EFFECT OF STORAGE PERIOD AND PACKAGING MATERIALS ON TEXTURAL, PHENOLIC, ANTIOXIDANT PROPERTIES OF COOKIES MADE FROM RAW AND GERMINATED MINOR MILLET BLENDS FLOUR

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Abstract
This study evaluated the effect of storage period and packaging materials on the quality attributes of raw and germinated minor millet blend flour cookies. Quality characteristics such as moisture, a_w, texture profile, over all acceptability (OAA) and shelf stability parameters viz. total phenolic content, antioxidant activity, free fatty acid (FFA) and peroxide value (PV) of gluten free cookies made from raw and germinated minor millet based composite flourwere investigated during accelerated storage at 25±2ºC and 50%. The moisture content and a_w of cookies increase while hardness decreased with increase in storage time of cookies packed in both METPPE and LDPE, whereas, decrease was more in cookies packed in LDPE laminate as compared to cookies packed in METPPE laminated. During storage, moisture content and a_w increased more in LDPE as compared to MET-PPE packed cookies. The FFA and PV of cookies increased in both packaging material during storage whereas, highest increase was observed in cookies packed in LDPE as compared to MET-PPE laminate. The highest average OAA was fetched for cookies packed in MET-PPE laminate. The MET-PPE was found better packaging material than LDPE with respect to sensory, texture and shelf stability characteristics of cookies.

Keywords: Physiochemical, Total phenolic content and *in- vitro* antioxidant properties, Textural properties, Packaging materials.

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1. INTRODUCTION

Celiac disease affected patients have permanent intolerance to ingested gluten; hence they need to adhere to a gluten free diet, (Samasca et al., 2014). The ingredients used in commercial bakery product such as biscuits, crackers and cookies are refined flour, hydrogenated fats and sugar along with emulsifiers and other additives which lack in important nutrients. The refined flour sued lacks in dietary fiber and micronutrients which are important health promoting component. In the preparation of bakery and extruded products millets have increased their popularity for substitution with other cereals due to their nutritional and economic important. On the other hand, high yielding capacity, resistance to diseases and nutritional benefits in terms of complex carbohydrate and high dietary fiber, compared to other cereals present the suitability of millets for convenience, therapeutic and ready to eat (RTE) products (Kumar et al., 2015). With proper preparation, 30% of minor millets is being gainfully substituted for value added foods such as bakery products, extruded foods and allied mixes for the convenient preparation by rural and town folk at low cost. Further, in the present existing situation of the society it is the need of the day to exploit the positive nutritional benefits of millets and popularize them among all sectors of the society for achieving nutritional and therapeutic food security (Saleh et al., 2012).
For the baked products like bread, cookies, cakes, and biscuits having low moisture content ensures their resistance to microbial spoilage and confers a long shelf life to them. Such characteristics of these products exploit them for possible large scale production and distribution (Lean & Mohamed, 1999). Similarly, good eating quality makes them attractive for fortification and other nutritional improvement. Cookies are available in

different unit packages in various flavours, shapes, sizes and with excellent organoleptic characteristics. The cookies are popular even in traditional food cultures of India due to their excellent shelf life at ambient conditions, simplicity, and ease of handling during use, transport and availability at affordable prices for the diverse consumers. The cookies, if modified suitably are probably the best vehicles to carry the nutrients to meet the nutritional demand of common consumers (Noorfarahzilah et al., 2014). The physiochemical and organoleptic properties of cookies increase by the addition of germinated lupin flour have been observed by Obeidatet al. (2012).

According to Baixauli et al. (2008) storage stability or the shelf-life of baked products could be defined as maintenance of the sensory and physical characteristics associated with freshness. In general, cookies have the property of bending after baking unlike biscuits that break. This fact dependency of the products like cookies is due to their higher water activity and moisture content (Dhankhar, 2013). The cookies have three main hurdles for maintenance of the their fragrance during storage viz., a) the standard of hygiene and the nutritional quality ; the contact with air (oxygen) which can accelerate the lipids oxidization, b) the enzymatic activity which contributes to the acceleration of shelf-life and, c) the contaminant bacteria, molds and yeasts that represent a real microbiological risk. Packaging materials can have an important role to minimized or delay the texture changes and flavor loss manifest over the shelf life of a soft-baked goods and play an important role in extending the shelf life of other cereal-based goods (toast, frozen products, biscuits, cakes, pastas) (Galic et al., 2012). Effect of multi grains powder and additives on the cookies has their influence on the physical, sensory and nutritional qualities of the cookies (Jyotsna et al., 2015). The need is sought in enhancing the nutritional quality of raw material by natural means and its application in sought after and easily available products, in the present research, using the alternative material other than wheat flour, such as composite flour blend of raw and germinated foxtail, barnyard and kodo millets flour in different proportion based on our previous studies, cookies were prepared and storage stability based on physicochemical, textural and sensory characteristics were evaluated using two different packaging materials under accelerated storage conditions.

