Research Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2023.54.008530

Physico-Chemical, Textural and Sensory Stability of Cookies Made from Germinated Finger Millet and Pearl Millet Flour

Shikha Sharma[1] and Amar P Garg[2]*

[1]*School of Biological Engineering & Life Sciences, Shobhit Institute of Engineering & Technology, (NAAC Accredited Grade "A", Deemed to-be-University), India*

[2]*Swami Vivekanand Subharti University, India*

***Corresponding author:** Amar P Garg, Dean Academics and Director Research, Swami Vivekanand Subharti University, NH-58, Subhartipuram, Meerut-250005, India

ARTICLE INFO

Received: December 12, 2023

Published: January 03, 2024

Citation: Shikha Sharma and Amar P Garg. Physico-Chemical, Textural and Sensory Stability of Cookies Made from Germinated Finger Millet and Pearl Millet Flour. Biomed J Sci & Tech Res 54(2)-2023. BJSTR. MS.ID.008530.

ABSTRACT

During this study, we examined the effects of various packaging materials like Low Density Polyethylene (LDPE) and Metallized Polyester (MP) pouches, on the physical, chemical, and sensory properties of multi-millet cookies. The cookies were made with optimized flour blends consisting of 30% germinated finger millet, 30% germinated pearl millet, and 40% wheat flour. The cookies were packed sin LDPE bags and stored for 120 days at Room Temperature (RT) and 37 °C, the moisture content of the cookies rose from 3.4% to 4.8% and 4.0%, respectively. The breaking strength of the multi-millet cookies dropped as their moisture level increased. When cookies were packaged in LDPE pouches and kept at room temperature and 37 °C, their peroxide value increased to 9.7 and 13.8 meqO2/Kg of fat respectively, from 3.7 meqO2/Kg of fat when they were fresh. Thiobarbituric acid (TBA) of cookies at an initial stage was 0.02 mgMA/kg that increased to 1.20 mgMA/kg in LDPE packed cookies stored at 37 °C. Free fatty acid (FFA) of cookies increased from 0.4% oleic acid to 1.63, 1.91, 0.78 and 1.09% oleic acid in cookies packed in LDPE pouch, stored at RT, 37°C and packed in MP pouch, stored at RT, 37 °C respectively. Studies on sensory evaluations showed that MP-packed cookies were more stable than LDPE-packed cookies and could be kept for up to 120 days at room temperature and 100 days at 37 °C without compromising their sensory quality. The use of millet in our diet will improve nutritional quality of food and will help in healthy life style and well being to fulfill Sustainable Development Goal (SDG) no. 3 of United Nations.

Keywords: Finger Millets; Pearl Millets; Cookies; Nutrition Rich Diet; Sustainable Development Goal; Storage Study; Packaging Material; Sensory Attributes

Abbreviations: LDP: Low Density Polyethylene; MP: Metallized Polyester; RT: Room Temperature; TBA: Thiobarbituric Acid; FFA: Free Fatty Acid; SSG: Sustainable Development Goal; PV: Peroxide Value

Introduction

The baking sector, a significant part of world's food industry, generates around US$1.66 tonnes in 2023. Popular food items include cookies, bread, buns, rusk and toast, bagles, loaf breads, muffins, cakes, chips, and namkeen (salty preparation in various combinations), which are popular due to their nutritional value and variety. These foods are commonly marketed under various brand names, some even as functional foods [1]. A cookie is a traditional wheat flour-based food item that is made by heating unpalatable dough to create an enticing final product [2]. Bread and its various products are widely consumed by people of all ages worldwide [3]. Cookies are ready-to-eat, affordable, and convenient snack foods, easy to serve, store and transport that contain important nutritional and digestive guidelines. The main ingredients are water, fat, sugar, and wheat flour; additional ingredients that are optional are milk, salt, food additives, flavoring agents, and aerating agents. The main ingredient used to make cookies is soft wheat flour, which is imported

DOI: 10.26717/BJSTR.2023.54.008530

by nations like Nigeria, Arabian and some African countries that have unfavorable climates. The rise in imports may put the economy at risk, drive up the cost of these baked goods, and jeopardize food security. During war times, like Russian-Ukraine and Israel-Hamas, it has created problems before several countries. This makes it necessary to develop a strategic plan for using low-cost local resources to produce cookies. Cookies are popular in traditional international food cultures due to their excellent shelf life, simplicity, ease of handling, transport, and affordability. If modified, they can meet common consumer nutritional demands. The physiochemical and organoleptic properties of cookies increase with the addition of germinated lupin flour, as observed by Shikha and Garg earlier that are healthy and rich in nutrients [4].

The increase of nutritional quality of food will greatly facilitate us to achieve "good heath and well being" as one of the important sustainable development goals (SDG) no. 3 set by United Nations. Finger millet (*Eleusine coracana* L), a small cereal grain grown in Africa and Asia, is a staple food due to its high protein and mineral content. It is rich in amino acid methionine, which is essential for the diets of millions of poor people who rely on starchy staples like cassava, plantain, polished rice, and maize meal [5]. Finger millet is also rich in magnesium, phosphorous, potassium, iron, and has 5-30 times the calcium content found in other cereals. It is also rich in magnesium, phosphorous, potassium, iron and has been reported to have 5-30 times the calcium content found in other cereals. These crops are climate resilient and in coming years will become the requirements of farmers to meet the growing challenges of climate change. Further, the millets provide balanced nutrition and there is a focus of world population from wheat and rice to millets. In view of the high nutritional value of millets, United Nations has referred 2023 as "International Year of Millets". Pearl millet, a Kharif food crop in western India, Gujarat, Rajasthan, and Haryana, is the fourth most important cereal in India after rice, wheat, and sorghum. It is considered the wholesome and cheapest food for poor people and animals. A total of 30.1 million tons of millet were produced worldwide in 2021, with 41% of the total output coming from India [6].

