STUDIES ON DEVELOPMENT OF GLUTEN FREE MALTED MULTI-MILLET COOKIES

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Abstract

The present investigation was undertaken to standardize and develop gluten free malted multi-millet cookies by utilization of Malted millet flour blends viz. Pearl millet, Finger millet and Sorghum with 100% wheat flour cookies as control. The cookies with 50% sorghum flour, 25% pearl millet flour and 25%finger millet flour had higher sensory scores. The sensorially acceptable flour blend was then utilized for development of gluten free malted multi-millet cookies in which partial replacement of flour blend with roasted flaxseed powder at the substitution level of 0, 10, 20, 25, 30 was done to enhance the nutritive value of cookies. Overall acceptability of samples judged by semi-trained panel members found in between 7.54 to 8.57. The cookies with 30% of roasted flaxseed powder and 70% of malted millet flours blend were found to be highly acceptable by the panellist. With increase in the percentage of roasted flaxseed powder the increase in the proximate composition, minerals and omega-3 fatty acids was observed. Malting improved the chemical properties of the millet flour and increase in the mineral content of malted millet flour as compared to unmalted millet flour was recorded. Resulting gluten free malted multi-millet cookies could not only contribute to celiac patients but also to the growing health conscious population.

Keywords: Pearl millet, Finger millet, Sorghum, Flaxseed, Malting, Gluten free cookies, Nutritional quality, Sensory evaluation

1. INTRODUCTION

In the rural areas of India, millets are considered to be the staple traditional food grains and are majorly utilized for consumption at household level (Dayakar Rao *et al.*, 2007). Due to their sustainability in adverse agro-climatic conditions they are considered to be food security crops (Ushakumari *et al.*, 2004). Genetic diversity in the food basket can be broadened due to these crops as they have substantive potential and they can also ensure improved food and nutrition security (Mal *et al.*, 2010). Millets help in the management of various disorders like diabetes mellitus, obesity, hyperlipidaemia, etc. due to intake of nutritional ingredients in daily diet (Veena 2003).

Finger millet (*Ragi*) is available in yellow, white, tan, red, brown or violet colour depending on the variety. Red coloured variety of finger millet is most common and cultivated worldwide. It is a rich source of carbohydrates and comprises of free sugars (1.04%), starch (65.5%) and non-starchy polysaccharides or dietary fibre (11.5%). Prolamins are considered as major fractions of finger millet protein. Finger millet is exceptionally rich in calcium (344mg%), potassium (408mg%) compared to all other cereals and millets and also contains phosphorus and iron. Finger millet the seed coat in particular, contain several phytochemicals that may have multiple health benefits. Finger millet is rich in calcium and helps in keeping the bones and teeth healthy and helps in fighting osteoporosis. It helps in controlling diabetes as its seed coat is abundant in polyphenols and dietary fibres as compared to rice, maize or wheat. It is also rich in iron which can help to fight anaemia (Gopalan *et al.*, 2009).

Sorghum (*Sorghum bicolor* L.) is one amongst the key cereal crops consumed in India after rice (*Oryza sativa* L.) and wheat (*Triticum aestivium* L.). It is commonly known as as *jowar* or *great millet*. The crop is primarily cultivated in Maharashtra and Southern states like Karnataka and Andhra Pradesh. It was discovered that sorghum has 11.9% of moisture and about 10.4% of protein and 1.9% of fat. The fibre and mineral content of grain sorghum was found to be around 2.1% and 1.6% respectively. It is a decent source of energy and provides about 349 Kcal/100g and 72.6% of carbohydrates (Gopalan *et al.*, 1996).

Pearl millet (*Pennisetum glaucum*) is recognized as an important crop in terms of food security and meeting the nutritional demands of an increasing population. For the large segment of poor population it acts as an important source of dietary calories and protein in the regular diet (Simwemba *et al.*, 1984). It was observed that pearl millet had significant amount of resistant starch, soluble and insoluble dietary fibre's, minerals, and antioxidants which depicts the nutritional significance of pearl millet in daily diet (Ragaee *et al.*, 2006). Results revealed pearl millet has 92.5% dry matter, 2.1% ash, 2.8% crude fibre, 7.8% crude fat, 13.6% crude protein, and 63.2% starch (Ali *et al.*, 2003).