2. MATERIALS AND METHODS

2.1 Packaging and storage studies of cookies

2.1.1 Preparation of flour blends

Blends for the preparation of cookies were prepared by mixing foxtail, barnyard and kodo millets flour in the ratios totalling to 100% as shown in Table 1.

Table 1 Preparation of flour blends

Sample (Flour)	Foxtail millet (%)	Barnyard millet (%)	Kodo millet (%)	Wheat flour (%)
A_1 (Optimized Raw)	70	20	10	0
A_2 (Optimized germinated)	70	20	10	0

2.1.2 Preparation of cookies

The cookies were prepared with slight modification in standard method of AACC 10-50D (2000) using following ingredients Blend Flour (100 g), sodium bicarbonate (1.0 g), salt (1.0 g), skim milk powder (20 g),shortening (Butter-50 g), sugar (40 g) and distilled water (20 ml). Shortening and sugar were creamed using an electric mixer at medium speed for 5 min. Eggs (1) and milk (20ml) were added while mixing and the resultant mix was mixed for a period of 3 min. Blend Flour, sodium bicarbonate , and salt were mixed thoroughly and added to the cream mixture where they were all mixed together to form a dough. The dough was kneaded to a uniform thickness of 0.25 cm using hand driven sheeter and cut into circular shapes of 5 cm diameter with the help of die cutter. Baking was carried out at 185°C for 20 ± 5 min in baking oven. Cookie samples were cooled and stored in airtight containers until needed.

2.1.3 Packaging materials

Two packaging materials (provider by Polymer(India) Private limited)have been used for the storage of cookies such as MET-PPE (metalized polyester polyethylene) and LDPE (Low density polyethylene). Optimized raw and germinated cookieswere packed (6 cookies in one packet and 48 packages for one packaging materials) in the two packaging materials, heat sealed using heat seal machine (Bosch GCO200) and stored for 120 days at room temperature around (25-35ºC). Cookies were withdrawn periodically after every 20 days for analysis as per the work plan elaborated in subsequent sections.

2.1.4 Moisture content of cookies

Moisture content of sample was measured in accordance with AOAC (2012). Approximately 5g sample was taken in previously dried and weighed Petridish. The sample was then dried in a hot air oven at a temperature of 70 °C until a constant weight was obtained. The sample was analyzed in triplicates and the mean was recorded. The percent moisture content was calculated as:

$$Moisturecontent(\%) = \frac{(w_2 - w_3)}{(w_2 - w_1)} \times 100$$

W1 = weight of container with lid; W2 = weight of container with lid and sample before drying; and W3 = weight of container with lid and sample after drying.

2.1.5 Water activity of cookies

Water activity (a_w) of the samples was measured using a_w measurement device (Hygrolab, Cole Parmer) with an accuracy of ±0.001 at 25°C. Prior to each test, the water activity meter was turned on and allowed to warm up for 30 min. Each sample was measured by covering the bottom of a plastic disposable cup, placing the cup into the sample holder, and taking the reading as per instrument protocol

2.1.6 Free fatty acids contents

Standard method of AOAC (2001) was used for determination of free fatty acids in crude oil. 10 gm ground sample of stored cookies was taken in flask. 50 ml benzene was added and kept for 30 min for extraction of free fatty acids. 5 ml extract was taken in flask to which 5 ml benzene, 10 ml alcohol and phenolphthalein as indicator was added and titrated against 0.02 N KOH till light pink colour appeared and persisted for 15 sec.. Percentage free fatty acid was expressed as oleic acid. The FFA analyses were performed in triplicates

$$FFA(\%) = \frac{282 \times 0.02NKOH \times mlofalkaliused \times 100}{(\% \, oleicacid)1000 \times Wt.ofsampletake} \times dilutionfactor \times 100$$

2.1.7 Peroxide value of cookies

Peroxide value was determined by iodometric titration method of(AOCS, 2003).Sample (5 g) was weighed into a 250 ml iodine flask and 50 ml of chloroform was added. The mixture was shaken for 1 h in a mechanical shaker and filtered through Whatman No. 1 filter paper. 20 ml of filtrate was transferred to another iodine flask and 30 ml acetic acid was added followed by 1 ml saturated potassium iodide solution. It was kept in dark for half an hour. Then the flask was removed and 50 ml distilled water was added. The contents of flask were titrated against sodium thiosulphate solution (0.02 N) using starch (1%) as indicator to colorless end point.

$$Peroxidevalue \ (meqO2 \ /Kgfat) = \frac{TitrevaluexNormalityofsodiumthiosulphatex \ 1000}{Weightoffat \ *}$$

*Note: In case of samples, with less than 1g fat content, the PV values are expressed on sample basis.

2.1.8 Hardness of the cookies

Hardness of the cookies was measured using a texture analyzer (TA-XT2i, Stable Micro Systems, UK) in a compression mode with a sharp blade-cutting probe. Pre-test, test, and post-test speeds were 1.5, 2.0, and 10.0 mm/s, respectively. Hardness (a maximum peak force) was measured for more than six cookies for each sample. The peak force to snap the cookies was reported as fracture force in 'N'.

