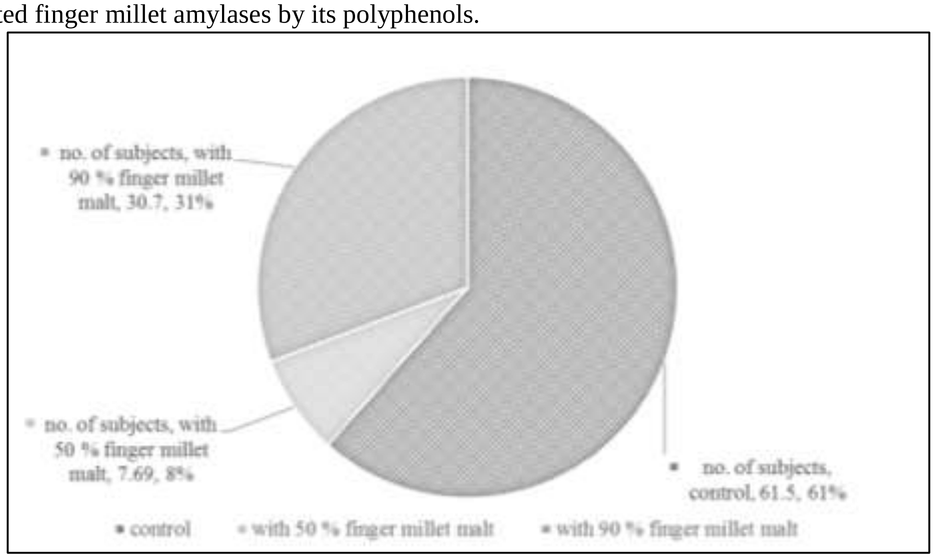

Fig. 3: Consumer preference for muffins prepared with finger millet malt flour

Figure 3 depicts, when consumers were asked how often they would like to have the product, 71.7 % responded occasionally and 10.2 % responded daily. When asked if consumers would buy if product is available in the market, 84.6 % responded positively while 7.6 % whereas not sure about it.

F. Textural Profile Analysis

Texture profile analysis is a very useful technique for examining food products. The test comprises of compressing the sample two times in a reciprocating motion that imitates the action of the jaw and extracting from the resulting force-time curve a number of textural parameters that correlate well with sensory evaluation of those parameters. In the present study, the TPA parameters of muffins with and without finger millet malt flour substitution were determined from the texture analyzer using double compression tests and are depicted in Table 7.

Table - 7
Effect of malting on textural parameters of finger millet flour muffins

Sample	*Hardness (g)*	*Springiness*	*Cohesiveness*	*Gumminess*	*Chewiness*
Control	*2882.619±0.02*	*0.885±1.18*	*0.615±0.47*	*1772.56±0.54*	*1568.94±0.01*
50% FMM	*2974.375±0.11*	*0.864±0.89*	*0.612±0.68*	*1710.18±0.51*	*1645.49±0.24*
90% FMM	*1936.294±0.14*	*0.787±0.71*	*0.627±0.81*	*1294.26±0.67*	*1024.97±0.04*

*Values are mean ± standard deviation of triplicate independent determinations (dry weight basis).
FMM- Finger millet malt