Antinutritional factors such as phytate oxalate tannins, trypsin inhibitor are decreased when germination and malting of millets is carried out and increase in various minerals and vitamins such as B1, B2, B6, niacin folic acid, tryptophan, biotin, vitamin C is observed upon malting (Briggs 1998). Germination is the process in which the grain is rehydrated which causes an increase in metabolic activity and results in reactivation of dormant enzymes. Primary and secondary metabolites are produced due to the increase in the metabolic activity. Germination and malting also enhance the nutritional and functional properties of the grain (Bohoua and Yelakan 2007).

Flaxseed is known as a potential functional food ingredient as it offers various health benefits along with nutritional value (Eyres 2015). It is an underutilized crop, but gained importance in the last few decades due to its unique nutrient profile, mainly omega-3 fatty acid, lignans, and fibre (Goyal *et al.*, 2014).

Celiac disease is autoimmune disease that causes irritation and inflammation in small intestine and is caused due to the consumption of storage protein gluten, in the diet. Wheat, rye and barley are the gluten containing food (Cheng *et al.*, 2010). The only treatment of celiac disease is of lifelong gluten free diet (Bao and Bhagat 2012).

Bakery products are an important source to deliver the required nutrients due to its docility for fortification with cereals, millets or other ingredients. These products are an effective medium for delivering functional ingredients to consumers. Cookies that are available in market are mostly deficient in ALA and dietary fibre (Ganorkar and Jain 2014). Use of refined ingredients makes biscuits/cookies deprive of grain components that are protective of health thus addition of functional ingredients can help to enhance the overall nutritive value of these products (Fardet 2010).

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Ingredients

The raw materials sorghum, pearl millet, finger millet and roasted flaxseed powder were procured from the local market of Pune.

2.1.2 Chemicals

Chemicals of analytical grade were made available in the laboratories of MIT College of Food Technology.

2.1.3 Processing Equipment

The analytical equipment's like muffle furnace, soxtron, fibrotron, kjeldahl, spectrophotometer were made available in the laboratories of MIT College of Food Technology.

2.2 Methods

2.2.1 Production of malted millet flour

The millet grains viz. pearl millet, finger millet and sorghum were subjected to malting followed by milling. The millet grains were properly cleaned and soaked for 12 h in water at room temperature. Then the millet grains were placed in muslin cloth and frequent watering was done for full 48 h. The sprouted millets were then kiln dried at 60°C and rootlets removed followed by milling of millets. The malted millet seeds were properly cleaned to remove culms or radicles if any and milled in local flour mill and sieved through 40 mesh sieve size to obtain malted millet flours. The technical procedure for the production of malted millet flour is depicted in Fig.1.

Cleaning and washing
↓
Steeping in water (12 h)
↓
Germination (@ 25-30°C, 48 h)
↓
Kilning (@ 60°C for 8 h)
↓
Removal of culms/radicles and cleaning
↓
Malted millet seeds
↓
Cleaning
↓
Grinding
↓
Sieving (40 mesh sieve)
↓
Malted millet flour

Fig.1. Technological flowchart for production of malted millet flour

2.2.2 Preparation of flour blends

Flour blends were prepared by mixing malted millet flours as per the formulation given in Table 1 and the most acceptable blend was chosen for preparation of gluten free malted multi-millet cookies. The most acceptable flour blend was then replaced with roasted flaxseed powder at substitution level of 0, 10, 20, 25 and 30% (w/w). The blends were then used for preparation of gluten free malted multi-millet cookies.

2.2.3 Preparation of gluten free malted multi-millet cookies

The gluten free malted multi-millet cookies were prepared by using traditional creaming method. Fat and sugar were creamed until light and fluffy. Flour was sieved with sodium bicarbonate and salt. The cream was mixed with flour and sufficient quantity of water was added to form dough. The dough was divided into smaller pieces. The pieces were rounded, flattened and placed in a baking tray smeared with fat and baked at 150°C for 15 min. The technical flowchart for preparation of gluten free malted multi-millet cookies was given in Fig.2.

Creaming of fat and sugar
↓
Addition of ghee roasted malted millet flour,
roasted flaxseed powder, sodium bicarbonate
↓
Formation of dough
↓
Sheeting and cutting
↓
Baking (@150°C for 15 min)
↓
Cooling
↓
Packaging
↓
Storage

Fig.2. Technological flowchart for preparation of gluten free malted multi-millet cookies

2.2.4 Treatment Details

The treatment details for development of cookies are given below.