In India, 46% of pearl millet is used for human food, 37.5% for animal feed, 7.7% for poultry feed, 8.8% for the brewing industry, and a small amount (0.4%) is used for seed purposes. It is a good source of energy, protein, essential minerals, and dietary fiber. The chemical analysis of pearl millet shows that it contains 12% moisture, 12g protein, 5g fat, 2g minerals, 1g fiber, 67g carbohydrates, 42g calcium, 242m phosphorus, 8g iron, and 360 calories. Any product's shelf life is a crucial component that interests all parties involved in the food chain, from producers to consumers. A carefully thought-out and executed consumer acceptance test, using the right sensory analysis, is crucial to the shelf-life assessment of any product. The main determinants of shelf life are moisture content and water vapor transport [7]. Food can lose shelf life due to physicochemical changes that occur during storage, which will lower the food's quality. The main reasons why packaged food is rejected by customers are bad tastes, off odors, and loss of crispness. These might be brought on by the food's oxidative rancidity, migration, permeability, and interactions between the food and packaging components [8]. Therefore, the present work was undertaken to evaluate the quality and shelf life of cookies prepared with different level of germinated finger millet and germinated pearl millet flour incorporation. The aim was to investigate the quality changes and shelf life of the formulated cookies during storage.

Materials and methods

Preparation of Flour Blends

Blends for the preparation of cookies were prepared by mixing wheat flour, finger millet and pearl millets flour in following ratios as shown in Table 1.

Table 1: Preparation of flour blends.

Sample (flour)	Wheat Flour (%)	Finger Millet Flour (%)	Pearl Millet Flour (%)
T_1 (Optimized Germinated flour)	40	30	30

Cookies Preparation

The following components were used to produce the cookies, slightly altering the AACC 10-50D [9] standard technique. 100 g of flour was mixed together with 1.0 g of sodium bicarbonate, 1.0 g of salt, 20 g of skim milk powder, 50 g of shortening (Butter), 60 g of jaggery, and 20 mL of distilled water. An electric mixer was used to cream shortening and jeggery for five minutes at medium speed. After adding 20 ml of milk and mixing for three minutes, the final mixture was prepared and mixed well. After properly combining flour, salt, and sodium bicarbonate, they were added to the cream mixture and combined to make a dough [10]. Using a hand-driven sheeter, the dough was kneaded to a consistent thickness of 0.25 cm. A die cutter was then used to cut the dough into circular forms with a diameter of 5 cm. In the baking oven, baking was done for 20 ± 5 minutes at 185°C. Before being used, cookie samples were chilled and kept in sealed containers.

Packaging Materials

Two different types of packaging materials were employed for the study: Metallized Polyester (MP) and low-density polyethylene (LDPE), which were purchased for the purpose of packing cookies from the Meerut, Uttar Pradesh, India market. Metallized polyester film, also called as metalized PET film, met PET film, or aluminized PET film, is a plastic film that is treated in such a way that a layer of aluminum particles is put on one side of the film. The amount of aluminum applied allows for various levels of tinting. This aluminized PET film has physical, mechanical, optical, thermal, electrical and chemical properties that make it very well suited for many specialized applications and packaging. The best raw and germinated cookies were put in two different types of packaging materials (eight cookies per packet and forty packets for each packaging material), heat sealed using a Bosch GCO200 heat seal machine, and then kept for a period of 120 days at both room temperature and 37 ºC. According to the work plan described in the sections that follow, cookies were taken out for examination once every 20 days at both temperatures.

Evaluation of Cookies Quality During Storage Period

Textural Characteristics: Using Gains' [11] specified triple beam snap (three-point break) approach, the texture analyzer (TA-HD plus, Stable Micro Systems, Surrey, U.K.) estimated the force necessary to break the cookies. The peak force from the resultant curve is what is used to calculate the biscuit's breaking strength. Three separate determinations were recorded, with the mean value.

Chemical Analysis: The moisture, water activity of the cookies was measured according to (AACC [10]) methods and Peroxide Value (PV), free fatty acids were estimated by the standard method of (AOCS [12]), whereas thiobarbituric acid value was determined using (Tarledgis, et al. [13]) method.

Sensory Evaluation: Twenty panelists, ranging in age from 25 to 50, including both genders and with prior expertise in sensory evaluation of bakery items, assessed the cookies' sensory quality. They received additional instruction in four sessions, lasting two hours each. Using the Larmond [14] approach, each panelist assessed three cookies in triplicate for flavor, texture, and general acceptability on a nine-point hedonic scale (1 being strongly disliked, 5 being neither liked nor disliked, and 9 being extremely liked). The panelist was shown the samples in a random sequence after they were coded and identified.

Statistical Analysis: Statistical analysis of data was done by using ANOVA (Analysis of variance) two way with replication and critical differences was analyzed by excel software. The significant differences were at 5% level.

Results and Discussion

The cookies were kept in storage at both Room Temperature (RT) and an accelerated, controlled temperature of 37°C. Biscuits are typically kept in a room temperature, which might change based on the outside environment. But still. Accelerated circumstances allow temperature control and faster, more precise outcomes. Changes in color, chemical measures such as moisture, Peroxide Value (PV), free Fatty Acid (FFA), and Thiobarbituric Acid Value (TBA), and sensory characteristics such as flavor, texture, and overall acceptability were used to examine the storage durability of multi-millet cookies. The two main elements that cause cookies to deteriorate while they are being stored are an increase in moisture content and a rotten flavor.

