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Effect of Storage on quality Parameters of Foxtail Millet Biscuit with different Packaging Materials

Soumya Hiregoudar[1]* and Mamatha, H.S.[2]
[1]Ph.D. Scholar, Department of Food Science and Nutrition,
University of Agricultural Sciences, GKVK, Bengaluru (Karnataka), India.
[2]Associate Professor, Bakery Training Unit,
University of Agricultural Sciences, Hebbal, Bengaluru (Karnataka), India.

(Corresponding author: Soumya Hiregoudar)*
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ABSTRACT: Millets provide a wide range of health benefits and are good source of energy, protein, fiber, minerals and vitamins. The additional benefits of the millets are gluten-free protein content and low glycaemic index. The present study was designed to develop and standardize the foxtail millet based biscuit and to evaluate the effect of storage on quality parameters of foxtail millet biscuit with different packaging materials.

Estimation of different quality parameters of foxtail millet based biscuit like moisture, free fatty acid, peroxide value, microbial load and organoleptic parameters were analysed by using standard procedure at different storage period from 0th day to 30th days interval in Metallised Polyester Polyethylene (MPP) and Polypropylene (PP) packaging materials. The study resulted in cent percent foxtail millet based biscuit had high free fatty acid and peroxide value compared to control. Moisture content and microbial load were high in control compared to foxtail millet based biscuit. The PP packaged biscuit showed high moisture, free fatty acid, peroxide value, microbial load compared to MPP packaged biscuit. Organoleptic evaluation showed high score in MPP packaged biscuit compared to PP packaged biscuit.

Replacement of refined wheat flour with foxtail millet flour in bakery products become one of the ways to increase nutritional properties in bakery product. The technology of the products developed under present study can be extended for commercialization.

Keywords: Foxtail millet, Metallised Polyester Polyethylene (MPP), Polypropylene (PP), Storage study, organoleptic evaluation.

INTRODUCTION

Foxtail millet is one of the oldest cultivated crops, identifies as major millet in terms of word wide production, belong to the *Serataria* genus of *poaceae* family. It contains protein, fibre, minerals, phytochemicals, tannins and also hypolipidemic, low glycaemic index and antioxidant characters (Sharma and Niranjan 2018). Processing techniques include drying, roasting, germination and fermentation can produce products that can be nutritionally preferable, various products like biscuit, cookies, breads and porridge can be prepared. 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 per cent respectively of total bakery products produced in the country. Biscuit are available in wide variety and in many combinations (salt, high/low fat biscuit etc.). The nutritional value of biscuit can be enhanced by fortification and supplementation with protein, fiber rich cereals, pulses and millets (Ahmad and Ahmed 2014).

Nowadays, bakery units made many advances in this sector by using additives and packaging materials to increase shelf life of products. The acceptability of a biscuit or any snack items are based on the deterioration level and rancidity is the main cause for deterioration. This in turn causes foul smell, loss of nutritional quality, undesirable texture, colour and also threat to food safety. Another important factor is packaging. It forms an integral part of manufacturing process for filling the gap between producer and consumer. Apart from this, it also facilitates for storing of food items. Thus, it is not only important to understand the effect of supplementation of foxtail millet flour on the physico-chemical and sensory properties; but it is also important to understand its behaviour during storage and the resultant effect on the quality of the food product. Hence, the present investigation was aimed to study and compare the effect of different packaging materials on sensory attributes, microbial load and chemical properties of foxtail millet based biscuit during storage period of 30 days.

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 such as Metalized Polyester Polyethylene (MPP) and Poly Propylene (PP) were procured from the local market, Bangalore.

Development and standardization of millet based biscuit. The formulation for the control biscuit was based on the recipe of Sudha *et al*. (2007) by creaming method.

Standardization of foxtail millet based biscuit. After the successful preparation of the control biscuit, the experimental biscuit were prepared by replacing refined wheat flour with foxtail millet flour at different levels *viz.*, 50, 60, 70, 80, 90 and 100 per cent. 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 millet based biscuit is presented in Table 1. The method of preparation remains the same as that of the control biscuit.

Table 1: Composition of Foxtail millet based biscuits.

Foxtail millet flour based biscuits			
Treatments	**Ingredients**		
	Refined wheat flour (g)	**Foxtail millet flour (g)**	**Water (ml)**
Control	100	00	35
FBT_1	50	50	40
FBT_2	40	60	43
FBT_3	30	70	45
FBT_4	20	80	45
FBT_5	10	90	46
FBT_6	00	100	50
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			

Shelf life study of best accepted millet based biscuit. The products were stored up to 30 days at room temperature. Two types of packaging materials were used. Each product was stored in Polypropylene (PP) and Metalized Polyester Polyethylene (MPP) was kept in ambient condition. The products were evaluated for their organoleptic acceptability, quality parameters (moisture, free fatty acid and peroxide value) and total microbial load at 7 days interval of one month duration.

