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Evaluation of Physico-Chemical Properties of Foxtail Millet (*Setaria italica)* Based Biscuits

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ABSTRACT

Now a day's bakery industry is looking forward for newer options to ingredients having functional and nutraceutical properties as refined wheat flour a major ingredient in bakery industry is a poor source of dietary fiber and protein. Hence, there is a need for partial or full substitution of refined wheat flour by fiber and protein rich natural ingredients and also to increase the number of nutritious snacks containing low fat composition and total caloric value. Millets provide a wide range of health benefits and are good source of energy, protein, fiber, minerals and vitamins, additional benefits of the millets like gluten-free protein content and low glycaemic index. Hence, the present study was designed to develop and standardize the foxtail millet based biscuit. Biscuits were developed by incorporation of foxtail millet flour at 50 to 100 % containing 20 % fat. Physical parameters of foxtail millet based biscuit showed increase in diameter (4.16-5.03 cm), spread ratio (5.36-8.11), hardness (10.43-13.27 N) and decrease in thickness (0.80-0.62 cm), density (1.02-0.96 g/cm^3) and fracturability (15.32-13.06) compared to control (Refined wheat flour biscuit). The significant result was observed only in taste and aroma, mouth feel. Sensory scores revealed that 100% of foxtail millet (FBT6) biscuit was best accepted with nonsignificant result in volume, crust color and surface colour, crumb color, crumb texture and overall acceptability. Nutrient content of 100% foxtail millet based biscuit increased fiber, calcium and iron content compared to control and was best accepted with improved nutritional quality.

Keywords Foxtail millet, Refined wheat flour, Physical parameters, Nutrient content.

INTRODUCTION

Foxtail millet (*Setaria italica*) is one of the earliest cultivated crops, grown in arid and semiarid regions of Asia and Africa. Foxtail millet also called as Italian millet, German millet, Chinese millet. It is a major millet in terms of worldwide production, sixth highest yielding grain. Belonging to the Setaria genus of poaceae family. It contains a pertinent amount of nutritional components such as starch, protein, vitamins and minerals due to coarse nature of foxtail millet grains, the digestible portion constitutes about 79 % and remaining portion contains about fiber as

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well as antinutritional component. Millet helps to induce bowl movement, thus providing laxative effect that is beneficial for a healthy digestive system. Foxtail millet also possess several health benefits like prevention of cancer, hypoglycaemic and hypolipidemic effect (Sharma and Niranjan 2018). Processing techniques include drying, roasting, germination and fermentation can produce products that can be nutritionally preferable, various products like biscuits, cookies, breads and porridge can be prepared. Hence the present study is an attempt to develop and evaluate the Physico-chemical parameters of foxtail millets based biscuits.

Biscuit industry is India's largest industry amongst processed food industries, with an estimated production of 70,000 tones and cost of three thousand billions US Dollar. Biscuit along with bread forms major baked food accounting to over 30 and 50% respectively of total bakery products produced in the country. Biscuits are available in wide variety and in many combinations (salt, high/low fat biscuits). The nutritional value of biscuit can be enhanced by fortification and supplementation with protein rich, fiber rich cereals, pulses and millets (Ahmad and Ahmed 2014). Per capita consumption of biscuits in India is 2.1 kg, compared to more than 10 kg in USA, UK and West European countries and above 4.25 kg in South-east Asian countries, includes Singapore, Hong Kong, Thailand, Indonesia.. Per capita consumption of China has 1.90 kg, while in the case of Japan it is estimated at 7.5 kg (Kachave, 2018).

MATERIALS AND METHODS

Procurement and processing of raw materials

Refined wheat flour, foxtail millet, sugar, hydrogenated fat, sodium bicarbonate, ammonium bicarbonate, skim milk powder, vanilla essence and packaging materials were procured from local market, Bangalore. The foxtail millet grains were cleaned to remove dust and other foreign materials and then grounded in a commercial centrifugal food processing machinery (Serial number: CFPM-B44 with RPM of 2800) and equipment with a 250-µm mesh sieve, flour was sieved using a BS 40 mesh sieve to obtain fine flour and was stored in stainless steel containers.

Table 1. Composition of Foxtail millet based biscuits. Other ingredients: Sugar-30 g, Fat-20 g, Skimmed milk powder-02 g, Ammonium bicarbonate-01g, Salt-1g, Sodium bicarbonate-0.5 g, Vanilla essence-01 ml. *All other ingredients are kept constant for all the variations in little millet based biscuits. FB : Foxtail millet flour based biscuit.

