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## Development and standardization of foxtail millet (*Setaria italica*) gluten-free biscuit

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### Abstract

Millets are unique among the cereals because of their richness in calcium, dietary fiber, polyphenols and protein. Millets are gluten-free cereal grain, an excellent source for people suffering from celiac diseases. Millets are with superior nutritional qualities and antioxidant properties. Though incorporation of these millet flours can enhance the nutritional value of conventional cereal flours, the functional properties of the flour can greatly be affected due to varied protein and fiber content. The present study was undertaken with the aim of preparing gluten free biscuit by using foxtail millet flour and to evaluate the physical, sensory quality parameters and consumer preference test for the acceptability of the product. Foxtail millet biscuit with refine wheat flour (50:50, 60:40, 70:30, 80:20, 90:10, and 100:0) were prepared. The panelists evaluated volume, crust colour and surface character, crumb colour, crumb texture, mouth feel, taste and aroma and overall acceptability of the biscuits. The sensory parameters revealed that 100% of foxtail millet biscuits were acceptable by the panel members. The physical parameters like thickness ranged (3.75-4.03mm), diameter (37.83-38.66cm), spread ratio (9.52-10.05) was observed. 100% of foxtail millet biscuit found to be gluten free biscuit for celiac patients and also for non celiac symptoms.

**Keywords:** foxtail millet, gluten-free biscuit, celiac diseases

### Introduction

Bakery products account for a major part of the processed food market and this industry is rapidly changing with advancements in nutraceutical and new product developments. With regard to bakery products, consumers have great concern for quality and nutritional contents of bakery products and hence, bakery industry is looking forward for newer options to ingredients having functional and nutraceutical properties in place of refined wheat flour. This can be achieved and the nutritional value of bakery products can be enhanced with a use of wide variety of nutri-cereals (Saleh, A. S. *et al.*, 2013) [8]. Biscuits are prominent ready-to-eat baked snack among the people, globally. They are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven (Kure, O. A., *et al.*, 1998) [6]. Biscuits are usually made with refined wheat flour and it does not contain fiber and quality of the protein is inferior because it is deficient in essential amino acids such as lysine and threonine. The protein gluten found in wheat is responsible for severe discomforts in people who suffer from celiac disease; a condition resulting from an intolerance to gluten (Anju, T. and Sarita, S., 2010) [3]. Celiac disease is a chronic disease of the gastrointestinal system, in which characteristic damage of the small intestinal mucosa occurs in genetically susceptible people in response to the presence of gluten in food. So development of gluten free biscuit with millets helps to overcome from celiac

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disease and also helps to improve nutritional quality of biscuit (Taylor, J. R., & Emmambux, M. N., 2008) [10]. In developing countries, millets are consumed by people from the low economic strata and as forage crop. Millets are nutritionally comparable or even superior to staple cereals such as rice and wheat (Gopalan *et al.*, 2004) [4]. Millets provide a wide range of health benefits and they are a good source of energy, proteins, minerals, vitamins, essential amino acids and additional benefits like millets contain gluten-free proteins and are suitable for celiac disease patients. They have higher proportions of non-starchy polysaccharides and dietary fiber. Millets release sugars slowly and thus have a low glycaemic index (Karuppasamy, P. *et al.*, 2013) [5]. Bakery products are usually made with refined wheat flour and it does not contain fibre and quality of the protein is inferior. It is possible to replace the wheat flour in bakery products by using millets. Foxtail millet contains a pertinent amount of nutritional components, especially starch, protein, vitamins, and minerals. Due to coarse nature of foxtail millet grains, the digestible portion constitutes about 79%, and the remaining

indigestible part of the grain contains relatively high levels of fiber as well as some anti-nutritional components (Anju, T. and Sarita, S., 2010) [3]. Foxtail millet is a good source of crude fiber helps in the digestive process and helps to induce bowel movement, thus producing a laxative effect that is beneficial for a healthy digestive system. All these nutritional properties have made foxtail millet an important ingredient for preparing bakery products. In addition to its nutritional properties, foxtail millet has also shown to possess several health benefits like prevention of cancer, hypoglycemic, and hypolipidemic effects (Saleh, A. S. *et al.*, 2013) [8]. Replacing wheat flour with foxtail millets in bakery products is to add more functional and nutritional value to the bakery products. Identifying the right proportion of such replacement products in the biscuit preparation has always been a major challenge. Hence, the present study was undertaken to develop and standardization of foxtail millet flour biscuit and also aim to develop gluten free biscuit by replacing refined wheat flour at 100 per cent.