Table 1 Treatment details of cookies prepared from malted millet flours

Ingredients (g)	Treatments				
	TF_0	TF_1	TF_2	TF_3	TF_4
Wheat flour	100	-	-	-	-
Malted Sorghum flour	-	30	40	50	60
Malted Finger Millet flour	-	35	30	25	20
Malted Pearl millet flour	-	35	30	25	20
Sugar	60	60	60	60	60
Fat	60	60	60	60	60
Baking Powder	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5

T_0=Control sample (1000% of Wheat flour)
T_1 = Cookies with malted flours of sorghum(30%):finger millet (35%):pearl millet(35%)
T_2 = Cookies with malted flours of sorghum(40%):finger millet (30%):pearl millet(30%)
T_3 = Cookies with malted flours of sorghum(50%):finger millet (25%):pearl millet(25%)
T_4 = Cookies with malted flours of sorghum(60%):finger millet (20%):pearl millet(20%)

Table 2 Treatment details of Gluten-free Malted Multi-Millet Cookies

Ingredients (g)	Treatments				
	TF_0	TF_1	TF_2	TF_3	TF_4
Wheat flour	00	00	00	00	00
Malted Sorghum flour	50	45	40	30	35
Malted Pearl millet flour	25	22.5	20	22.5	17.5
Malted Finger millet flour	25	22.5	20	22.5	17.5
Sugar	60	60	60	60	60
Fat	60	60	60	60	60
Roasted Flaxseed Powder	00	10	20	25	30
Baking Powder	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5

TF_0=Control sample (0% of flaxseed power)
TF_1 = Cookies with malted millet flour substituted with RFSP (10%)
TF_2 = Cookies with malted millet flour substituted with RFSP (20%)
TF_3 = Cookies with malted millet flour substituted with RFSP (25%)
TF_4 = Cookies with malted millet flour substituted with RFSP (30%)

2.2.5 Proximate analysis of unmalted millet flour, malted millet flour and cookies

The control and gluten free malted multi-millet cookie samples were analysed by standard method for moisture, crude protein, ash, crude fiber, total fat by method given by Ranganna (1995). The carbohydrate content was calculated by difference method.

2.2.6 Determination of Mineral Content

The mineral content viz. calcium, iron and phosphorus were analysed by method given by Ranganna (1995).

2.2.7 Determination of Omega 3 content

The quantification of omega-3 were conducted under the AOAC 996.06 method by an accredited laboratory (FHHL) in Pune.

2.2.8 Sensory Analysis

Sensory evaluation of cookies will be done by 9-points Hedonic scale method (Amerine *et al*., 1965).

2.2.9 Statistical analysis

All the processing equipment's and analysis of samples were run in triplicate. The data obtained for various treatments was recorded and statistically analyzed by complete randomized design (CRD) to find out the level of significance as per the method proposed by (Panse and Sukhatme 1967). The analysis of variance revealed at significance of $p<0.05$ level, S.E. and C.D. @ 5% level is mention wherever required.

3. RESULTS AND DISCUSSION

3.1 Proximate analysis of raw and malted flours

The proximate composition plays a significant role for deciding the nutritional and functional qualities of flour. The proximate analysis of raw and malted flours of pearl millet, sorghum and finger millet are depicted in Table 3.

Table 3 Proximate composition of raw and malted millet flours

Sample		Parameter (%)					
		Moisture	Fat	Ash	Fibre	Protein	Carbohydrates
Pearl millet flour	Unmalted	12.34 ±0.022	5.89 ±0.048	1.63 ±0.032	1.04 ±0.016	9.78 ±0.058	69.32 ±1.32
	Malted	12.59 ±0.036	6.30 ±0.052	1.78 ±0.040	1.18 ±0.004	10.43 ±0.032	67.72 ±1.59
Finger millet flour	Unmalted	11.60 ±0.038	1.06 ±0.042	1.73 ±0.028	3.52 ±0.035	7.46 ±0.026	74.63 ±1.97
	Malted	12.98 ±0.024	1.12 ±0.061	1.89 ±0.043	3.71 ±0.017	7.58 ±0.037	72.72 ±1.22
Sorghum flour	Unmalted	11.43 ±0.039	4.59 ±0.022	1.37 ±0.028	2.03 ±0.008	12.58 ±0.018	68 ±1.47
	Malted	11.92 ±0.042	4.62 ±0.069	1.43 ±0.023	2.14 ±0.027	13.08 ±0.030	66.81 ±1.23

Each value is an average of three determinations
Values are means (± standard deviation)

3.1.1 Moisture

The increase in moisture content was observed for malted flours among which malted finger millet flour (12.98%) had the highest moisture content followed by malted pearl millet flour (12.59%) and lowest for malted sorghum flour (11.92%). Among the unmalted millet flours the moisture content of unmalted pearl millet flour (12.34%) was highest followed by unmalted finger millet flour (11.60%) and unmalted sorghum flour was found have lowest moisture content (11.43%).