Treatments	Foxtail millet flour based biscuits Ingredients		
	Refined wheat flour (g)	Foxtail millet flour (g)	Water (ml)
Control	100	00	35
FBT1	50	50	40
FBT2	40	60	43
FBT3	30	70	45
FBT4	20	80	45
FBT5	10	90	46
FBT6	00	100	50

Development and standardization of foxtail millets based biscuits

The formulation for the control biscuit was based on the recipe of Sudha *et al.* 2007 by creaming method.

Standardization of foxtail millet based biscuits

After the successful preparation of the control biscuit, the experimental biscuits were prepared by replacing refined wheat flour with foxtail millet flour at different levels viz., 50, 60, 70, 80, 90 and 100% Amount of fat, sugar, milk powder, ammonium bicarbonate, sodium bicarbonate, salt, vanilla essence were kept constant to 20 g, 30 g, 02 g, 01g, 0.5g, 01g, 01ml respectively on 100 g flour weight basis for all variations, differing in the amount of water added. The composition of millets based biscuits is presented in Table 1. The method of preparation remains the same as that of the control biscuit.

Physical characteristics of developed biscuits

Physical characteristics of the biscuits i.e. dough weight, baked weight and baking loss were calculated. Whereas diameter (D) and thickness (T) were measured by considering eight pieces of biscuits from each formulation were placed edge to edge and stacked one above the other to measure the diameter (D) and thickness (T), respectively. The average values of diameter (D) and thickness (T) were expressed

in mm, according the method described by Bala *et al.* 2015. The spread ratio of biscuits was derived from diameter and width. The density of the biscuits were determined according to method used by Mamat *et al.* 2010 using solid replacement technique.

Textural properties of developed biscuits

The hardness and fracturability profiles of biscuits were determined using texture analyzer TA-XT plus (Stable Micro Systems). The Texture Analyzer settings were: Pre-test speed at 5.0 mm/s, Test speed at 1.0 mm/s, Post-test speed at 5.0 mm/s, Distance at 5 mm and 2 mm probe. The load cell used was 100 kg. Fracturability refers to the ease with which the material will break. Fracture profiles of biscuits were determined by placing each biscuit on a heavy duty platform table with a holed plate and the penetration test was performed using P/6 element moving at 1 mm/s. The probe penetrated completely through the biscuits. Hardness was measured with the maximum force and the distance to break off the sample. The measurements were carried out on the day of baking. The results of the experiments were given as the average of three replicates. Each replicate (a new piece of biscuit) was obtained from separately prepared batch of dough.

Sensory evaluation of developed biscuits

Biscuits were evaluated for their sensory attributes by a panel of 21 semi trained members using composite score test suggested by Ranganna (1986). The panellists evaluated organoleptic characteristics such as volume, crust color and surface character, crumb color, crumb texture, mouth feel, taste and aroma and overall acceptability.

Nutrient composition of best accepted foxtail millet based biscuit with apple pomace pectin as a fat replacer

Foxtail millet based biscuit were powdered sieved through 40 mesh and stored in air tight sample containers. Analysis was done for the nutrients namely moisture, protein, fat, crude fiber, ash, calcium and iron by using standard procedure (AOAC 2005), carbohydrate was calculated by difference method and energy was computed. Results were expressed on dry weight bases,

Statistical analysis

In the present study one way ANOVA was applied. The data was tabulated and analyzed by keeping in view of the objectives and parameters of the study. All the analyses were performed in triplicate and the data was analysed using EXCEL.

RESULTS AND DISCUSSION

Physical, textural and sensory characteristics of foxtail millet based biscuits

The physical and textural characteristics of foxtail millet flour based biscuits are presented in Table 2.

Physical characteristics

The mean value of before and after baking weight and baking loss for control was 181.7 g, 142.3 g and 21.7% respectively. The before and after baking weight was significantly increased with the increase in replacement of refined wheat flour with foxtail millet flour ranged from 186.5 g to 193.2 g and 144.3 g to 150.1 g respectively. The effect of level of incorporation of foxtail millet flour was not influenced much on baking loss but varied in all treatments ranged from 22.1 to 22.6 per cent and was statistically nonsignificant. This could be due to the fact that as the level of foxtail millet flour increases, water absorption power also increased than refined wheat flour due to high fiber content. Singh *et al.* (2005) reported that higher water absorption by various millet flours were attributed to differences in particle size of flour, presence of large portion of husk in whole flours, percentage of damaged starch in milled flours and protein content of different millet flours. The mean values of diameter and thickness for all formulations ranged from 4.86 to 5.03 cm and 0.62 to 0.76 cm respectively. The diameter of foxtail millet based biscuits increased and thickness decreased with the increase in substitution of foxtail millet flour compared to control (4.16 cm and 0.80 cm). The highest diameter (5.03 cm) and lowest thickness (0.62 cm) was recorded for cent per cent replacement (FBT6).