Moisture Content of Cookies During Storage Period

Due to their highly hygroscopic nature, cookies need to be kept out of the air during storage in order to avoid or at least slow the accumulation of moisture. One of the most crucial variables to keep an eye on while storing cookies is moisture content. Decreases or increases in moisture can cause significant texture changes in baked goods and may also contribute to chemical and microbiological deterioration in low- and intermediate-moisture items. The variations in the moisture content of cookies during the course of storage have demonstrated that, regardless of packing and storage temperature, the moisture content of cookies rose in all samples (Figure 1). The moisture level of the cookies was 3.34 percent at the beginning and grew dramatically to 4.80 percent and 4.00%, respectively, after they were held at 37°C and RT in an LDPE bag. However, because MP pouches have moisture barrier qualities, the rise in moisture content of cookies packed in them and kept at both temperatures was not statistically significant. According to (Kathalsar, et al. [15]), who reported increased moisture content of cookies packed in MP pouches, the increase in moisture content of cookies packed in LDPE pouches may be due to absorption of moisture from the surrounding environment as LDPE pouches have low barrier to moisture and water vapor transmission. On the other hand, the increase in moisture content of cookies packed in MP pouches may be due to water diffusion and redistribution within the porous structure of food products. In contrast to cookies packaged in LDPE packaging, the results indicated that the moisture content was below the maximum value at the end of the shelf life packed in MP pouches up to 120 days. Similar increases in moisture content were seen in barnyard millet cookies [16] and breakfast cereals by (Butt, et al. [17]) after a 6-month storage period.

DOI: 10.26717/BJSTR.2023.54.008530

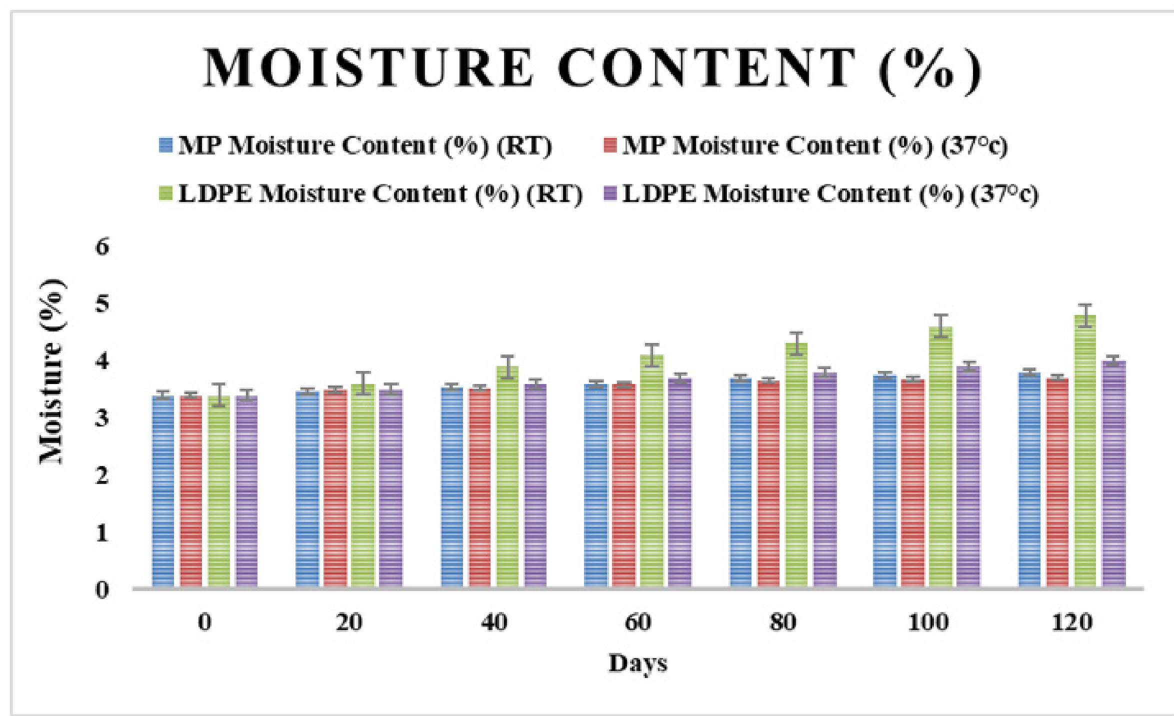

Figure 1: Per cent moisture content of cookies packed in LDPE- Low density polypropylene; MP- Metalized polyester and stored at room temperature and 37°C (Mean and standard deviation of triplicates, significantly ($p \leq 0.05$).

Peroxide Value of Cookies During Storage Period

Cookies are extremely sensitive to moisture and, because of their high fat content, can develop both hydrolytic and oxidative rancidity at very low moisture contents [18]. During storage, both kinds of rancidity were kept an eye on in cookies. While triglycerides of lipids are transformed into free fatty acids and glycerol in hydrolytic rancidity, which gives cookies their characteristic soapy smell, oxidative rancidity is caused by the oxidation of unsaturated fatty acids into hydro peroxides, which subsequently generates aldehydes and ketones. The amount of peroxide and melonaldehyde in the fat that was removed from the cookies indicated how much of it had autooxidized. As a measure of the concentration of primary oxidation products such peroxides and hydro peroxides created in the early stages of lipid oxidation, peroxide value is one of the most widely used and traditional chemical tests to detect oxidative rancidity [19]. Most of the primary constituents in cookies, such as sugar, fat, and wheat flour, are reactive to oxygen. According to (Kumar, et al. [20]), cookies' greater surface area exposes them to lighter and oxygen, which might result in enhanced oxidation. Cookies stored in LDPE packaging had a greater peroxide value than cookies packaged in MP, although as a function of storage, the peroxide value increased more in 37 °C than in RT samples. When cookies were first packaged in an LDPE container and held at room temperature and 37 °C, their peroxide value was 3.70 meqO2/Kg fat.