3.1.2 Fat

The fat content for unmalted pearl millet, finger millet and sorghum flour was found to be 5.89%, 1.06% and 4.59% respectively while that of malted pearl millet flour, malted sorghum flour and malted finger millet flour the fat content was found to be 6.30%, 1.12% and 4.62% respectively. Slight increment in the fat content of malted millet flours was observed from Table 3.

3.1.3 Ash

It is clearly seen that the ash content of malted pearl millet (1.78%), finger millet (1.89%) and sorghum flour (1.43%) is slightly higher than that of unmalted pearl millet flour (1.63%), unmalted finger millet flour (1.73%) and unmalted sorghum flour (1.37%) i.e. the untreated plain flours.

3.1.4 Crude Fibre

The crude fibre content varied among the unmalted and malted millet flours. Among the malted millet flours, malted finger millet flour (3.71%) recorded highest crude fibre content followed by malted sorghum flour (2.14%) and malted pearl millet flour (1.18%) recorded lowest crude fibre content. The highest crude fibre content among the unmalted millet flours was observed for unmalted sorghum flour (3.52%) followed by unmalted finger millet flour (2.03%) and unmalted pearl millet flour (1.04%) was found to have lowest crude fibre content.

3.1.5 Protein

The protein content of unmalted millet flours of pearl millet, finger millet and sorghum was found to be 9.78%, 7.46% and 12.58% respectively while that of malted millet flours of pearl millet, finger millet and sorghum was observed to be 10.43%, 7.58% and 13.08% respectively.

3.1.6 Carbohydrates

The carbohydrate content of unmalted pearl millet, finger millet and sorghum flour was found to be 69.32%, 74.63% and 68% respectively and was observed to be higher than that of malted millet flours viz. malted pearl millet flour (67.72%), malted finger millet flour (72.72%) and malted sorghum flour (66.81%).

3.2 Mineral content of raw and malted millet flour

The mineral composition of raw and malted flours of pearl millet, finger millet and sorghum were analysed and are presented in Table 4.

Table 4 Mineral composition of raw and malted millet flours

Sample		Parameter (mg/100g)		
		Calcium	Iron	Phosphorus
Pearl millet flour	Unmalted	43.09±0.001	4.82±0.001	236.22±0.003
	Malted	53.66±0.004	6.54±0.003	275.45±0.005
Finger millet flour	Unmalted	301.08±0.002	12.32±0.002	235.67±0.001
	Malted	333.8±0.003	13.20±0.004	253.80±0.003
Sorghum flour	Unmalted	13.03±0.001	3.24±0.001	214.07±0.001
	Malted	21.27±0.002	3.37±0.003	223.28±0.002

Each value is an average of three determinations
Values are means (± standard deviation)

3.2.1 Calcium

It was observed that calcium content significantly increased due to malting of millets. The calcium content of malted finger millet flour (333.8 mg/100g) was found to be highest followed by malted pearl millet flour (53.66 mg/100g) while malted sorghum flour (21.27 mg/100g) had lowest calcium content among malted millet flours. The lower calcium content were observed for unmalted millet flours viz. unmalted pearl millet flour (43.09 mg/100g), unmalted finger millet flour (301.08 mg/100g) and unmalted sorghum flour (13.03 mg/100g).

3.2.2 Iron

The iron content for the unmalted pearl millet, finger millet and sorghum flour was 4.82 mg/100g, 12.32 mg/100g and 3.24 mg/100g respectively while that of malted millet flours of pearl millet, finger millet and sorghum was 6.54 mg/100g, 13.20 mg/100g and 3.37 mg/100g respectively. Unmalted finger millet flour (12.32 mg/100g) was found to have the highest iron content while unmalted sorghum flour had lowest iron content (3.24 mg/100g). Among the malted millet flours malted finger millet flour (13.20 mg/100g) had highest iron content while malted sorghum flour (3.37 mg/100g) showed lowest iron content.