**Table 1:** Comparison of nutritive value of foxtail millet and refined wheat flour

SI No.	Name	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Crude fiber (g)	Iron (mg)	Calcium (mg)
1	Refined wheat flour (Gopalan <i>et al.</i> , 2004) [4]	348	11	0.9	73.9	0.3	2.7	23
2	Foxtail millet (Ahmed, S.M. <i>et al.</i> 2013) [1]	351	11.2	4	63.2	6.7	2.8	31

## Materials and Methods

### Source of raw materials and pre preparation

The essential ingredient such as foxtail millet was procured from the local departmental stores, Bengaluru. The millet was cleaned, washed and sundried and subjected to grinding in a commercial flour mill exclusively meant for millet grinding and sieved in order to obtain fine flour for the study. Other ingredients like refined wheat flour, sugar powder, vegetable fat, sodium bicarbonate, ammonium bicarbonate, skim milk powder, iodized salt, and other general ingredients were also procured from the local market in reputed departmental stores.

### Development and Standardization of foxtail millet-based biscuit

Control with cent per cent refined wheat flour and experimental biscuits at different levels of foxtail millet and refined wheat flour at the ratio of 50:50 (T<sub>1</sub>), 60:40 (T<sub>2</sub>), 70:30 (T<sub>3</sub>), 80:20 (T<sub>4</sub>), 90:10 (T<sub>5</sub>) and 100:0 (T<sub>6</sub>) were prepared by following AACC 10-50D(2000) method.

### Determination of physical properties of biscuits

Physical parameters such as Dough weight (g), Baked weight (g), Baking loss (%), Thickness (mm), Diameter (mm), Spread ratio (D/T), Spread Factor (%) were determined by following standard procedure. From the weight of pre and post cooking biscuits the product yield was also calculated and baking loss (%) was analyzed. A biscuit frame of 0.6cm thickness and biscuit cutter with 4.8cm diameter was used to get uniform thickness and diameter of the product both in control and experimental biscuits.

- Thickness of biscuit (mm) was determined by stacking six biscuits on top of one another, restacking and re-measured. The average height of the biscuits was the average of the two readings divided by six. These measurements were taken on 3 sets of biscuits from the same batch for each variation and values are presented as mean thickness in milimetre.

- Biscuit diameter (mm) was measured by laying six biscuits edge to edge with the help of scale and then rotating them by 90° and re-measuring. The average diameter of the biscuits was the average of the two readings divided by six. These measurements were taken on 3 sets of biscuits from the same batch for each variation and values are presented as mean milimetre.
- Spread ratio which is defined as a ratio of average diameter to average thickness of the biscuits was then arrived at.
- Spread Factor (%) was calculated by dividing spread ratio of blend (Experiment) to the spread ratio of control.

### Organoleptic or Sensory Quality Analysis of foxtail millet-based biscuit

The sensory evaluation of the developed foxtail millet biscuits were carried out by semi trained 21 sensory panel members. The panelists, made up of Staff and students of the Department of Food Science and Nutrition, University of Agricultural Sciences, Bengaluru, who were familiar with quality attributes of biscuits. The samples were coded and presented in identical containers. Questionnaire for entering scores and portable water for mouth-rinsing between each tasting was made available to the panelists. The sensory characteristics of the samples were evaluated by use of composite scoring test as suggested by Ranganna (1986) [7]. The score judgments were made through rating the products on a scale mentioned below with corresponding descriptive terms.

#### The score judgments were made through rating the products

Parameters	Scores
Appearance	25
Crust colour	10
Crumb grain	20
Texture	20
Taste and odour	25

### Consumer preference Test for foxtail millet gluten-free biscuit

Collecting appropriate information concerning consumer's needs and expectations are essential requirements of a consumer-oriented product development. Consumer's preference tests were carried out by choosing all the 120 consumers who visited the Bakery Training Unit outlet, on a particular day thus making the entire population as the sample size. The consumers were asked to rate the biscuits on different parameters either to accept, partially accepted or not accepted. The responses were analyzed with frequency and percentage.

### Results and Discussions

#### Physical properties of foxtail millet-based biscuits

The result presented in table 2 showed the physical properties of foxtail millet-based biscuits. The dough weight was 161.6g for control and millet added biscuits showed higher dough

weight. Higher water absorption by the millet flour compare to control (refined wheat flour) can be related to the higher water absorption capacity. The high-water absorption is the characteristics of fiber supplemented flours as reported by Karuppasamy P *et al.*, 1991 [5]. The water absorption was differ in the various millet flours are attributed to differences in particle size of flour, presence of large proportion of husk in whole flours, percentage of damaged starch in milled flours and protein content of different millet flours (Singh *et al.*, 2005) [9]. This adverse effect was observed along with increase in millets at 80% of replacement of refined wheat flour. Baking loss increased with the flour replacement and there was a decrease in thickness and diameter remains same for all the biscuit. Spread ratio also decreased compared with the control. Spread factor percentage also decreased compared with the control but with full replacement of refined wheat flour to foxtail millet had 96 per cent.