This value rose to 9.71 and 13.82 meqO2/Kg fat when cookies were packed in an MP package and stored at room temperature and 37 °C, respectively (Figure 2). Samples packaged in LDPE packaging showed the highest PV during the whole storage process, indicating a high degree of oxidation, whereas cookies placed in MP packaging showed a gradual increase in Peroxide value. Similar trends of rising PV values for multigrain biscuits during storage were noted by (Kathalsar, et al. [15,21]) with cookies containing rice bran extract. Thiobarbituric Acid (TBA) test is a known and accurate indicator of lipid peroxidation. Melonaldehyde is a secondary or end result of auto oxidation of poly unsaturated fatty acids [22]. By reacting with 2-thiobarbituric acid during the last step of lipid oxidation, the TBA test quantifies the synthesis of saturated aldehydes, 2-enals, and 2-dienals. In cookies packaged in LDPE packaging and kept at 37 °C, the highest amount of thiobarbeturic acid (melonaldehyde) MA/kg grew to 1.2 mg MA/kg from the initial 0.02 mg MA/kg (Figure 3). According to (Romani, et al. [23]), the breakdown of hydro peroxides, the fracture of long fatty acid chains into individual fatty acid moieties, and higher lipid hydrolysis at elevated temperatures are all responsible for the rise in the rate of auto oxidation as shown by peroxide value and TBA.

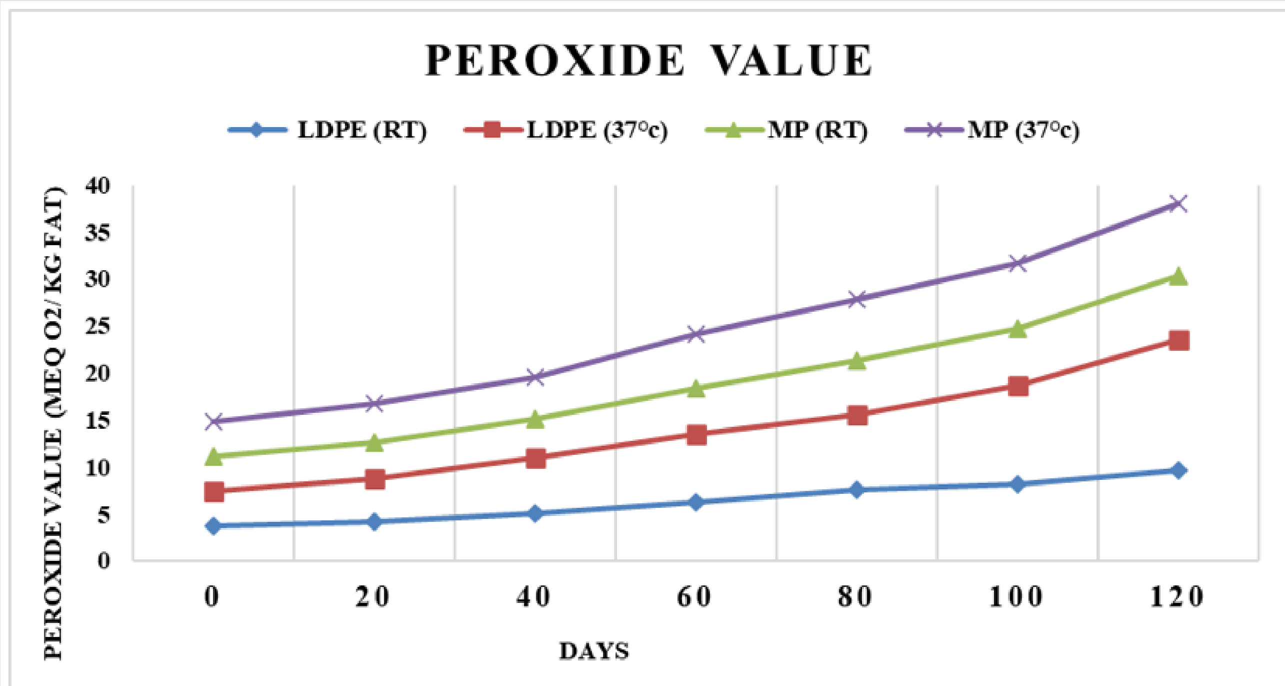

Figure 2: Changes in peroxide value during storage period of multi millet cookies packed in LDPE- Low density polypropylene; MP- Metalized polyester and stored at room temperature and 37°C (Mean and standard deviation of triplicates, significantly ($p \leq 0.05$).