Hardness is defined as the maximum peak force during the first compression cycle (first bite) and has often been substituted by the term firmness. It is observed from the data that the hardness 50 % FMM flour muffin is similar to that of control cake whereas as the finger millet malt ratio increased the hardness lowers down in comparison of the control cake (Table 7). However cohesiveness is defined as the ratio of the positive force area during the second compression to that during the first compression. Cohesiveness may be measured as the rate at which the material disintegrates under mechanical action, oscillated between 0.615 and 0.627 with no significant difference between any samples with or without addition of finger millet malt flour (Table 7). Springiness relates to the height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite. No significant difference was observed in baked muffins with and without supplementation of finger millet malt flour (Table 7). Gumminess is defined as the product of multiplication of hardness and cohesiveness, whereas according to Karaoglu and Kotancilar (2009) chewiness can be defined as the energy required to masticate solid food to a state of readiness for swallowing which is obtained from the multiplication of hardness, cohesiveness and springiness. The muffins developed with or without finger millet malt flour unveiled a parallel drift with the hardness values of the muffins (Table 7). Lower chewiness and gumminess were observed in the 90% finger millet malt flour muffins. These results indicates that with the increase in the ratio of finger millet malt flour in the muffin improves the texture of the muffin by increasing the cake volume as finger millet malt flour has higher capacity of absorbing water hence the softer texture which is well supported by lesser values of hardness, chewiness and gumminess (Table 7). Similar results were also observed by Chaiya and Pongsawatmanit (2011) on substitution of tapioca starch blended cakes. The hardness, chewiness and gumminess values decreased with the simultaneous increase in blended ratio of tapioca starch.

G. *Proximate Analysis and Chemical Composition of Muffins Supplemented With Finger Millet Malt Flour*

The proximate analysis and chemical compositions of cakes prepared from supplemented ragi flour were determined and obtained results were tabulated in Table 8. The data showed that there were no significant differences in moisture, protein and fat content between samples supplemented with or without finger millet malt flour. On the other hand crude fiber content also increased, this change in fiber content may be accredited to the fact that the seed fiber may be solubilized enzymatically during seed sprouting phase of malting (El Maki et al. 1999). Singh et al. 2006 reported similar increase in crude fiber content in cake samples prepared with malted pearl millets flour was increased. The mineral contents viz. calcium, iron and phosphorus of muffins supplemented with finger millet malt flour were higher than the control muffin sample. According to Platel et al (2010) bio accessibility of minerals like iron and manganese are increased during malting of finger millet. Similar results were also reported by Rateesh et al (2012) and Desai et al (2010) that malting increased the bio accessibility of calcium, iron, and zinc. In another study by Sangita and Sarita 2000 reported that supplementation of malted finger millet flour increases mineral contents i.e. calcium, iron and phosphorus of burfi.

Table - 8
Proximate analysis and chemical composition of muffins supplemented with finger millet malt flour

Samples	*Control*	*50% FMM*	*90% FMM*
Moisture (%)	*20.41±0.14*	*20.57±0.04*	*22.62±0.12*
Protein (%)	*12.22±0.34*	*11.67±0.27*	*10.18±0.28*
Fat (%)	*30.7±0.66*	*30.2±0.74*	*31.7±0.51*
Crude fiber (%)	*0.67±0.01*	*1.97±0.20*	*2.61±0.16*
Calcium (mg/100g)	*121.2±0.73*	*148.7±0.85*	*158.1±0.01*
Phosphorus (mg/100g)	*396±0.51*	*423±0.43*	*467±0.26*
Iron (mg/100g)	*1.67±0.35*	*7.46±0.23*	*9.82±0.17*

*Values are mean ± standard deviation of triplicate independent determinations (dry weight basis).
*FMM= Finger millet malt

IV. Conclusion

The study indicated that phytic acid and tannic acid were reduced significantly after various processing treatments. Malting shows the maximum reduction in both phytic acid and tannic acid content, as malting awakens the enzymes and makes the nutrients available in its predigested form as well increases the activity of certain bound enzymes which ultimately leads to releasing of anti-nutritional factors which are bound to the nutrients hereby increasing the bioavailability of nutrients. Snacking is becoming a common practice especially in children and adults therefore an attempt was made to develop some healthy snacks from processed malted finger millet 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 90% malted finger millet flour replacement was acceptable in muffins, as they are better than the control refined flour muffins in nutritive, sensory and textural parameters. Therefore, malting holds a good potential for improving the nutritional value of finger millet by reduction in antinutrient and thereby enhancing its utilization.

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