2.1.9 Overall acceptability of cookie

Overall acceptability of cookies was determined according to the methods of Meilgaard et al. (1999) was selected and trained following (ISO, 1985).

2.2 Statistical analysis

The analyses were carried out in triplicates and subjected to one way ANOVA by Duncan's test using Statistica-7. The mean values have been represented in the Tables at $p<0.05$ level.

3 RESULTS AND DISCUSSION

3.1 Chemical composition

In previous study (Sharma et al. 2016) have been reported that the nutritional analysis of cookies prepared from flour blends of germinated minor millets optimized sample (A_2) had higher than raw minor millet flour blend (A_2) of same formulations (Table 2).

The present investigation was to follow the changes occurred in optimized raw and germinated flour blended cookies during 120 days of storage at ambient temperature in two different packaging material i.e. MET-PPE (metalized polyester polyethylene) and LDPE (Low density polyethylene). It would be helpful to predict the most suitable packaging material and also shelf life characteristics prediction of optimized product using modified formulation. Moisture content, water activity, peroxide value, free fatty acid, hardness and sensory score were considered as response parameters for optimized raw and germinated flour blend cookies. During 120 days of storage, at every 20 days of interval, samples of cookies were analyzed for their respective response parameters and results are discussed as follows.

3.2 Effect of packaging material and storage on characteristics of cookies

3.2.1 Moisture content and water activity

The observations of effects of two packaging materials (MET-PPE and LDPE) on the moisture content and water activity of cookies prepared from raw and germinated flour blends of millets during 120 days of storage at ambient temperature are presented in Figures 1 and 2. It was observed that two laminates significantly affected moisture content and water activity during storage. The highest average moisture value of 4.58% and 5.08 %,

Table 2. Nutritional and functional characteristics of cookies prepared from optimized flour blend of raw and germinated minor millets* (Sharma et al. 2016)

Samples	Moisture (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	Ash (g/100 g)	Total CHO (g/100 g)	Dietary fiber (g/100 g)	TPC (mg GAE/g)	DPPHA (%)
Raw (A_2)	6.74 ± 0.54^{b}	9.72 ± 0.01^{b}	6.72 ± 0.34^{a}	2.54 ± 0.45^{b}	44.65 ± 1.23^{b}	29.7 ± 0.46^{b}	32.23 ± 0.34^{b}	60.34 ± 0.43^{b}
Germ (A_2)	7.34 ± 0.67^{a}	11.06 ± 0.12^{a}	6.69 ± 0.23^{a}	2.78 ± 0.61^{b}	37.74 ± 1.45^{c}	34.34 ± 0.76^{a}	45.43 ± 0.21^{a}	64.23 ± 0.45^{a}

Samples	Hunter colour values		
	L-value	*a*-value	*b*-value
Raw (A_2)	59.13 ± 2.45^{c}	9.71 ± 0.25^{b}	31.27 ± 1.77^{b}
Germ (A_2)	50.01 ± 1.99^{b}	11.45 ± 0.13^{a}	30.86 ± 1.23^{C}

*n=3, Mean ±standard deviation values in the same column which are not followed by the same letter are significantly different ($p < 0.05$). A_2 refers to cookies made from flour blend of raw and germinated foxtail, barnyard and kodo millets flour in the proportions of 70:20:10, respectively

respectively, were observed for raw and germinated flour cookies packed in LDPE, while the lowest average moisture values, 4.38 % and 4.93 % were observed for raw and germinated flour cookies, respectively, packed in MET-PPE laminate. A similar observation for cookies was observed by Jan et al. (2017).

Water activity is one of the most important determinants of storage life of dehydrated products, whereas; a higher water activity value of (>0.8) facilitates diverse microbial growth (Al-Eisa et al., 2006) at varying temperature (Ellin, 2007). The highest average water activity was shown by the raw and germinated cookies as 0.72 and 0.78, respectively packed in LDPE laminate while the lowest average water activity was values were 0.51 and 0.58, respectively, for raw and germinated millets flour cookies packed in MET-PPE laminate. The range (0.4–0.6) of water activity values denotes the potential for a shelf stability of the products (Vadukapuram et al., 2007). Lipids are most stable to oxidation when water activity is within the range of 0.3–0.6 and all water activities under 0.75 values are considered acceptable in preventing microbial growth (Dar et al., 2014).

Moisture content plays a critical role in determining the shelf stability of food products. It is also evident from the Figure 2 (b) that moisture content values increased significantly in germinated flour blend cookies as compared the raw millet flour cookies packed in two different packaging materials. The increase of a_w and moisture content of packed (MET-PPE/LDPE) cookies may be due to a water diffusion phenomenon of packaging materials. Cookies samples packed in METPPE had lower moisture and water activity as compared to LDPE packed because the METPPE is considered having low water vapour transmission rate (WVTR). Although a significant increase in the average moisture content in both raw and germinated flour cookies had been observed up to 120 days of storage, however the average increase was less significant between 80 and 100 days of storage interval. This may be the result of attaining the maximum instant absorption of water by organic polymers of cookies followed by internal migration of water and further increase in water absorption capacity.