3.2.3 Phosphorus

The phosphorus content for unmalted pearl millet, finger millet and sorghum flour was found to be 236.22 mg/100g, 235.67 mg/100g and 214.07 mg/100g respectively while that for malted pearl millet, finger millet and sorghum flour the phosphorus content observed was 275.45 mg/100g, 253.80 mg/100g and 223.28 mg/100g respectively. Among the unmalted millet flours the highest phosphorus content was observed for unmalted pearl millet flour (236.22 mg/100g) and lowest for unmalted sorghum flour (214.07 mg/100g). The maximum rise in phosphorus content among the malted millet flours was found to be in malted pearl millet flour (275.45 mg/100g) while malted sorghum flour had lowest phosphorus content (223.28 mg/100g).

3.3 Sensory evaluation of cookies

Table 5 Sensory Profile of Malted multi-millet cookies

Sample	Sensory Parameters				
	Color and Appearance	Texture	Flavor	Taste	Overall Acceptability
T_0	8.51	8.42	8.44	8.56	8.58
T_1	7.65	8.17	6.87	6.34	7.30
T_2	7.48	8.20	8.16	8.23	8.25
T_3	8.41	8.45	8.41	8.63	8.56
T_4	8.32	8.35	8.21	8.53	8.36
SE±	0.03	0.04	0.04	0.04	0.05
CD@5%	0.12	0.15	0.15	0.13	0.17

**Each value is an average of ten determinations*

T_1, T_2, T_3, T_4 as in Table 1.

The organoleptic assessment scores of malted millet based cookie samples are presented in table no. 5 and the index of acceptability for gluten free malted multi-millet cookies is presented in Fig.3. The Colour and appearance values for T_0, T_1, T_2, T_3 and T_4 was found to be 8.51, 7.65, 7.48, 8.41 and 8.32 respectively. The lowest colour and appearance value was observed for T_1 (7.65) and highest for T_3 (8.41). There was no significant change in colour as the colour of both sorghum flour and wheat flour was nearly similar. The taste value of samples T_0, T_1, T_2, T_3, T_4 were 8.56, 6.34, 8.23, 8.63 and 8.53 respectively. The highest value for taste was observed for T_3 (8.63) and lowest for T_1 (6.34). The texture for T_0, T_1, T_2, T_3 and T_4 was found to be 8.42, 8.2, 8.17, 8.45 and 8.35 respectively. Texture was observed to be highest for T_3 (8.45) and lowest for T_1 (8.17). Overall acceptability of T_3 (8.56) was highest and of T_1 (7.30) was found to be lowest. Hence, the cookies with 50% proportion of malted sorghum flour and 25% of malted finger millet flour and 25% of malted pearl millet flour was found to be sensorially acceptable.

