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Development of high fiber cookies supplemented with pomegranate seed flour

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Abstract

High-fiber cookies were developed by incorporating pomegranate seed flour (PSF) at 5.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0%. Among these, cookies containing 15% PSF were identified as the best in baking quality and sensory attributes, making them suitable for further shelf-life studies. A decrease in moisture content was observed in cookies stored in polypropylene (PP) and aluminum (AL) packaging materials, making the cookies dry and eventually unacceptable. Water activity was higher in the control cookies compared to those made with PSF. Under ambient conditions, the cookies made with PSF remained acceptable for up to 75 days, while the sensory panel rejected the control cookies after 60 days. The overall acceptability of the cookies decreased during storage as they hardened due to moisture loss and changes in surface texture. Cookies with 15% PSF showed no visible microbial growth for up to 90 days of storage, but sensory properties began to decline after 75 days at 30±2°C. The fiber content in the developed cookies was measured as 5.82%.

Key word: Cookies, pomegranate, fiber, seed flour, shelf-life, baking quality, sensory attributes

Introduction

The global bakery market is expected to grow from $871.04 billion in 2021 to $950.72 billion in 2022 at a compound annual growth rate (CAGR) of 9.10 %. The market is expected to grow to $1,293.64 billion in 2026 at a compound annual growth rate (CAGR) of 8 %. Biscuits and cookies of over 632 thousand metric tons were produced in the South Asian country of India during fiscal year 2020.

The biscuit market is the fastest-growing sector within fast-moving consumer goods (FMCG). The global market is projected to reach USD 121 billion by 2021 with a CAGR of 3.7%, and USD 164 billion by 2024 with a CAGR of 5.08%. From 2017 to 2025, a strong CAGR of 4.7% is expected (Anonymous, 2019). Bread and biscuits account for nearly 80% of this market, with India being the second-largest producer after the US. Due to their nutritional value and affordability, bakery products are widely consumed. The industry faces challenges in meeting the demand for fortified options like fibre, antioxidants, omega-3 oils, vitamins, and minerals, requiring modifications to existing formulas to create new products.

Pomegranate (*Punica granatum*) is a perennial plant usually planted in tropical and subtropical regions (Schubert *et al.,* 1999). The edible part of the pomegranate fruit (50 %) consists of 40 % arils and 10 % seeds. Pomegranate seeds contain even higher amounts of specific nutritionally valuable and biologically active components than edible fruit, which holds great potential through appropriate processes to be converted into value-added products. So, pomegranate by-products could be used as a substrate to produce nutritionally valuable diets. The utilization of this industrial waste and the production of a functional food ingredient could potentially add high value to the food industry.

A study by Simsek *et al.* (2009) reported that the pomegranate seed showed an immunosuppressive effect in rats; thus, they utilized it as an antioxidant in the protection of erythrocytes and the treatment of leukaemia. Pomegranate seed contains lignin, cellulose and polysaccharides (Dalimov *et al.,* 2003) and high concentrations of conjugated fatty acids such as conjugated linolenic acid (Kohno *et al.,* 2004). Vroegrijk *et al.* (2011) proved that the pomegranate seed might bring potential health benefits for humans. Seeds also contain protein, crude fibers, vitamins, minerals, pectin, sugars, polyphenols, isoflavones, phytoestrogens, coumestrol and the sex steroid (androgens, estrogens, and progestogens), estrone (Aruna *et al.,* 2016).

Pomegranate seed flour is rich in sulfur-containing amino acids (methionine and cysteine), aromatic amino acids (phenylalanine and tyrosine), as well as leucine and isoleucine, which are significantly higher compared to the reference protein pattern established by FAO/WHO (Syed *et al*., 2007). During pomegranate juice processing, large amounts of pomace-containing peels and seeds are generated. However, waste products are difficult to dispose of as they cause environmental pollution. Therefore, it is commonly assessed as a supplement for inclusion in animal feed (Akhtar *et al.,* 2015).