It was observed from Figure 2 (a-b) that germinated flour cookies continued to gain more moisture content as compared to raw blended flour cookies similarly the increase in the moisture content of cookies packed in LDPE was more as compared to METPPE laminate. Nagi et al. (2012) reported that the moisture gets absorbed in biscuits during three months of storage whereas, the moisture content was absorbed lesser in product that were packed in laminated pouches during storage which might have been due to the impervious nature of aluminum foil in laminate to air and water vapour. The moisture content of flaxseed cookies does not change significantly during storage up to 90 days at 26-280°C in metalized polyester pouches (Rajiv et al., 2012). The gain in moisture content in product might be due to hygroscopic nature of dried product, storage environment (temperature and relative humidity) as well as nature of packaging material (Nagi et al.,2012). The maximum limit of moisture content is 5.0% recommended by Bangladesh Standards and Testing Institution (BSTI) for biscuits (BDS383 2001). The result showed that the moisture content was below the maximum value at the end of shelf life packed in METPPE laminate up to 120 days as compared to cookies packed in LDPE laminate. Butt et al. (2004) observed a similar increase in moisture content of breakfast cereals during a storage period of 6 months and in barnyard millet cookies (Surekha et al., 2013).

3.2.2 Hardness of cookies

Hardness is the main criteria for assessing the overall quality of end products like cookies. The texture changes during storage at room temperature, in terms of hardness of cookies samples of raw and germinated millets are shown in Tables 3 and 4. Hardness decreased with increase in storage time of cookies packed in both METPPE and LDPE, whereas, decrease was more in cookies packed in LDPE laminate as compared to cookies packed in METPPE laminated.

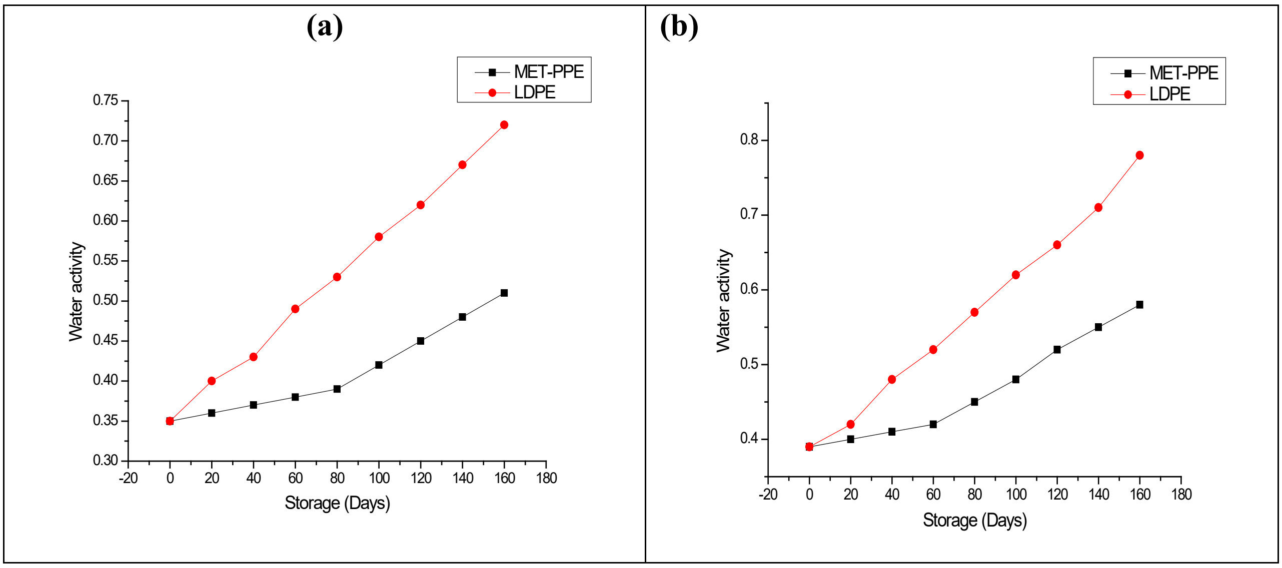


Figure 1. Effect of storage periods and packaging materials on water activity of cookies prepared from flour blends of (a) raw, and (b) germinated minor millets