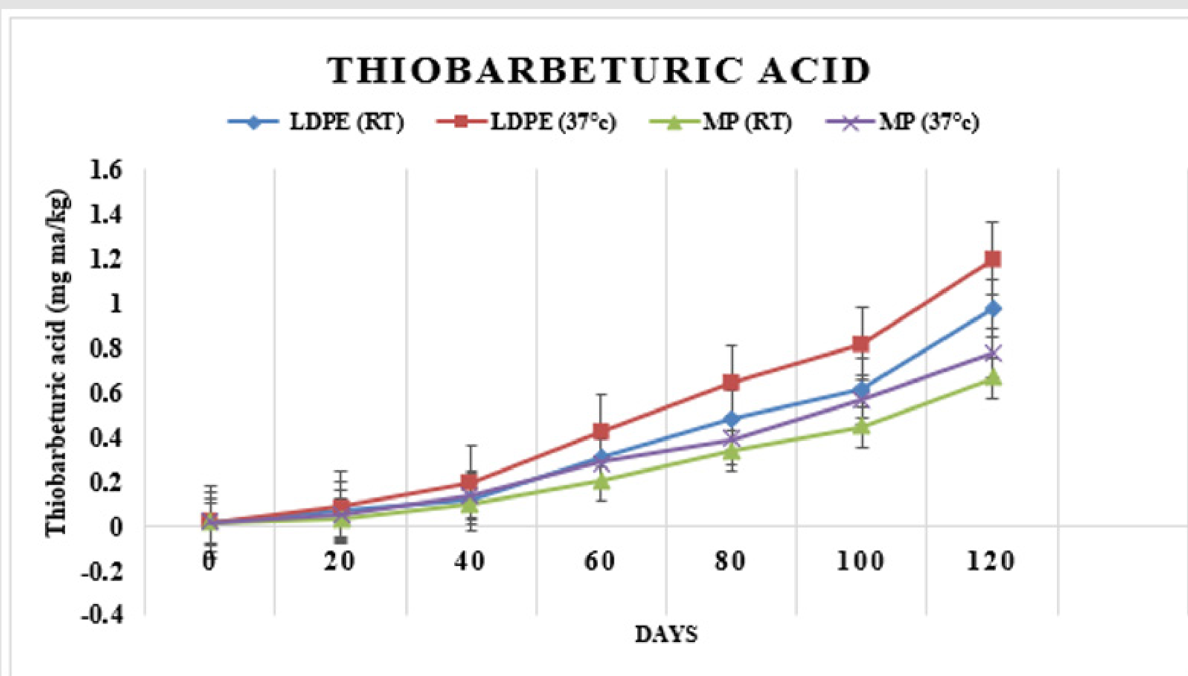

Figure 3: Changes in Thiobarbeturic Acid value during storage period of multi millet cookies cookies packed in LDPE- Low density polypropylene; MP- Metalized polyester and stored at room temperature and 37°C (Mean and standard deviation of triplicates, significantly ($p \leq 0.05$).

 DOI: 10.26717/BJSTR.2023.54.008530

Free Fatty Acid of Cookies During Storage Period

Food rancidity can also be determined by measuring the content of Free Fatty Acids (FFAs), which are formed when triglycerides hydrolyze and release free fatty acids or phospholipids. The presence of moisture can further exacerbate the formation of FFAs, which is another indicator of food rancidity [24]. The FFA of cookies was directly impacted by the length of storage and the kind of packaging used; in cookies wrapped in LDPE packaging and kept at RT, 37 °C, it climbed from 0.41 % oleic acid to 1.63, 1.91, 0.78, and 1.09 % oleic acid, respectively (Figure 4). The maximum FFA limit as oleic acid in biscuits by mass, according to the BIS standard, is 1.2%, as previously reported by (Kathalsar, et al. [15]). This was the sole restriction that the cookies packaged in MP lamination and kept at RT had. While the naturally occurring enzyme lipase facilitates lipid hydrolysis of food products during storage [25], lipases in cookies must have been destroyed by the heat used during baking; as a result, the breakdown of hydro peroxides during storage led to the formation of free fatty acids in cookies. According to (Khan, et al. [26]), the presence of high PV and TBA content in mutimillet cookies was associated with a higher FFA level, indicating the potential role of lipid auto-oxidation in this process.

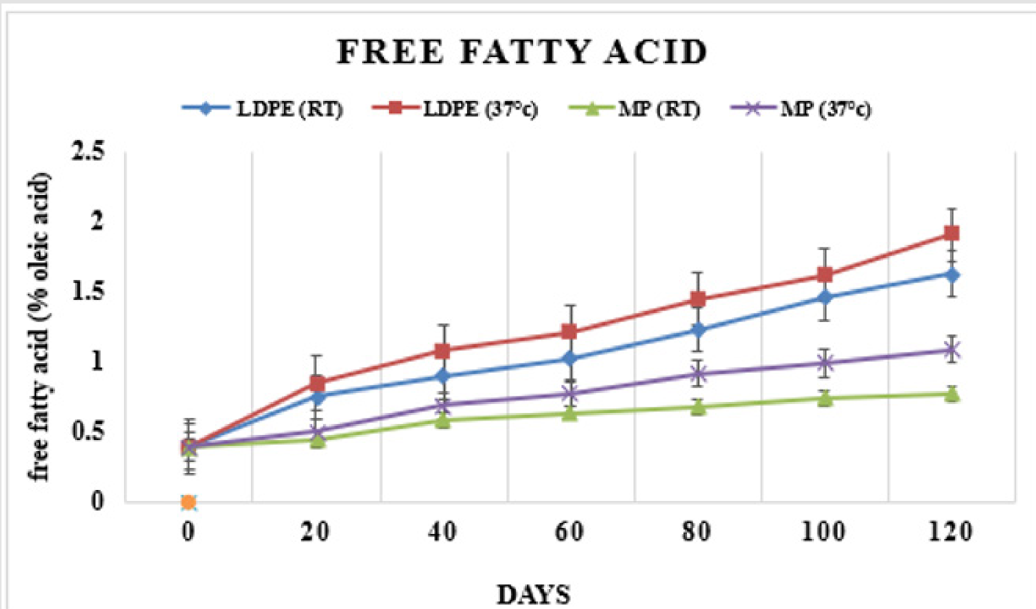

Figure 4: Changes in Free Fatty Acid value during storage period of multi millet cookies packed in LDPE- Low density polypropylene; MP- Metalized polyester and stored at room temperature and 37°C (Mean and standard deviation of triplicates, significantly ($p \leq 0.05$).