**Table 2:** Physical properties of foxtail millet-based biscuits

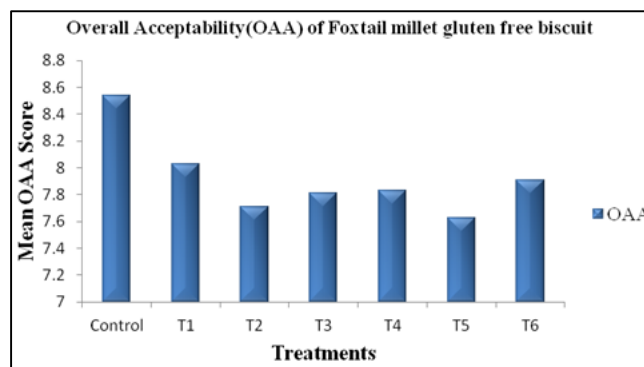
Parameters	Control	T1	T2	T3	T4	T5	T6
Dough weight (g)	161.6	166.2	168.0	170.5	167.5	164.5	164.8
Baked weight (g)	134.8	142.3	141.9	147.8	140.8	147.8	145.8
Baking loss (%)	15.8	14.15	15.13	13.2	15.16	16.16	12.16
Thickness(mm)	3.75	3.86	3.81	3.90	3.90	4.03	3.90
Diameter (mm)	38.03	38.66	37.83	38.00	38.00	38.43	38.00
Spread ratio (D/T)	10.05	9.96	9.89	9.74	9.74	9.52	9.74
Spread Factor (%)	--	99	98	96	96	94	96

#### Organoleptic quality parameters of Foxtail millet-based biscuit

The sensory evaluation of the foxtail millet-based biscuits results (Table 3) indicated that, there was a non-significant difference was observed to volume, crust colour and surface character, crumb colour, crumb texture, aroma and overall acceptability for all the levels of the refined wheat replacement. Taste and mouth feel shows significant difference. This may be due to the presence of fiber and course nature of the grain even after milling to fine flour and baking, make the residue to remain in the mouth after taste. The figure 1 showed the overall acceptability of the foxtail millet-based biscuit. The scores showed non-significant result for cent per cent replacement of refined wheat flour with foxtail millet flour and the one adjudged to be the most acceptable by considering the health benefits of millets.

**Table 3:** Organoleptic quality parameters of foxtail millet-based biscuit

Treatments	Sensory Attributes					
	Volume	Crust colour and surface character	Crumb colour	Crumb texture	Taste and aroma	Mouth feel
Control	8.57	8.19	9.30	17.76	26.61	8.29
T1	8.28	8.19	9.00	18.39	25.59	8.11
T2	8.02	7.90	7.91	17.47	25.90	7.66
T3	8.25	7.90	8.04	17.46	26.57	7.98
T4	8.36	7.94	8.02	16.77	22.16	8.00
T5	8.05	7.66	8.66	15.83	22.80	7.88
T6	8.40	8.06	8.95	17.60	27.23	8.23
F value	NS	NS	NS	NS	*	NS
SEM $\pm$	0.31	0.32	1.22	0.79	1.68	0.34
CD	0.62	0.65	2.42	1.58	3.33	0.68