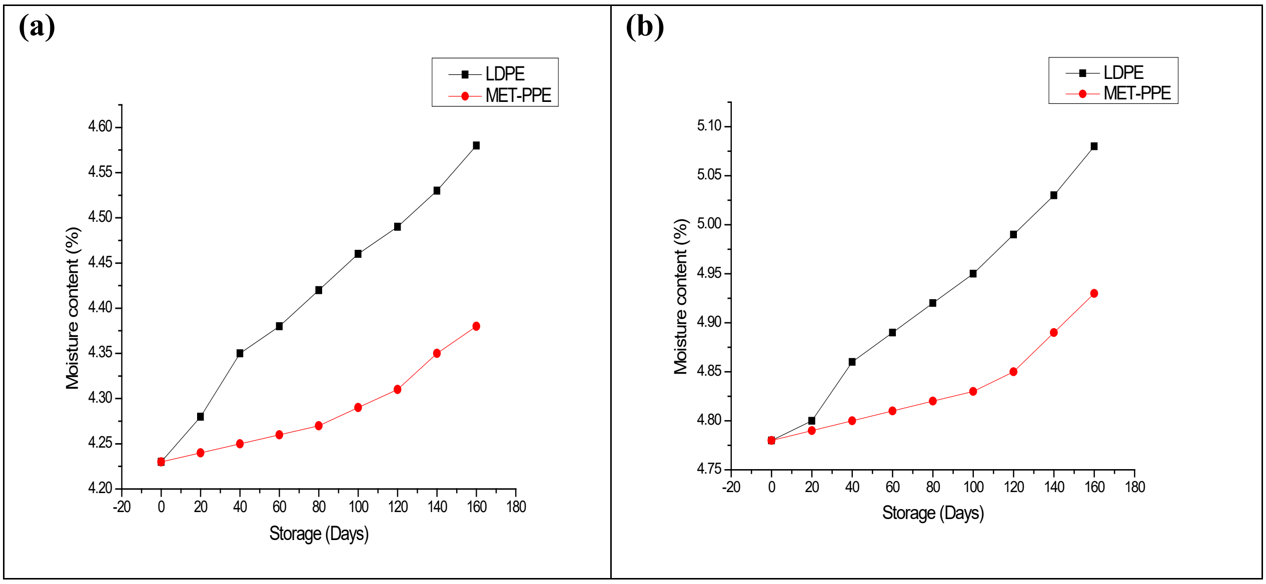


Figure 2. Effect of storage periods and packaging materials on moisture content of cookies prepared from flour blends of (a) raw, and (b) germinated minor millets

The hardness of dry/dehydrated foods is affected by the moisture content and water activity and other physicochemical aspects related to the product composition, i.e. interactions between ingredients, such as fat, sugar, flour. The effect of water activity on crispness was more important than temperature. Cookie samples at water activity values less than critical water activity values maintained their crispness and texture Carter et al. (2015). Moisture migration and redistribution, physical changes of the main cookies components and the interactions between them which become highly heterogeneous during storage have a significant impact on product texture. The value of water activity and moisture content corresponding to consumer rejection varies according to the type of product. Hough et al. (2001) reported that loss of crispness of biscuits during storage is evident when water activity values range between 0.43 and 0.60. Similar results were reported by Charunuch et al. (2007) in rice snacks stored for 4 months.

3.2.3 Peroxide value

Peroxide value is the measure of fat stability in food and is an index of its shelf stability, (Gunstone, 2008), the oils having peroxide value of above 10 m eq/kg are considered rancid. Packaging material significantly affected the peroxide value of raw and germinated millet flour cookies. The lowest peroxide value was observed for raw as well as germinated flour cookies packed in METPPE laminate while the highest peroxide values were found for raw and germinated flour cookies packed in LDPE. The peroxide value increased with increase in storage time and reach to a maximum value after 120 days of storage (Tables3 and 4). Rajiv et al.(2012) also reported that peroxide value of cookies increases during storage upto 120 days, due to increase in their moisture content which promoted fat hydrolysis during storage. Pearson (1970) reported that peroxide value range of 10-20 meq/kg indicates that food product is considered rancid but still acceptable, while more than 20 meq/kg, the food product can be considered already rancid and unacceptable to consume. The peroxide values of the raw and germinated flour cookies packed in MET-PPE laminate up to 120 days were well below the maximum desirable value as compared to cookies packed in LDPE. Other researchers also reported an increase in peroxide value of cookies during storage (Arogba, 2002).

3.2.4 Free fatty acid

A significant ($p \leq 0.05$) increase in the average free fatty acid content of raw and germinated millet flour cookies was observed up to 120 days of storage except between 80 and 100 days of interval (Tables 3 and 4). The lowest free fatty acid content was observed on 0 day of storage while the highest free acid content was found on 120 days of storage. It was observed that increase in the free fatty acid content of cookies packed in LDPE laminate was more as compared with MET-PPE laminate. This might be due to decrease in water activity, i,e. free water as observed in water active analysis however the free fatty acid increase during storage in cookie can be considered as hydrolytic rancidity phenomenon. Anonymous, (1991) reported that, according to the Turkish standards, a FFA value is allowed to go as high as 1.5% for biscuits and similar products. FFA values of the all raw and germinated cookies in present case were below the maximum value at the end of storage period of 120 days when packed in MET-PPE laminate up to 120 days. Ajay Singh & Pradyuman Kumar (2019) also reported an increase in free fatty acid content of biscuits during storage. Similar increase of free fatty acid content during storage of wheat flour based cookies has been reported (Butt et al., 2004).The products that develop rancid flavor when free fatty acid percentage increase above1% are unfit for consumption (Erickson & Frey, 1994).