Table 2. Physical and textural characteristics of foxtail millet based biscuits (Mean ± SD). FM: Foxtail millet based biscuits. *Significant at 5%. NS-Non Significant.

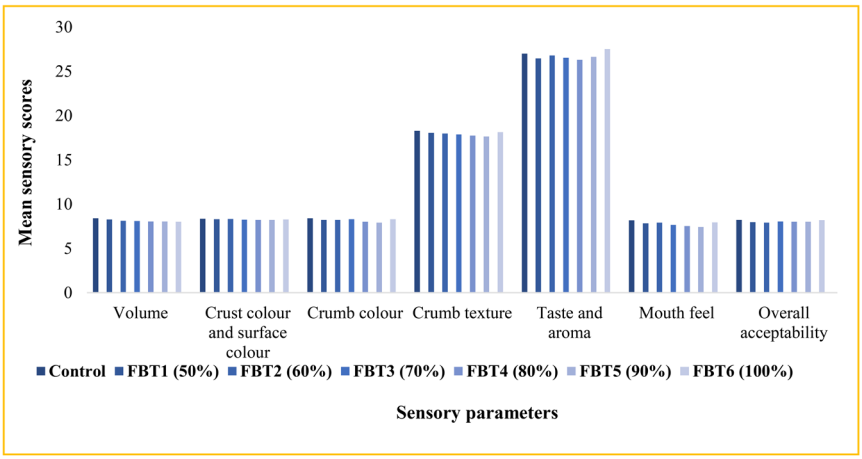
Treatments	Physical parameters										Textural parameters	
	Before baking weight (g)	After baking weight (g)	Baking loss (%)	Diameter (cm)	Thickness (cm)	Spread ratio (D/T)	Spread factor (%)	Mass (g)	Volume (cm^3)	Density (g/cm^3)	Hardness (N)	Fracturability (N)
Control (100% RWF)	181.7 ±0.02	142.3 ±0.05	21.7 ±0.11	4.16 ±0.01	0.80 ±0.01	5.36 ±0.04	--	8.12 ±0.07	7.99 ±0.12	1.02 ±0.01	10.43 ±0.21	15.32 ±0.45
FBT1 (50%)	186.5 ±0.50	144.3 ±0.15	22.6 ±0.15	4.86 ±0.02	0.76 ±0.01	6.39 ±0.04	119.2 ±1.52	7.76 ±0.11	7.65 ±0.05	1.01 ±0.10	11.43 ±0.08	13.67 ±2.02
FBT2 (60%)	188.7 ±0.20	146.1 ±0.11	22.2 ±0.25	4.95 ±0.04	0.72 ±0.02	6.87 ±0.12	128.0 ±2.09	7.61 ±0.02	7.61 ±0.04	1.00 ±0.01	13.01 ±0.48	12.34 ±0.88
FBT3 (70%)	190.3 ±0.14	148.2 ±0.17	22.1 ±0.11	4.97 ±0.36	0.68 ±0.01	7.30 ±0.04	136.1 ±3.03	7.08 ±0.73	7.07 ±0.05	1.00 ±0.02	12.48 ±0.07	13.26 ±0.21
FBT4 (80%)	190.6 ±0.60	148.4 ±0.37	22.1 ±0.26	4.97 ±0.01	0.67 ±0.01	7.41 ±0.13	138.2 ±1.18	6.86 ±0.08	7.03 ±0.06	0.97 ±0.01	13.95 ±0.08	13.96 ±0.77
FBT5 (90%)	193.2 ±0.05	150.0 ±0.15	22.4 ±0.20	4.97 ±0.01	0.67 ±0.01	7.41 ±0.01	138.1 ±0.56	6.85 ±0.06	7.00 ±1.01	0.96 ±0.02	13.83 ±0.57	14.50 ±1.00
FBT6 (100%)	193.2 ±0.15	150.1 ±0.05	22.3 ±0.05	5.03 ±0.06	0.62 ±0.01	8.11 ±0.14	151.1 ±2.84	6.80 ±0.06	7.00 ±0.23	0.96 ±0.02	13.27 ±0.19	13.06 ±0.14
F-value	*	*	NS	*	*	*	*	*	*	*	*	*
SEm±	0.27	0.16	0.15	0.02	0.007	0.07	2.25	0.24	0.09	0.03	0.29	0.78
CD @ 5%	0.59	0.35	0.33	0.06	0.01	0.17	5.09	0.52	0.20	0.07	0.63	1.70

There was a significant difference observed for diameter and thickness. The increase in diameter of millet biscuit might be due to the lower viscosity of flour than the wheat flour. The decrease in the thickness was might me due to the dilution of gluten (Aslam *et al.* 2014). Chauhan *et al*. (2016) had also noticed that diameter of cookies increased with increasing level of amaranth flour. This was due to the lower viscosity of flour resulted reduced dough viscosity as an addition of amaranth flour increases and increased in spread rate. While thickness of gluten free biscuit (foxtail millet flour) had reduced thickness compared with the wheat flour biscuit (Thejashri *et al.* 2017).