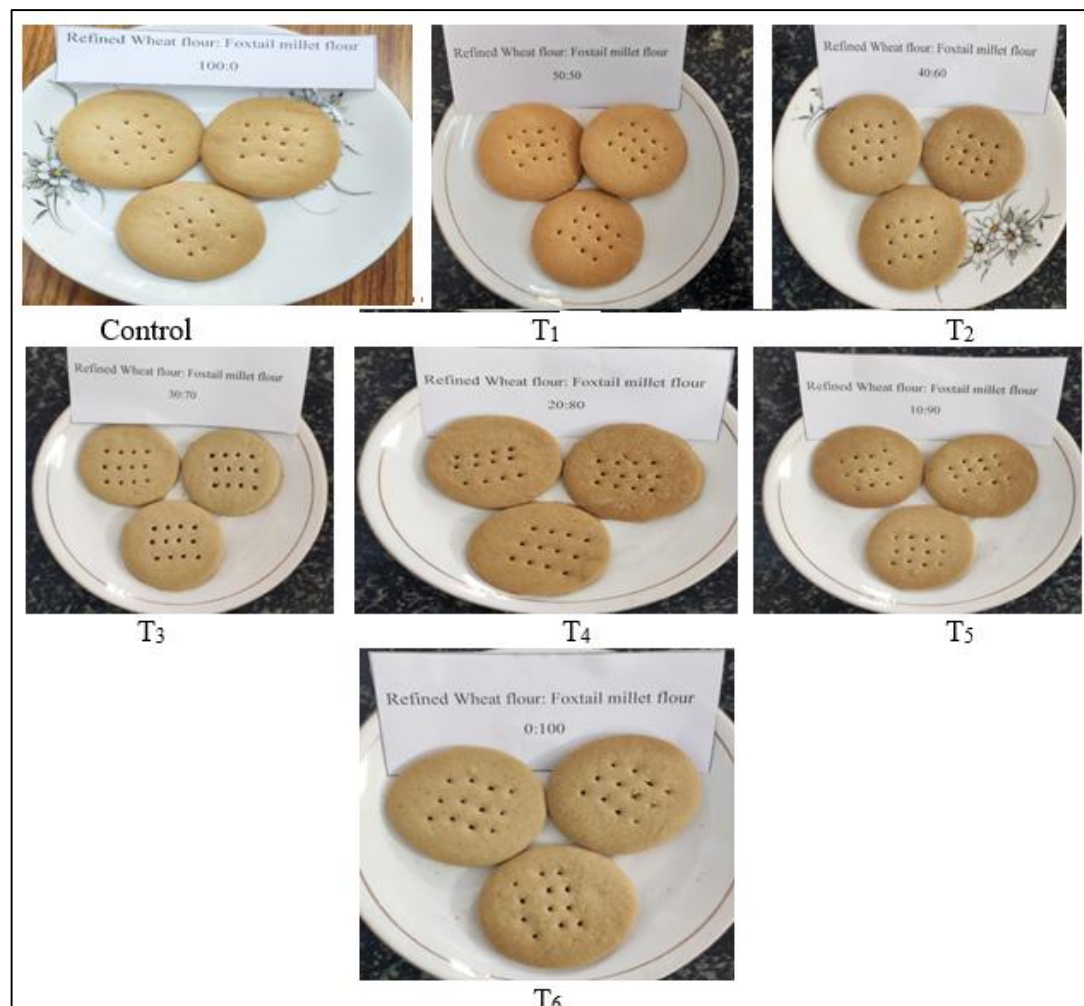
**Fig 1:** Overall acceptability of Foxtail millet-based biscuit

#### Consumers preference test for foxtail millet gluten-free biscuit

Sensory quality and consumers preference are useful and important for product development and quality control. Consumer-oriented food product development needs to be considered as a tool for building competitive advantage and long-term enterprise success in the market and for prevention of negative changes in product quality and acceptability. Hence, the results indicated that for all the parameters more than 85 percent of the consumers expressed acceptability towards the product except appropriate packaging and taste of the product. This may be due to the accustomed habit of consuming refined wheat flour-based bakery products for a long time. Further 20 percent of the consumers not accepted packaging which was done with food grade poly ethylene for the developed product. This may indicate that, there is a scope for up grading of packaging technologies which suits to the needs of the consumers to pack foxtail millet-based biscuit to preserve sensory attributes and to extend the shelf life of the products.

**Table 4:** Consumers preference test of foxtail millet gluten-free biscuit (n=120)

Parameters	Accepted		Partially accepted		Not accepted	
	n	%	n	%	n	%
Nutrition	111	92.5	7	5.83	2	1.67
Price	108	90.0	6	5.00	6	5.0
Freshness	109	90.8	8	6.70	3	2.5
Taste	98	81.7	10	8.30	12	10.0
Variety	103	85.8	7	5.83	10	8.3
Consistency	103	85.8	9	7.50	8	6.70
Convenience	102	85.0	7	5.83	11	9.17
Ingredient labeling	109	90.8	7	5.83	4	3.33
Appropriate packaging	92	76.7	8	6.70	20	16.7



### Conclusion

The use of foxtail millet flour in biscuit making would greatly enhance the utilization of this crop in developing countries for therapeutic purpose especially for celiac disease patient. The nutritional quality of refined flour biscuits could be improved with foxtail millet. From the study it is clear that hundred per cent of replacement of refined wheat flour shows non-significant difference in volume, crust colour, crust texture. Significant difference in taste and aroma compared with control sample due to the fiber content of foxtail millet flour. Hundred per cent of foxtail millet-based biscuit was accepted by the panelist during sensory evaluation. It can be concluded that gluten free biscuit, can be consumed by the celiac patient and also to the people with non-celiac symptoms.

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