Table 3Effect of storage on various quality parameters of cookies prepared from raw minor millets flour blends[*]

Storage Periods	Hardness (N)		Free fatty acid (mg KOH/g)		Peroxide value (m eq. peroxide/Kg)	
	MET PPE	LDPE	MET PPE	LDPE	MET PPE	LDPE
0	44.71±0.30[a]	44.30±0.30[a]	0.26±0.01[a]	0.26±0.01[a]	1.74±0.03[a]	1.80±0.03[a]
20	44.11±0.60[a]	43.47±0.40[b]	0.26±0.03[b]	0.39±0.05[a]	1.78±0.03[b]	1.98±0.06[a]
40	43.80±0.40[a]	42.07±0.60[b]	0.37±0.05[b]	0.43±0.03[a]	1.87±0.05[b]	2.28±0.20[a]

60	43.56±0.80[a]	41.54±0.10[b]	0.42±0.03[b]	0.68±0.08[a]	1.96±0.08[b]	2.54±0.22[a]
80	42.98±0.12[a]	39.98±0.80[b]	0.58±0.04[b]	0.79±0.11[a]	2.12±0.11[b]	2.99±0.30[a]
100	42.34±0.10[a]	38.89±0.10[b]	0.69±0.04[b]	0.86±0.14[a]	2.34±0.14[b]	3.18±0.22[a]
120	41.46±0.14[a]	37.17±0.16[b]	0.76±0.08[b]	0.98±0.20[a]	2.56±0.11[b]	3.52±0.11[a]
140	40.06±0.11[a]	35.41±0.11[b]	0.79± 0.11[b]	1.45±0.25[a]	2.68±0.09[b]	3.85±0.16[a]
160	39.76±0.13	33.23±0.60[b]	0.89±0.02	1.67±0.34	3.45±0.03	4.13±0.13

***n=3,**Mean values in the same row which are not followed by the same letter are significantly different ($p \leq 0.05$).Values represent mean ± standard deviation (n = 3), MET PPE -metalized polyester polyethylene, LDPE -Low density polyethylene

Table 4Effect of storage on various quality parameters of cookies prepared from germinated minor millets flour blends*

Storage Periods (days)	Hardness (N)		Free fatty acid (mg KOH/g)		Peroxide value (m eq. peroxide/Kg)	
	MET PPE	**LDPE**	**MET PPE**	**LDPE**	**MET PPE**	**LDPE**
0	39.99±0.30[a]	39.99±0.30[a]	0.30±0.01[a]	0.30±0.01[a]	2.66±0.03[a]	2.66±0.03[a]
20	39.50±0.60[a]	39.34±0.40[b]	0.35±0.03[b]	0.45±0.05[a]	2.69±0.03[b]	2.75±0.06[a]
40	39.20±0.40[a]	38.20±0.60[b]	0.46±0.05[b]	0.53±0.03[a]	2.78±0.05[b]	2.88±0.20[a]
60	38.96±0.80[a]	36.67±0.10[b]	0.52±0.03[b]	0.68±0.08[a]	2.83±0.08[b]	3.15±0.22[a]
80	38.11±0.12[a]	37.11±0.80[b]	0.61±0.04[b]	0.72±0.11[a]	2.92±0.11[b]	3.65±0.30[a]
100	37.89±0.10[a]	36.02±0.10[b]	0.70±0.04[b]	0.89±0.14[a]	3.66±0.14[b]	3.93±0.22[a]
120	37.56±0.14[a]	35.30±0.16[b]	0.88±0.08[b]	0.99±0.20[a]	3.73±0.11[b]	4.27±0.11[a]
140	36.16±0.11[a]	34.54±0.11[b]	0.94± 0.11[b]	1.17±0.25[a]	3.80±0.09[b]	4.98±0.16[a]
160	35.56±0.12[b]	33.45±0.23[c]	1.06±0.14[c]	1.78±0.03[b]	4.23±0.04[c]	5.02±0.18[b]

*n=3; Mean values in the same row which are not followed by the same letter are significantly different ($p \leq 0.05$), Values represent mean ± standard deviation (n = 3), MET PPE-metalized polyester polyethylene, LDPE-Low density polyethylene

3.2.5 Total phenolic content and antioxidant properties

The effect of storage period on total phenolic content and *in vitro* antioxidant properties of raw and germinated millet flour cookies are described in Table 5. The *in vitro*antioxidant activity of raw and germinated millet flour cookiesevaluated by total phenolic content and

DPPH (%) fall during 6 months of storage. The decrease in total phenolic content and *in vitro*antioxidant activity during first 3 months was less prominent compared to last 3 months of storage. The TPC (mg GAE/g) of bran enriched extruded snac raw and germinated millet flour cookies ranged from 32.23 to 25.21 mg GAE/g and 45.43 to 38.31 mg GAE/g, respectivily similarly, DPPH (%) ranged from 60.34 to 53.34 % and 64.34 to 56.45 %. The antioxidant activity decrease during storage may be attributed to dilution of antioxidant components by increased moisture and also to possible oxidation of antioxidant components under favorable conditions during storage. Camire et al. (2007) while working on lipid oxidation in extruded corn reported that phenolic components are lost during storage.