Sensory Properties of Multi Millet Cookies During Storage

Table 2 displays the results of the sensory analysis of cookies, which included color and appearance, taste, texture, flavor, and overall acceptability. The evaluation was done for cookies that were stored. The sensory examination of the cookies revealed that during storage, there is a noticeable drop in sensory characteristics including flavor, texture, and acceptability overall. After being kept at Room Temperature (RT) for 120 days, the cookies that were packaged in LDPE bags were found to be mushy and have a rancid taste. By the end of 120 days, however, cookies packaged in LDPE and kept at 37 °C had developed a rancid flavor and taste. The taste and flavor of the cookies had an initial sensory score of 8.3 and 8.0 on a 9-point hedonic scale, respectively. However, after that, they dropped to 6.2 and 5.8 (Table 2). Although they changed after 80 days, the multi-millet cookies packaged in MP pouches and kept at 37 °C had a taste and flavor that was similarly acceptable to those cookies packed in MP pouches and kept at room temperature. While cookies kept under refrigeration (RT) had an acceptable taste even after 120 days of storage, cookies stored at 37 °C had acceptable taste and flavor for up to 100 days and showed maximum rancidity flavor at 120 days, as evidenced by a lower score for taste and flavor In their investigations, (Seema, et al. [18]) suggested that laminated might be an appropriate packaging material for cookies line products..

 DOI: 10.26717/BJSTR.2023.54.008530

Table 2: Effect of different packaging materials on sensory attributes of the multi millet cookies during storage for 120 days at room temperature and 37°C (each figure is an average of 3 independent replicates).

Parameter	Packaging Material	Storage (days)						
		0	20	40	60	80	100	120
Colour and Appearance	LDPE (RT)	8.4	8i.1	7.9	7.7	7.4	7.0	6.7
	LDPE (37°C)	8.4	8.0	7.8	7.6	7.2	6.7	6.4
	MP (RT)	8.4	8.1	7.9	7.7	7.5	7.4	7.2
	MP(37°C)	8.4	8.2	8.0	7.8	7.5	7.2	6.9
Texture	LDPE (RT)	8.4	8.1	7.9	7.7	7.4	6.8	6.5
	LDPE (37°C)	8.4	8.0	7.8	7.5	7.1	6.5	6.2
	MP (RT)	8.4	8.2	8.0	7.8	7.7	7.5	7.4
	MP(37°C)	8.4	8.2	8.0	7.9	7.8	7.7	7.5
Taste	LDPE (RT)	8.3	8.0	7.7	7.4	7.0	6.6	6.4
	LDPE (37°C)	8.3	8.0	7.6	7.2	6.9	6.5	6.2
	MP (RT)	8.3	8.1	7.9	7.5	7.4	7.2	7.0
	MP(37°C)	8.3	8.2	8.0	7.8	7.2	7.0	6.7
Flavour	LDPE (RT)	8.0	7.7	7.4	7.0	6.6	6.3	6.0
	LDPE (37°C)	8.0	7.6	7.2	6.9	6.5	6.0	5.8
	MP (RT)	8.0	7.9	7.8	7.6	7.2	7.0	6.8
	MP(37°C)	8.0	7.9	7.7	7.4	7.1	6.9	6.7
Overall Acceptability	LDPE (RT)	8.2	7.9	7.7	7.2	6.6	6.4	6.1
	LDPE (37°C)	8.2	7.8	7.5	6.9	6.5	6.2	5.9
	MP (RT)	8.2	8.1	8.0	7.9	7.9	7.7	7.5
	MP(37°C)	8.2	8.0	7.9	7.7	7.6	7.4	7.1

The breaking strength of cookies might be related to their texture. Similar to the breaking strength of cookies, the texture parameters' sensory scores also showed a similar tendency. The multimillet cookies packaged in LDPE pouches saw a reduction in crispiness before those packed in MP pouches. Even after 120 days, there was little change between the MP pouch packed cookies maintained at 37 °C and Room Temperature (RT) (Figure. 5). When cookies were first stored at room temperature (RT), their overall acceptability (OAA) score was 8.2. However, when cookies were placed in an LDPE pouch at 37 °C, their OAA ratings dropped to 6.1 and 5.9, respectively, indicating that they were only acceptable for 40 days. The acceptance threshold for the cookies' shelf-life was set at an overall acceptability of 7.0. When kept for up to 120 days at room temperature and 100 days at 37 °C, MP packed cookies exhibited greater stability compared to LDPE pouches, and their sensory quality remained satisfactory (Figure 6). According to Sharma [27], after three months of storage, the rice-mung bean snacks were within an acceptable range. According to Nadarajah and Mahendran [28], biscuits with defatted coconut flour and packaged in MP pouches have a strong moisture and water vapor barrier, which allows them to be preserved for an extended amount of time [29].