Peroxide value

In the oxidative rancidity, oxidation of fat due to the combination of oxygen with unsaturated fatty acids takes place and results in the formation of compounds with a peroxide structure.

$$\text{Peroxide value of oil } (\text{mEqO}_2/\text{kg}) = \frac{(\text{Titre - blank}) \times \text{N} \times 1000}{\text{Wt. of oil (g)}}$$

Free fatty acid. Free fatty acid value of sample was determined according to AOAC method. Percentage of free fatty acids was calculated using oleic acid as a factor and expressed as per cent of oleic acid/100g of sample.

Microbial analysis of best accepted foxtail millet based biscuit. All products were stored for a period of one month in polypropylene and metalized polyester polyethylene pouches under room condition. Initial plating was done at 0^{th} day and after 7 days of interval for up to 1 month. Products were tested for total bacterial, fungal and *E. coli* counts. The media used was nutrient agar (NA), Martin rose Bengal agar (MRBA) and Eosine methylene blue agar (EMB) respectively. It was carried out by serial dilution and pour plate method.

Statistical analysis. In the present study one-way ANOVA was applied. The data was tabulated and analysed 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 and three-way ANOVA was applied for storage study interactions.

RESULTS AND DISCUSSION

Effect of storage on moisture, peroxide value (PV) and free fatty acid (FFA) of best accepted foxtail millet-based biscuit. Table 2 depicts the effect of storage in different packaging material on moisture, peroxide value (PV) and free fatty acid (FFA) content in ambient condition for foxtail millet-based biscuit.

Moisture is one of the important component of food thus the free water content in foods present has an important relationship in conservation of chemical, physical and rheological attributes during storage. These alterations may affect the organoleptic characteristics of the product.

In context, moisture content of control, foxtail millet biscuit was 2.87 and 1.42 g respectively in both the packages during initial period of storage. However, moisture content increased to 3.00 and 1.80 g in PP and 2.94 and 1.50 g in MPP package respectively at the end of the storage period (30^{th} day) at ambient condition. In the MPP package the moisture content of all the products remained constant up to 7^{th} day compared to PP package and not much change in moisture content was observed in MPP package during the storage period.

Three-way statistical analysis was done to know the significant difference of the interaction effect of different factors and observed that, there was non-significant difference between treatments (a) and

significant difference was observed between irrespective of the interaction effect of all the conditions *i.e.* the treatments (a), packaging (b) and storage period (c).

Khatoniar (2015) reported that moisture content of salty biscuit gradually increased as days increased, maximum increment of moisture was observed in PP pouches, followed by HDPE pouches then airtight container.

Peroxide value (PV) is an amount of oxygen consumed in the reaction that reduces the unsaturated (C=C) bonds in a given amount of lipid mixture during oxidation. The peroxide value of control and foxtail millet biscuit was 1.86 and 1.89 mEq O_2/kg of fat in both packaging on initial day of storage. Compared to control (1.86 mEq O_2/kg) the foxtail millet biscuit had high content of PV (1.89 mEq O_2/kg). The peroxide value of control and foxtail millet biscuit increased from 1.86 to 2.31 mEq O_2/kg and 1.89 to 2.30 mEq O_2/kg respectively on storage in PP package. Whereas in MPP package the PV was slightly increased from 15th to 30th day but less increased as value compared to PP biscuit i.e. ranged from 1.86 to 2.00 mEq O_2/kg for control and 1.89 to 2.10 mEq O_2/kg for foxtail millet biscuit at ambient condition. There was a significant relationship found between the treatments (a), package (b), storage (c) and irrespective between the a×b, a×c, b×a, a×b×c from initial to final storage period of the products. The results indicated that least changes in peroxide value was observed in MPP than PP package.

The free fatty acid content was more foxtail millet (0.32 %) compared to control (0.29 %). There was an increased in free fatty acid content of control and foxtail millet biscuit from 0.29 to 0.34 per cent and 0.32 to 0.40 per cent in PP and from 0.29 to 0.30 per cent and 0.31 to 0.34 per cent in MPP package respectively from initial to final days of storage under ambient condition. In the present study the products packed in PP package found highest level of free fatty acid by the end of 30th day compared to MPP package. Statistically significant interaction observed between all the conditions irrespective of the factors during the storage period. This might be due to the fact that millet based products are more prone for oxidative rancidity than refined wheat flour products. Mridula *et al*. (2009) reported that free fatty acid content increased mainly from degradation products of hydro peroxide which is directly related with relative humidity and moisture content of the products.