The control biscuit had minimum spread ratio

Table 3. Mean sensory scores of foxtail millet based biscuits (Mean±SD). RWF: Refined wheat flour, FB: Foxtail millet based biscuits, Significant at 5%, NS-Non Significant.

Treatments	Sensory parameters						
	Volume	Crust color and surface color	Crumb color	Crumb texture	Taste and aroma	Mouth feel	Overall acceptability
Control (100% RWF)	8.39±1.04	8.35±0.99	8.40±0.89	18.28±1.49	27.00±1.30	8.16±1.02	8.20±0.88
FBT1 (50%)	8.25±0.68	8.30±0.61	8.22±0.86	18.05±1.31	26.46±1.39	7.83±0.83	7.95±0.73
FBT2 (60%)	8.10±0.93	8.31±0.89	8.20±0.79	17.97±1.81	26.78±0.69	7.91±0.66	7.90±0.64
FBT3 (70%)	8.09±0.92	8.23±0.92	8.28±0.82	17.87±1.53	26.53±1.66	7.65±0.77	8.03±0.79
FBT4 (80%)	8.03±1.00	8.21±0.80	8.00±1.15	17.74±1.69	26.30±1.95	7.50±1.00	8.00±0.96
FBT5 (90%)	8.03±1.04	8.20±1.14	7.90±1.07	17.64±1.51	26.64±1.82	7.41±0.90	8.01±0.91
FBT6 (100%)	8.00±0.88	8.25±0.91	8.30±0.85	18.14±1.61	27.50±1.28	7.93±1.15	8.19±0.85
F-value	NS	NS	NS	NS	*	*	NS
SEm±	0.3	0.34	0.35	0.54	0.56	0.37	0.31
CD @ 5%	0.70	0.68	0.70	1.07	1.13	0.75	0.62



RWF: Refined wheat flour biscuit **FB:** Foxtail millet based biscuit

Fig. 1.. Mean sensory scores of foxtail millet based biscuits.

(5.36) compared with the other treatments ranged from 6.39 to 8.11. However, the maximum spread ratio was observed in FBT6 (8.11). Spread ratio of foxtail millet flour incorporated biscuits significantly increased compared to control. Similar trend was recorded for spread factor also. The spread factor of foxtail millet flour based biscuits was also increased significantly with the increase in millet flour incorporation. The highest spread factor was observed for FBT6 (151.0 %). Sharma *et al.* (2016) reported that, gluten free cookies made from foxtail, barnyard and kodo millets in the ratio of 70: 20: 10 respectively showed increased spread ratio of cookies compared with the control cookies. Shiv Kumar *et al*. (2010) observed that, with increase in amount of kodo millet flour, thickness of biscuit decreased and spread ratio and per cent spread factor of the biscuit increased.

The data pertaining to mass, volume and density of all formulated biscuits showed decreased value and were ranged from 6.80 to 7.76 g, 7.00 to 7.65 cm^3 and 0.96 to 1.01 g/cm3 than control (8.12 g, 7.94 cm^3 and 1.02 g/cm^3). The lowest mass, volume and density were recorded for FBT6 (100 % foxtail millet flour). F value resulted in significant difference between the treatments and control biscuit. Balloli *et al.* (2014) and Mannuramath *et al.* (2015) reported similar result, reduced weight of the biscuit as with the increased replacement of refined wheat flour with foxtail millet flour. While foxtail millet biscuit had reduced density compared with the wheat flour biscuit reported by Thejashri *et al.* (2017).