DOI: 10.26717/BJSTR.2023.54.008530

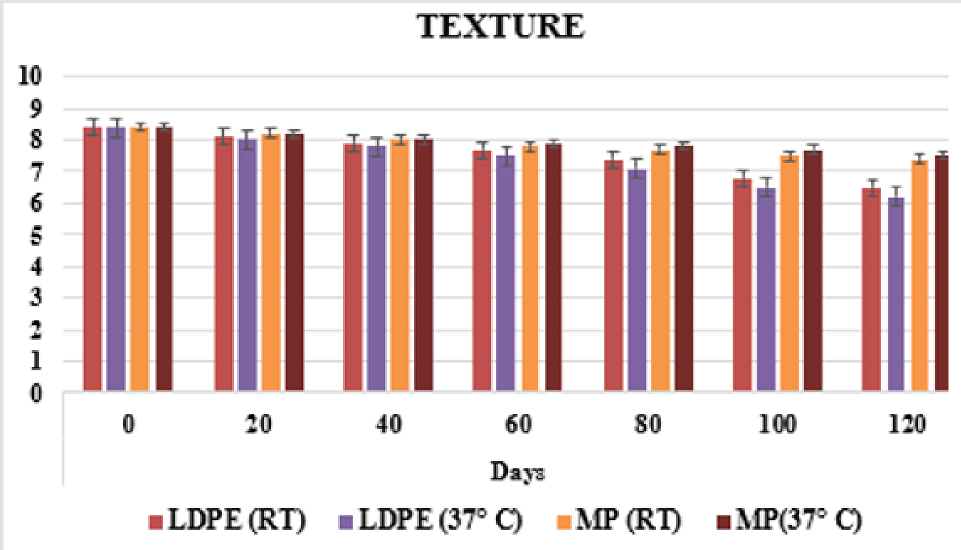

Figure 5: Texture score of cookies during storage after packing in LDPE- Low density polypropylene; MP- Metalized polyester and stored at room temperature and 37°C (Mean and standard deviation of triplicates, significantly ($p \leq 0.05$).

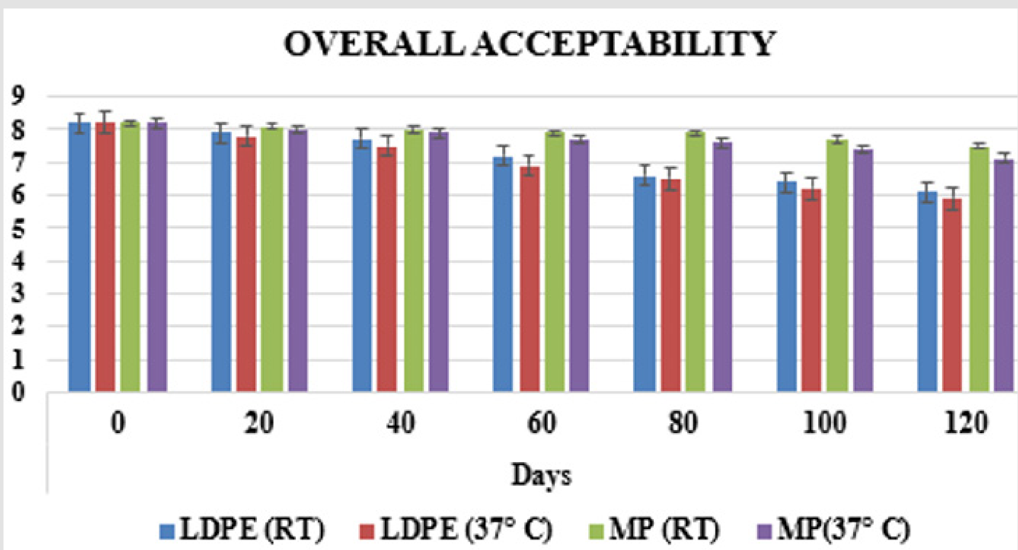

Figure 6: Overall acceptability of cookies during storage after packing in LDPE- Low density polypropylene; MP- Metalized polyester and stored at room temperature and 37°C (Mean and standard deviation of triplicates, significantly ($p \leq 0.05$).

Conclusion

This study's findings suggest that the shelf stability of items is influenced by the use of appropriate packing materials and storage settings. Products change chemically and physically during storage, which helps identify the best packaging material and storage conditions. The moisture level of multi millet biscuits packaged in LDPE pouches was shown to significantly increase. Nevertheless, for cookies packaged in MP pouches and kept at 37 °C as well as RT, the rise in moisture content was not appreciable. When the cookies absorbed moisture during storage, their breaking strength reduced; cookies packaged in LDPE pouches had the greatest reduction in breaking strength. Cookies were shown to have increased levels of peroxide value, thiobarbituric acid, and free fatty acid during storage; the degree of increase was dependent on the kind of packing utilized

 DOI: 10.26717/BJSTR.2023.54.008530

and the storage temperature employed throughout the investigation. Cookie packs made of LDPE and kept at 37 °C showed the largest increases in PV, TBA, and FFA content. These cookies were then packed in LDPE pouches and kept at ambient temperature, as well as MP pouches and kept at 37 °C. According to sensory tests, cookies packaged in MP pouches have a higher level of stability than cookies packed in LDPE pouches. They may also be kept for up to 120 days at room temperature and 100 days at 37 °C without losing any discernible quality. Multi millet cookies' physical and chemical properties lead to the conclusion that they may be kept at room temperature in metalized polyester pouches for up to 120 days without losing any of their sensory qualities.

Declarations

- Author contribution statement Shikha Sharma: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.
- Professor Dr. A.P. Garg: Designed and refined the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Finalized the paper.

Acknowledgement

The authors are thankful to Dr. Amit Nath and Director, IIFSR, Meerut for providing facilities to complete a part of this work.

Funding Statement

This research did not receive any specific grant from any funding agencies from the public, commercial, or not-for-profit sectors.

Declaration of Interest's Statement

The authors declare no conflict of interest.