Effect of storage on microbial load of best accepted foxtail millet based biscuit. The data given in Table 3 reflect the mean total bacterial count, fungi count and coli-form count of best accepted foxtail millet biscuit.

Generally, the total viable count indicated that the microbiological quality of any food product and the presence of high number of total viable counts is an indication for low expected shelf life of the product. Microorganisms play significant role in the determination of shelf life of food products.

There were no total bacterial and fungi count was observed on initial and 7th day, irrespective of packaging and storage condition. Whereas the bacterial count started to grow in Poly propylene (PP) stored products from 15th day with the load of 1×10^2 and 0.7×10^2 cfu/g in control and foxtail millet biscuit respectively and no growth was found in MPP. On 30th day, the similar level of total bacterial load (2.5×10^2 cfu/g) was observed in both control as well as foxtail millet based biscuit (2.1×10^2 cfu/g) in PP package. However, in MPP maximum bacterial load observed in control (2×10^2 cfu/g) followed by foxtail millet biscuit (1.7×10^2 cfu/g). The present study result indicated that mean bacterial count was less MPP stored biscuit.

The total fungi count detected from 30th day of storage in both the packaging material *i.e.* 0.6×10^2, 0.5×10^2 cfu/g in PP and 0.2×10^2, 0.2×10^2 cfu/g in MPP for control and foxtail millet biscuit respectively but lower count was observed in biscuit stored in MPP.

Coli-form count was not detected during the storage period in both the packaging material under ambient condition.

Effect of storage on sensory characteristics of foxtail millet based biscuit. Effect of storage on sensory quality of best accepted foxtail millet based biscuitis presented in Table 4.

The sensory characteristics of the best accepted foxtail millet based products after baking and storage period (0 to 30 days) at room temperature were assessed by semi trained panelists.

Appearance: The mean sensory scores of control (100 % refined wheat flour) and foxtail millet showed a mean sensory scores range of 9.00 to 8.50 and 8.96 to 8.35 in PP package and 9.00 to 8.70 and 8.96 to 8.84 in MPP package from initial to final day of storage period respectively. The result indicated that, there was less fluctuation in mean scores between the products and storage period and showed non-significant difference. However significant difference was observed between packaging material and other interactions. The mean scores of all the products in PP package decreased than the MPP package during the storage period (Table 3).

Texture. Texture and crispiness are the most important characteristics of biscuit evaluated by consumers. The mean sensory scores of control (refined wheat flour) biscuit stored in PP and MPP package showed 17.58 to 16.50 and 17.5 to 16.9 from initial period to final day of storage period. However, foxtail millet flour biscuit from initial to 30th day of storage in PP and MPP showed 17.6 to 16.5 and 17.6 to 16.9 respectively. statistically significant difference was not found between the best accepted products and packaging material, however significant difference was observed during storage period and other factor interaction.

Taste and aroma. It is evident from the results of sensory scores for taste and aroma that control and foxtail millet biscuit packed in PP and MPP pouch from initial to 30th day of storage showed a mean range of 25.3 to 20.2 and 25.3 to 24.6 and 27.5 to 23.2 and 27.5 to 25.1 respectively at ambient condition.

Mouth feel: The mouth feel of a product is a multidimensional oral sensation. The evaluation for property of mouth feel resulted in mean sensory scores of cent percent refined wheat flour as control (8.05 to 7.10 and 8.05 to 7.80) and foxtail millet based biscuit (7.56 to 7.00 and 7.56 to 7.20) stored in PP and MPP

package respectively from initial to final day of storage period under ambient temperature.

Overall acceptability. The mean sensory scores with respect to overall acceptability of control and millet based biscuit showed a significant decrease in both PP and MPP pouch during storage period.

Table 2: Effect of storage on moisture, peroxide value and free fatty acid value of best accepted foxtail millet based biscuit.

Packaging material (b)	Storage days (c)	Moisture (g)			Peroxide value (mEqO_2/ kg)			Free fatty acid value (% oleic acid)		
		Best accepted products (a)			Best accepted products (a)			Best accepted products (a)		
		Control	FB		Control	FB		Control	FB	
PP	Initial	2.87	1.42		1.86	1.89		0.29	0.32	
	7th	2.89	1.44		1.87	1.90		0.29	0.33	
	15th	2.90	1.50		2.00	1.98		0.31	0.36	
	30th	3.00	1.80		2.31	2.30		0.34	0.40	
MPP	Initial	2.87	1.42		1.86	1.89		0.29	0.32	
	7th	2.87	1.42		1.86	1.89		0.29	0.31	
	15th	2.89	1.46		1.87	1.93		0.30	0.32	
	30th	2.94	1.50		2.00	2.10		0.30	0.34	
		F-value	SEm±	CD	F-value	SEm±	CD	F-value	SEm±	CD
a		NS	0.04	0.20	*	0.02	0.22	*	0.04	0.22
b		*	0.13	0.57	*	0.32	0.42	*	0.14	0.30
c		*	0.13	0.37	*	0.34	0.35	*	0.15	0.32
a×b		*	0.05	0.16	*	0.32	0.23	*	0.07	0.23
a×c		*	0.01	0.20	*	0.22	0.24	*	0.01	0.25

PP: Polypropylene package **MPP:** Metalized polyester polyethylene package * significant; NS: non significant

Table 3: Effect of storage on microbial population of best accepted foxtail millet based biscuit.