3.3.6 Overall acceptability (Sensory Characteristics)

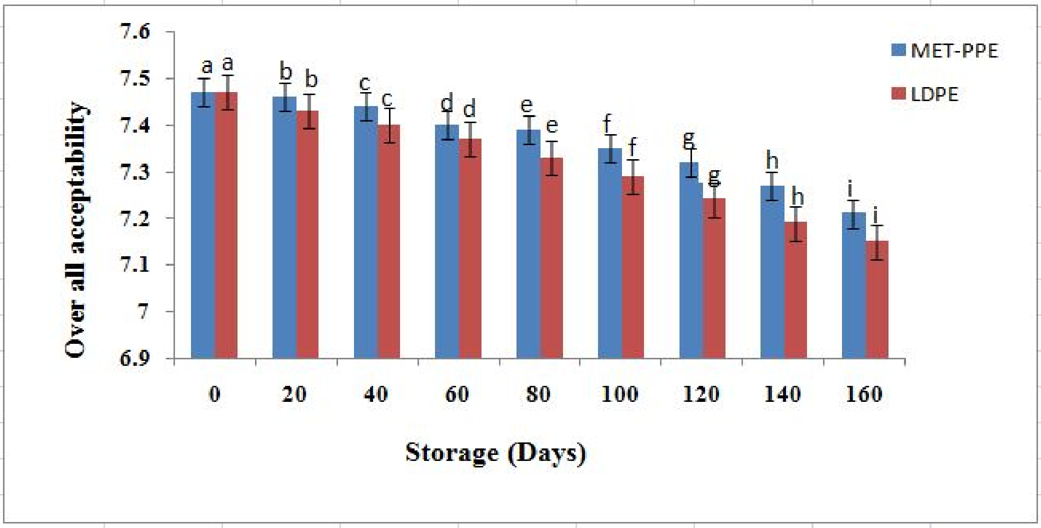
Sensory studies of the product are important for estimating its acceptability and commercial significance. Significant effect of packaging material on over all acceptability of raw as well as germinated millets flour cookies was observed (Figure 3 (a-b)). The highest average over all acceptability was observed for raw and germinated flour cookies packed in METPPE laminate while the lowest average over all acceptability was observed for cookies packed in LDPE laminate. Jan et al. (2017) proposed that laminated could be the suitable packaging material for cookies line product in their studies. No significant change in over all acceptability was observed in stored cookies up to 120 days but afterwards significant decrease in the overall acceptability was found. The highest average overall acceptability was observed up to 20 days of storage period while the lowest over all acceptability was observed at 120 days of storage which further decrease to lowest value. Decrease in the overall acceptability of cookies packed in LDPE laminate was more note worthy than METPPE laminate (Fig. 3 (a-b)). The overall change in the sensory acceptability of the samples could

Table 5. Effect of storage on total phenoliccontent and *in vitro* antioxidant activity of cookies prepared from raw and germinated minor millets flour blends*