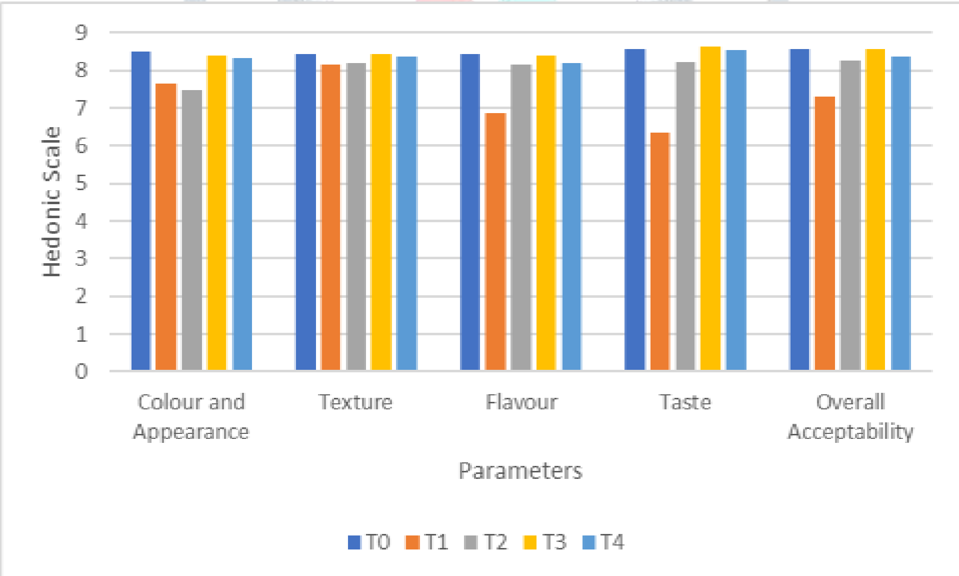

Fig 3. Sensory evaluation of Malted multi-millet cookies

Table 6 Sensory Profile of Gluten free malted multi-millet cookies

Sample	Sensory Parameters				
	Color and Appearance	Taste	Flavor	Texture	Overall Acceptability
TF_0	7.74	8	7.9	7.58	7.54
TF_1	7.6	8.06	7.42	7.94	7.94
TF_2	7.72	8.12	8.18	8.06	7.98
TF_3	8.00	8.46	8.24	8.16	8.41
TF_4	**8.28**	**8.68**	**8.37**	**8.23**	**8.57**

SE ±	0.1	0.06	0.09	0.14	0.1
CD@5%	0.31	0.2	0.28	0.42	0.32

**Each value is an average of ten determinations*
TF_0, TF_1, TF_2, TF_3 and TF_4 as given in Table 2.
RSFP= Roasted Flaxseed Powder

The data for organoleptic evaluation of cookies is presented in Table 6. As clear from the table, cookies prepared from malted flours blends of sorghum, finger millet and pearl millet with incorporation of roasted flaxseed powder (RFSP) were non-significantly different for all the organoleptic parameters except colour and appearance. The maximum scores were obtained for sample TF_4 (30% RFSP) followed by gluten free cookies prepared from malted flour blend incorporated with 25% RFSP i.e., sample TF_3. The index of acceptability for gluten free malted multi-millet cookies is presented in Fig.4. Among the gluten free malted multi-millet cookies TF_4 (30% flaxseed) was found to be most acceptable followed by product TF_4 (30% RFSP) and TF_3 (25% RFSP) while sample TF_0 (0% RFSP) was the least acceptable.

The Colour and appearance ranged from 7.74 (TF_1) to 8.28 (TF_4). The colour and appearance values of cookie samples were found to increase with increase in the percentage of RFSP. This decrease can be attributed to no replacement of flour with RFSP which led to the development of undesired colour, taste and flavour of the cookies. The taste value of samples TF_0, TF_1, TF_2, TF_3 and TF_4 were 8.0, 8.06 8.12, 8.46 and 8.68 respectively. The texture ranges from 8.58 (TF_0) to 8.23 (TF_4) and with the increase in the percentage of RFSP the texture of cookies was found to be improved. The flavour of cookies was found to increase with increase in percentage of RFSP and ranged from (TF_4) 8.37 to (TF_1) 7.9. Sensory attribute scores of sample TF_4 are higher than TF_0. Hence, incorporation of RFSP with 30% proportion was sensorially acceptable and can be used in development of other baked supplementary foods.