Textural characteristics

Texture of food relates to the mechanical work that occurs in food processing operations. During mastication, it is desirable to weaken the structure so that it will properly disintegrate when force are applied. Hardness and fracturability were measured using texture analyzer (Table 2). The mean values of hardness for formulated biscuits were 11.43, 13.01, 12.48, 13.95, 13.83 and 13.27 N of force for 50, 60, 70, 80, 90 and 100% of incorporated foxtail millet biscuits. The hardness of all the variations was higher compared to the control (10.43 N). However, the mean values for fracturability of control biscuit was 15.32 N and all other formulated biscuits differ significantly. The fracturability was decreased as increase in millet flour ranged from 14.50 to 12.34 N. Statistically significant difference was observed for both hardness and fracturability. The highest hardness and lowest fracturability was noticed for cent percent replacement of refined wheat flour. Singh and Kumar (2019) prepared gluten free biscuit from foxtail millet flour and copra meal flour, hardness of millet incorporated/gluten free biscuit was increased as compared with the control. Sandhu *et al.* (2017)

also reported that increase in hardness of biscuit as increase in level of corn fiber.

Mean sensory scores of foxtail millet based biscuits

The organoleptic quality parameters of a product assume pivotal role in anticipating the consumer preference to the product. The sensory characteristics of the biscuits were evaluated by semi trained panelists using composite scores test and are tabulated in Table 3 and Fig. 1.

The biscuit with cent per cent of foxtail millet flour was best accepted among the variations, attributed with higher composite sensory scores for all the sensory parameters compared to other treatments with the mean score of 8.00, 8.25, 8.30, 18.14, 27.50, 7.93 and 8.19 and control had 8.39, 8.35, 8.40, 18.28, 27.00, 8.16, 8.20 for volume, crust color and surface color, crumb color, crumb texture, taste and aroma, mouth feel and overall acceptability respectively. The statistically significant results were observed for taste and aroma and mouth feel. However volume, crust color and surface color, crumb color, crumb texture and overall acceptability showed non-significant results. The present study results was in agreement with the research conducted by Thejashri et al. (2017) where gluten free foxtail millet flour biscuits received higher score for taste and flavor. The similar finding was also observed by Sharma *et al.* (2016) cookies prepared from incorporation of foxtail, barnyard and kodo millets in the ratio of 70: 20: 10 respectively were most accepted by the sensory panelists. Navaneetha (2019) also studied on foxtail millet biscuit with incorporation of moringa leaves, 90% of foxtail millet biscuit had scored highest in overall acceptability while compared with the control and was taken for further incorporation of moringa leaves.

The data pertaining to physical, textural and sensory characteristics indicated that, the biscuit with cent per cent foxtail millet flour was better with all the variations. Hence FBT6 was selected as best among all foxtail millet based biscuits for further study.

Nutrient composition of best accepted millet based biscuit

The nutrient composition of foxtail millet flour based biscuit is presented in Table 4. The data on nutrient composition of foxtail millet biscuit (FB) was significantly high in crude fiber (1.40 g), protein (6.53 g), ash (1.39 g), calcium (25.04 mg) and iron (1.03 mg) compared to the control biscuit, However moisture, carbohydrate and energy content between of FB biscuit had 1.42 g, 75.20 g, 452.0 kcal respectively than control and results indicated non-significant difference. Due to the replacement of refined wheat flour with foxtail millet flour, there was an improvement in nutrient composition of millets based biscuits and were nutritionally superior in terms of protein, fiber, calcium and iron content. The increase in ash content with refined wheat flour replacement may be associated with the presence of greater ash content in the millet itself and and also markedly increased the mineral content. Significant calcium and iron levels were noticed indicating that utilization of millet flour would enhance the mineral content of the product and could serve as a source of essential micro nutrients (Hemalatha *et al.* 2006). Shiv Kumar *et al.* (2010) reported that, the incorporation of millet (Kodo and Kutki) flour at 70, 80 and 100 per cent level showed non-significant effect on moisture content and remained below 4% for all level of incorporation of millet flour.

Table 4: Nutrient composition of foxtail millet based biscuits.

Nutrients	Control	FB	T test
Moisture (g)	2.87±0.01	1.42±0.01	289NS
Ash (g)	0.99±0.01	1.39±0.01	56*
Fat (g)	13.01±0.11	13.86±0.02	9.13*
Crude fiber (g)	0.74±0.01	1.4±0.02	196*
Protein (g)	5.45±0.13	6.53±0.05	13*
Carbohydrates (g)	76.94±0.19	75.29±0.09	20.75NS
Energy (kcal)	446.65±0.22	452±0.34	59NS
Calcium (mg)	16.50±0.18	25.04±0.04	52**
Iron (mg)	0.86±0.01	1.03±0.02	21*

CONCLUSION

It can be concluded from the salient findings of the study would be efficient in utilization of millets by replacing refined wheat flour in bakery products will add more functional and nutritional value to the biscuit. Millets based biscuit can provide not only additional value added income to the industry, but

also a nutritious and healthy source of dietary fiber, protein and could be exploited to play important role in maintaining health. This also helps to increase the domestic consumption of healthy products over junk foods.

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