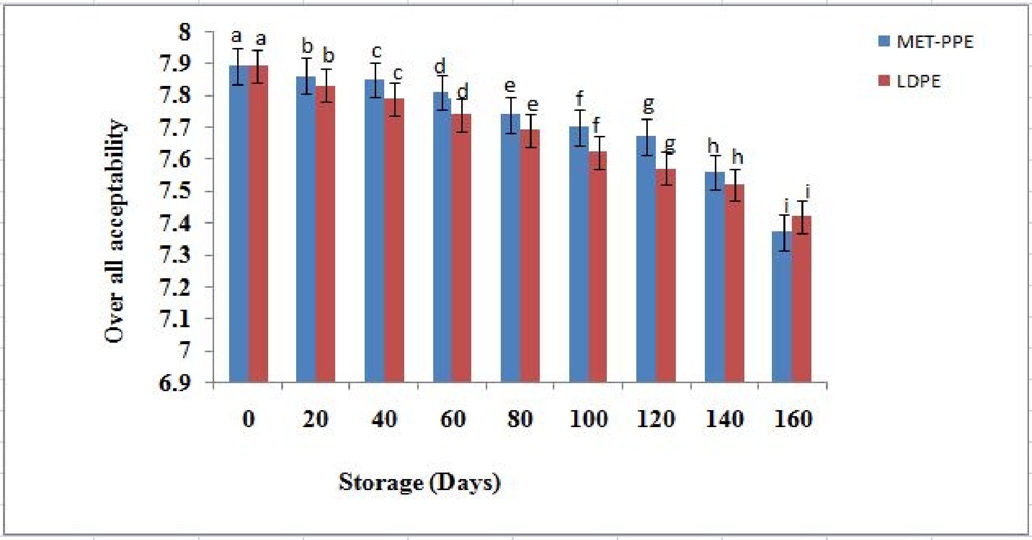
Storage period (Days)	Total phenolic content (mg GAE/g) (Raw A_2) LDPE	Total phenolic content (mg GAE/g) (Germ A_2) LDPE	DDPH(%) (Raw A_2) LDPE	DDPH(%) (Germ A_2)LDPE	Total phenolic content (mg GAE/g) (Raw A_2) MET PPE	Total phenolic content (mg GAE/g) (Germ A_2) MET PPE	DDPH(%) (Raw A_2) MET PPE	DDPH (%) (GerA_2) MET PPE
0	32.23±0.34^{a}	45.43±0.21^{a}	60.34±0.43^{a}	64.23±0.45^{a}	32.23±0.34^{b}	45.43±0.21^{a}	60.34±0.43^{a}	64.34±0.43^{a}
20	30.12±0.12^{b}	44.32±0.21^{b}	59.32±0.43^{b}	63.23±0.35^{b}	32.23±0.34^{b}	45.43±0.21^{a}	60.34±0.43^{a}	63.34±0.43^{a}
40	29.34±0.23^{c}	43.34±0.21^{c}	58.32±0.43^{c}	62.34±0.34^{c}	31.34±0.54^{b}	44.32±0.23^{b}	59.34±0.23^{b}	62.43±0.23^{b}
60	28.34±0.42^{d}	42.32±0.21^{d}	57.32±0.43^{d}	61.24±0.54^{d}	30.54±0.23^{b}	43.34±0.43^{c}	58.45±0.453^{c}	61.22±0.54^{c}
80	27.32±0.22^{e}	41.53±0.21^{e}	56.34±0.43^{e}	60.45±0.23^{e}	29.32±0.56^{b}	42.12±0.21^{d}	57.34±0.25^{d}	60.32±0.21^{d}
100	26.31±0.54^{f}	40.32±0.21^{f}	55.34±0.43^{f}	59.34±0.34^{f}	28.34±0.13^{b}	41.22±0.33^{e}	56.34±0.15^{e}	59.23±0.35^{e}
120	25.32±0.56^{g}	39.23±0.21^{g}	54.32±0.43^{g}	58.34±0.56^{g}	27.54±0.43^{b}	40.32±0.25^{f}	55.34±0.23^{f}	58.12±0.42^{f}

140	24.12±0.64^{h}	38.43±0.21^{h}	53.23±0.43^{h}	57.32±0.57^{h}	26.12±0.56^{b}	39.18±0.35^{g}	54.34±0.45^{g}	57.32±0.51^{g}
160	23.21±0.32^{i}	37.43±0.21^{i}	52.34±0.43^{i}	56.12±0.34^{i}	25.31±0.23^{b}	38.31±0.65^{h}	53.34±0.55^{h}	56.45±0.36^{h}

***n=3,**Mean values in the same row which are not followed by the same letter are significantly different ($p \leq 0.05$).Values represent mean ± standard deviation (n = 3), MET PPE -metalized polyester polyethylene, LDPE -Low density polyethylene



(a)



(b)

Figure 3 Effect of storage periods and packaging materials on overall acceptability of cookies prepared from flour blends of (a) raw, and (b) germinated minor millets

be due to change in color, taste and texture that contributed more to overall acceptability the products. This might be due to more moisture gain, high peroxide value (index of rancidity) and consequently loss of crispiness (Puyed, et al., 2010). Sharma (2012) reported that the rice-mung bean snacks were in acceptable range after 3 months of storage. Gulla & Waghray (2012) observed similar trend for cereal-legumes based ready to eat extruded snacks.

4. CONCLUSION

It can be concluded from this study, that quality attributes of raw and germinated minormillet blendflour cookies were significantly affected by storage and packaging material. Moisture content, water activity, free fatty acids and peroxide value of stored products increased in all packages, while as hardness, color values (L value) and sensory scores reduced. The free fatty acid contents for raw flour cookies remained between 0.89 and 1.67mg KOH/g, while for germinated flour cookies the increase was from 1.06 to 1.78mg KOH/g. Although there was an increase in free fatty acid content during storage but increase was under permissible limits. The water activity values indicated that the both raw and germinated flour cookies were stable and safe from microbial spoilage up to 120 days. The highest average over all acceptability was observed for cookies packed in METPPE laminate while the lowest average over all acceptability was observed for raw blend flour cookies and germinated blend flour cookies packed in LDPE.

Conflicts to interest

The authors have declared no conflicts of interest for this article.

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