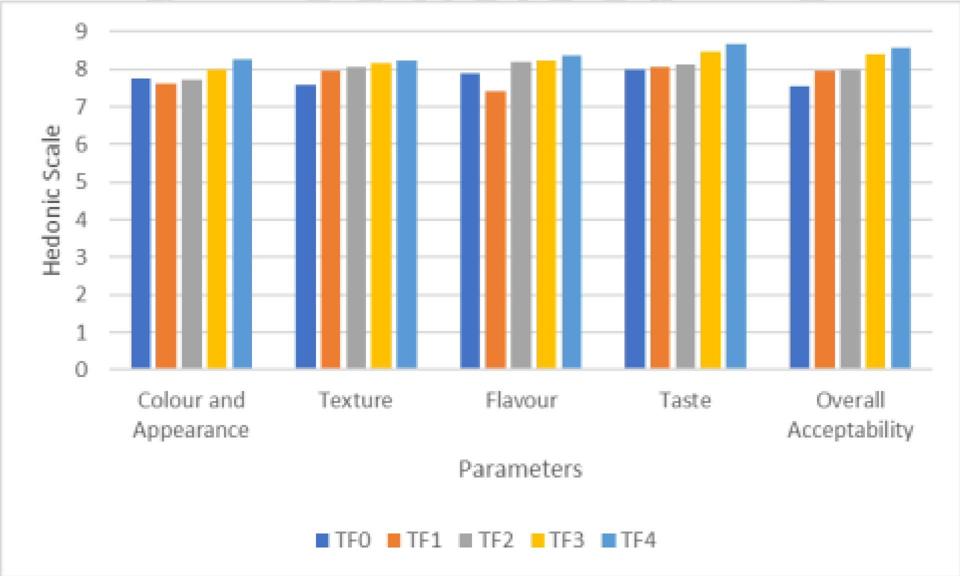

Fig 4. Sensory evaluation of Gluten free malted multi-millet cookies

3.4 Chemical composition of Gluten free malted multi-millet cookies

Table 7. Chemical Parameters of Raw Material

Parameters (%)	**Sample**				
	TF_0	**TF_1**	**TF_2**	**TF_3**	**TF_4**
Moisture	4.41 ±0.013	4.38 ±0.008	4.36 ±0.004	4.39 ±0.027	4.35 ±0.036
Protein	5.73 ±0.001	6.40 ±0.001	7.07 ±0.002	7.41 ±0.001	7.75 ±0.001
Fat	24.12 ±0.001	27.28 ±0.021	30.44 ±0.016	32.02 ±0.014	33.60 ±0.008
Fibre	0.34 ±0.025	0.37 ±0.028	0.40 ±0.002	0.42 ±0.016	0.44 ±0.038
Ash	0.29	0.36	0.43	0.46	0.50

	±0.003	±0.001	±0.006	±0.014	±0.010
Carbohydrates	65.11 ±0.018	61.21 ±0.032	57.30 ±0.054	55.30 ±0.026	53.36 ±0.004

**Each value is an average of three determinations*
Values are means (± standard deviation)
TF_0,TF_1,TF_2,TF_3,TF_4 as in Table 2.

The moisture content of cookies ranged from 4.35% to 4.41% which may be due to the effect of similar baking parameters for all the samples. The moisture content of all cookies were below 20% which reduced the spoilage caused by microorganisms and consequently increased shelf life. The fat content of cookies were found to be 24.12%, 27.28%, 30.44%, 32.02% and 33.60% for TF_0 (0% flaxseed), TF_1 (10% flaxseed), TF_2 (20% flaxseed), TF_3 (25% flaxseed), TF_4 (30% flaxseed) respectively. The significant increase in fat content of cookies might be due to the replacement of malted millet flour with roasted flaxseed powder which is a rich source of fats.

The protein content of cookies were found to be 5.73%, 6.40%, 7.07%, 7.41% and 7.75% for TF_0 (0% flaxseed), TF_1 (10% flaxseed), TF_2 (20% flaxseed), TF_3 (25% flaxseed) and TF_4 (30% flaxseed) respectively. It was observed that with replacement of malted millet flour with flaxseed powder in cookies the protein content of cookies were found to be increased. Ash content of food materials is an indication of the minerals present in the food. It is clearly seen that sample TF_4 had higher ash content (0.50%) than the other samples viz. TF_0 (0.29%), TF_1 (0.36%), TF_2 (0.43%) and TF_3 (0.46%). Reduction in case of sample TF_0, TF_1 and TF_2 may be attributed to the variation of flaxseed. The crude fibre content was found to be highest in TF_4 (0.44%) and lowest in TF_0 (0.34%). The highest carbohydrate content was observed in TF_0 (65.11%) followed by TF_1(61.21%), TF_2 (57.30%), TF_3 (55.30%) and TF_4 (53.36%) respectively.

3.5 Mineral content of Gluten free malted multi-millet cookies

The minerals like calcium, iron and phosphorus were analysed for gluten free malted multi-millet cookies and results are depicted in Table 8.

Table 8. Mineral content of Gluten free malted multi-millet cookies

Parameter (mg/100g)	Sample				
	TF_0	TF_1	TF_2	TF_3	TF_4
Calcium	31.43 ±0.002	42.12 ±0.001	52.81 ±0.004	58.15 ±0.002	63.50 ±0.003
Iron	2.92 ±0.003	3.08 ±0.004	3.24 ±0.001	3.32 ±0.002	3.40 ±0.005
Phosphorus	25.25 ±0.002	43.13 ±0.003	76.58 ±0.004	89.29 ±0.001	102 ±0.003

**Each value is an average of three determinations*
Values are means (± standard deviation)
TF_0, TF_1, TF_2, TF_3 and TF_4 as given in Table 2.