References

1. Maurya Puja, Er Dorcus Masih, Er Chitra Sonkar, Anupama Singh (2022) Formulation and quality evaluation of multigrain cookies. The Pharma Innovation Journal 11(1): 921-925.
2. Obasi NE, Uchechukwu N, Eke Obia E (2012) Production and Evaluation of Biscuits from African Yam Bean (*Sphenostylis stenocarpa*) and Wheat (*Triticum aestivum*) Flours. Food Science and Quality Management, p. 7.
3. Sharma, Shikha, Anurag, Amar P Garg (2023) Effect of germination on the physicochemical and anti-nutritional properties of finger millet (Eleusine coracana), pearl millet (*Pennisetum glaucum*), and sorghum (*Sorghum bicolor*). The Pharma Innovation Journal 12(3): 4763-4772.
4. Sharma, Shikha, Amar P Garg (2022) Evaluation of physical, chemical and sensory properties of multigrain cookies Prepared using wheat, oats and barley flours. International Journal of Plant & Soil Science 34(24): 908-921.
5. Wafula WN, Korir NK, Ojulong HF, Moses Siambi, Joseph Onyango Gweyi (2018) Protein, Calcium, Zinc, and Iron Contents of Finger Millet Grain Response to Varietal Differences and Phosphorus Application in Kenya. Agronomy 8(24): 1-9.
6. Sinthia Afsana Kheyaa, Shishir Kanti Talukdera, Prantika Dattab, Sabina Yeasmin, Harun Rashid, et al. (2023) Millets: The future crops for the tropics - Status, challenges and future prospects. Heliyon 9(11): e22123.
7. Kulkarni DB, Sakhale BK, Chavan RF (2021) Studies on development of low gluten cookies from pearl millet and wheat flour. Food Research 5(4): 114 -119.
8. Sharma, Shikha, Amar P Garg (2023) Studies the effect of germination to develop the chickpea-based cookies. The Pharma Innovation Journal 12(9): 2897-2901.
9. (2000) AACC. Approved Methods of the Association of Cereal Chemists International (10th Edn.)., American Association of Cereal Chemists, St. Paul, Minnesota, USA.
10. Sharma, Shikha (2022) "Evaluation of sensory accessibility and nutritive of jaggery millet cookies".
11. Gains CS (1991) Instrumental measurement of the hardness of cookies and crackers. Cereal Foods World 36: 989-991-994, 996.
12. (1990) AOCS. Approved Methods of the American Oil Chemists Society, "Official Methods and Recommended Practices," (4th Edn.)., AOCS Champaign.
13. Tarledgis BG, Watts BM, Younathan ME, Dugon LR (1960) A distillation method for the qualitative determination of malonaldehyde in rancid food. Journal of American Oil Chemists Society 37(1): 44-47.
14. Larmond E (1997) Laboratory Methods for Sensory Evaluation of Foods. Canada Department of Agricultural Publication, Ottawa.
15. Kathalsar, Ashwath Kumar, Sharma, Gopal Kumar (2020) Shelf Stability of Multigrain Incorporated Biscuits on Storage: Its Physico-Chemical, Textural and Sensorial Studies. Annals Food Science and Technology 21(2).
16. Surekha N, Naik RS, Mythri S, Devi R (2013) Barnyard millet (Echinochloa frumentacea Link) Cookies: Development, value addition, consumer acceptability, nutritional, and shelf life evaluation. IOSR J Environ Sci Toxicol Food Technol 7(3): 1-10.
17. Butt MS, Nasir M, Akhtar S, Sharif K (2004) Effect of moisture and packaging on the shelf life of wheat flour. Internet Journal of Food Safety 4(1): 1-6.
18. Sharma, Seema, Charanjit S Riar (2020) Effect of Storage Period And Packaging Materials On Textural, Phenolic, Antioxidant Properties Of Cookies Made From Raw And Germinated Minor Millet Blends Flour. Annals. Food Science and Technology 21(1).
19. Sengev IA, Gernah DI, Bunde Tsegba M C (2015) Physical, chemical and sensory properties of cookies produced from sweet potato and mango mesocarp flours. African Journal of Food, Agriculture, Nutrition and Development 15(5): 10429-10442.
20. Kumar PP, Manohar RS, Indiramma AR, Krishna, AG (2014) Stability of oryzanol fortified biscuits on storage. Journal of Food Science and Technology 51: 2552-2559.
21. Kumari, Neeta, Sangeeta C Sindhu, Varsha Rani, Varsha Kumari (2021) Shelf life evaluation of biscuits and cookies incorporating germinated pumpkin seed flour. International Journal of Current Microbiology and Applied Science 10(1).
22. Rajiv J, Indrani D, Prabhasankar P, Rao GV (2012) Rheology, fatty acid profile and storage characteristics of cookies as influenced by flax seed (*Linum usitatissimum*). Journal of Food Science and Technology 49(5): 587-593.

23. Romani S, Tappi, S, Balestra F, Maria Teresa Rodriguez Estrada, Valentina Siracusa, et al. (2015) Effect of different new packaging materials on biscuit quality during accelerated storage. Journal of the Science of Food and Agriculture 95(8): 1736-1746.
24. Erickson MD, Frey N (1994) Property-enhanced oils in food applications. Food technology (USA).
25. Clayton TA, Morrison WR (1972) Changes in flour lipids during the storage of wheat flour. Journal of Science of Food and Agriculture 23(6): 721-736.
26. Khan MA, Mahesh C, Semwal AD, Sharma GK (2012) Studies on the optimization and storage stability of virgicn coconut meal incorporated instant sooji halwa mix. Food and Nutrition Sciences 8(3): 1092-1099.
27. Sharma S, Saxena DC Riar CS (2016) Nutritional, sensory and *in-vitro* antioxidant characteristics of gluten free cookies prepared from flour blends of minor millets. Journal of Cereal Science 72: 153-161.
28. Nadarajah S Mahendran T (2015) Influence of Storage conditions on the quality characteristics of wheat-defatted coconut flour biscuits packed in metalized polypropylene. International Journal of Engineering Research and Technology 4(7): 948-951.
29. Vinoth A, Ravindhran R (2017) Biofortification in Millets: A Sustainable Approach for Nutritional Security. Front Plant Sci 8: 29.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2023.54.008530

Amar P Garg. Biomed J Sci & Tech Res