Packaging material	Storage days	Total Bacterial Count (cfux10^2/g)		Fungi count(cfux10^2/g)		*Coli-form* count (cfu/g)	
		Best accepted products		Best accepted products		Best accepted products	
		Control	FB	Control	FB	Control	FB
PP	Initial	ND	ND	ND	ND	ND	ND
	7th	ND	ND	ND	ND	ND	ND
	15th	01	0.7	ND	ND	ND	ND
	30th	2.5	2.5	0.6	0.50	ND	ND
MPP	Initial	ND	ND	ND	ND	ND	ND
	7th	ND	ND	ND	ND	ND	ND
	15th	ND	ND	ND	ND	ND	ND
	30th	2.0	1.7	0.2	0.20	ND	ND

FB: Foxtail millet flour biscuit; **ND:** Not detected
***Significant @ 5%; **NS:** Non Significant
PP: Polypropylene package; **MPP:** Metalized polyester polyethylene package

Table 4: Effect of storage on sensory quality of best accepted foxtail millet based biscuit.

Sensory parameters	Best accepted products (a)	Polypropylene package (b)				Metalized polyester polyethylene package (b)				Interaction between the factors							
		Storage days (c)				Storage days (c)											
		Initial	7th	15th	30th	Initial	7th	15th	30th		a	b	c	a×b	a×c	b×c	a×b×c
Appearance	Control	9.00	8.90	8.60	8.50	9.00	9.00	8.80	8.00	F-value	NS	*	NS	*	*	*	*
										SEm±	0.23	0.34	0.4	1.20	1.3	1.21	1.20
	FB	8.96	8.96	8.85	8.34	8.96	8.95	8.86	8.84	CD	0.05	0.01	0.05	0.33	0.13	0.12	0.13
Texture	Control	17.5	17.6	16.9	16.5	17.5	17.5	17.3	16.9	F-value	NS	NS	*	*	*	*	*
										SEm±	0.41	0.22	0.12	0.20	0.30	0.23	1.25
	FB	17.6	17.5	17.2	16.5	17.6	17.6	17.3	16.9	CD	0.06	0.04	0.23	0.57	0.32	0.42	0.13
Taste and aroma	Control	25.3	25.0	24.9	20.2	25.3	25.0	24.9	24.6	F-value	NS	*	NS	*	*	*	*
										SEm±	1.2	1.45	1.56	1.26	1.28	1.30	1.45
	FB	27.5	26.0	25.5	23.2	27.5	27.0	26.2	25.1	CD	0.57	0.68	0.56	0.55	0.57	0.45	0.46
Mouth feel	Control	8.05	7.90	7.90	7.10	8.05	8.00	7.90	7.80	F-value	NS	*	*	*	*	*	*
										SEm±	0.32	0.43	0.50	1.21	1.33	1.12	1.02
	FB	7.56	7.40	7.30	7.00	7.56	7.50	7.50	7.20	CD	0.23	0.34	0.15	0.20	0.22	0.28	0.18
OAA	Control	8.00	7.90	7.81	7.50	8.10	8.12	7.90	7.80	F-value	NS	NS	*	*	*	*	*
										SEm±	0.31	0.51	0.45	1.22	1.32	1.11	1.25
	FB	8.19	8.10	7.90	7.76	8.19	8.10	8.00	7.90	CD	0.12	0.05	0.43	0.56	0.36	0.32	0.33

FB: Foxtail millet biscuit; **OAA:** overall acceptability

CONCLUSION

Foxtail millet is good source of protein, fiber, vitamins, minerals and benefits of the millets like gluten-free proteins, high fibre content, low glycaemic index and richness in bioactive compounds made them a suitable health food. Replacement of refined wheat flour with foxtail millet flour in bakery products become one of the way to increase nutritional properties in bakery product. From the data on the moisture sorption characteristics, free fatty acid, peroxide value and microbial load metallised polyester polyethylene laminated pouches were assessed to be most suitable packing for the biscuit and conduct the storage studies.

FUTURE SCOPE

— The technology of the products developed under present study can be extended for commercialization.
— The further study can be taken up on use of millets in different bakery and value added products.
— Therapeutic value of these products can be taken forward through intervention studies.

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