From the Table 8 it was observed that the minerals showed an increasing trend with the replacement of malted flour with roasted flaxseed powder. Calcium content of cookies ranged from 63.50 mg/100g to 31.43 mg/100g. The highest calcium content was observed in sample TF_4 (30% RFSP) and lowest in sample TF_0 (0% RFSP). The results of iron content and phosphorus content also depicted that there was increase in their content in cookies with increase in the percentage of RFSP. The highest iron content was seen in TF_4 (3.40 mg/100g) followed by TF_3 (3.32 mg/100g), TF_2 (3.24 mg/100g) and TF_1 (3.08 mg/100g) and lowest for TF_0 (2.92 mg/100g). The phosphorus content in cookies was found to be highest in TF_4 (102 mg/100) and lowest in TF_0 (25.25 mg/100g). Significant increase in phosphorus was seen with increase in the level of flaxseed incorporated in cookies.

3.6 Omega 3 Content of Gluten free malted multi-millet cookies

The omega-3 content of gluten free malted multi-millet cookies were analysed and are presented in Table 9.

Table 9 Effect of Roasted Flaxseed powder on Omega-3 content of cookies

Parameter (g/100g)	Sample				
	TF_0	TF_1	TF_2	TF_3	TF_4
Omega-3	-	0.90 ±0.016	1.71 ±0.008	2.14 ±0.012	2.57 ±0.026

**Each value is an average of three determinations*
Values are means (± standard deviation)

TF_0, TF_1, TF_2, TF_3, TF_4 as given in Table 2.

The highest omega-3 content was found in sample TF_4 (2.57 g/100g) followed by TF_3 (2.14 g/100g), TF_2 (1.71 g/100g) and lowest for TF_1 (0.90 g/100g). Absence of omega-3 content was seen in sample TF_0 as it was not incorporated with flaxseed. ALA, which is an omega-3 fatty acid, forms the mass composition of polyunsaturated fatty acids in flaxseed. It makes up about 50% of the total fatty acids. ALA cannot be synthesised by the human body from any other substance therefore it is considered as an essential fatty acid. The essential fatty acid requirements for the human body can be fulfilled by consuming flaxseed products (Morris 2007).

3.7 Cost economics of cookies production

Cost of cookies production is given in Table 10. This cost was worked out on the basis of cost of raw materials, chemicals to be added, labour charges at prevailing rate of experimental period. The total cost of production for 1 kg of cookies was Rs. 130.

Table 10 Cost economics of cookies production

Sr. No.	Particular	Quantity (g)	Price per unit (Rs./kg)	Cost (Rs.)
1	Sorghum	158.37	45	7.12
2	Finger millet	79.18	58	4.59
3	Pearl millet	79.18	40	3.16
4	Sugar	271.50	35	9.50
5	Fat	271.50	50	13.57
6	Sodium bicarbonate	2.26	30	0.06
7	Salt	2.26	18	0.04
8	Roasted flaxseed powder	135.75	445	60.40
9	Packaging material (PP)		1.55 (per pouch)	1.55
10	Total Raw material cost			99.99
11	Processing cost @ 30% of Raw material cost			29.99
12	Profit @25%			19.23
13	Production cost for 1 kg of Gluten free malted millet cookies			149.21

The total raw material cost required for production of 100 kg of gluten free malted multi-millet cookies is Rs. 9,999/-. The processing cost charges, which were applied @ 30 % of the raw material cost is Rs. 2,999/-. Hence, the total production cost for production of 100 kg of gluten free malted multi-millet cookies will be Rs. 14,921/- and production cost for 1 kg of gluten free malted multi-millet cookies will be 149.21/- which is very cost effective as compared to the cookies available in the market.

4. CONCLUSION

Malting of the millets and its impact on the nutrient profile were reviewed in detail. Utilization of alternative gluten free sources in food products can help to suffice the demand for gluten free products. As gluten free diet is the only option to treat gluten related disorders the gluten free products can be developed by using the underutilized millets like sorghum, finger and pearl millet, foxtail millet, proso millet, etc. In present study, we employed finger millet, pearl millet and sorghum as the gluten free source and at the same time we enhanced nutritional value of cookies by incorporating roasted flaxseed powder. As per the results the cookies prepared from 70% of composite flour of malted millets with incorporation of 30% of roasted flaxseed powder were found to be superior than the other developed cookies with reference to their chemical and sensory quality attributes. Thus, it could be concluded that the millets with appropriate processing can be used to develop nutritionally enriched gluten-free products and could help to meet the demand for gluten free products.

5. FUTURE PROSPECTS

This research work is expected to open new avenues for developing nutrient dense products with potential utilization of underutilized millets and generate greater interest in the research of millets.

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