To the best of our knowledge, there have been no reports on using pomegranate seed flour (PSF) as a dietary fiber source in cookie making. This study aims to explore the potential of PSF as a functional ingredient in wheat cookies, focusing on its impact on total dietary fiber content, baking quality, textural properties, and sensory attributes. The study seeks to standardize the optimal level of PSF in cookies based on baking parameters, evaluate the overall acceptability of PSF-incorporated cookies, and assess their shelf life.

Materials and methods

Location and raw materials: The work was done in the College of Food Processing Technology and Bio Energy, Anand Agricultural University, Anand, Gujarat**.** The flour, sugar, pomegranate seed flour (5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0 % replaced with flour), salt and other ingredients as per the quantity given in the cookie-making formula was procured from the local market.

Preparation of pomegranate seed powder: Pomegranates were purchased from a market. Arils were separated from the fruit. Juice extracted from arils. The seeds were separated from the arils of pomegranate fruit. Then seeds were subjected for tray drying at 70°C. After drying, the samples were milled into powder using a mill.

Treatments: Use of pomegranate seed flour (PSF) in cookies (0, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0 %). Packaging of products in aluminum laminates (AL) and polypropylene (PP). Storage of cookies at 30±2°C temperature. Four repetitions of the entire experiment were carried out, and a single factorial and three factorials in a fully Randomized Design (CRD) were chosen for data analysis.

Analysis: Physico-chemical characteristics of raw materials were analyzed using standard procedures (AACC, 2000).

Moisture: Standard AACC (2000) procedure given under 44.15 A was followed. Two grams of sample was dried in a clean, dry and pre-weighed moisture dish at 130±1ºC for 1 hr, cooled in desiccator and weighed. The moisture loss was calculated and expressed as a percentage.

Protein: Standard AACC (AACC, 2000) procedure given under 46-11 A was followed. sample (weighed) was digested in Kjeldhal flask with a digestion mixture (copper sulphate and potassium sulphate in 1:10 ratio) and concentrated H_2SO_4 (20 mL) till light green color and cooled. Ammonia released by distillation of digested sample with saturated NaOH (80mL) was captured in 0.1N HCl to calculate percent nitrogen (N_2). The protein content was calculated as per cent N_2 x factor. The factor of 5.7 was used for calculation.

Ash: Standard AACC (AACC, 2000) procedure given under 08-01 was followed. Weighed sample (5 g) was charred on a hot plate and incinerated in a furnace at 550±10^{o}C for 3 hr. It was cooled, weighed and ash content was expressed as percent ash.

Fat: Standard AACC (AACC, 2000) procedure given under 30-10 was followed. Weighed sample was taken in thimbles and extracted using Soxhlet apparatus with petroleum ether. Ether was recollected and the round bottom flask was weighed after fat extraction. The results were expressed as percent fat.

Calorific value: Calorific value was determined by using a bomb calorimeter and Parr Calorimeter assembly-6100 (Parr Instrument Company, Moline, Ilinois 61265, U.S.A).

Product preparation: Cookies were prepared with 0, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0 % PSF according to standard procedures (AACC, 2000) as per the treatment combinations given in the Table.

To prepare cookies all the ingredients were weighed accurately. The sugar and fat were then creamed together until smooth. Milk/ water was added to the mixture. The dry ingredients were gradually incorporated into the creamed mixture to form the dough. The dough was then sheeted to the desired thickness and cut into shapes using a cookie cutter. The shaped dough was placed onto baking trays (panning) and baked at 180°C for 20 minutes. After baking, the trays were removed from the oven, and the cookies were allowed to cool for 30 minutes. Finally, the cooled cookies were packaged for storage. Cookies were packed in polypropylene and aluminum laminates and stored at 30±2°C.

Sensory evaluation: The product prepared was evaluated for sensory properties by a panel of semi trained judges (Larmond, 1970). Cookies are assessed for top grain, appearance, flavour, texture, taste, and overall acceptability. The nine-point hedonic scale was used for the evaluation. The sensory evaluation of the cookies was conducted using the following scorecard.

Physico-chemical analysis: Cookies were analyzed for moisture, protein, fat, ash, and textural properties by using AACC (2000) methods described in the previous section.

Cookie quality: Cookies were evaluated for thickness, diameter and spread ratio. The thickness and diameter of six cookies were measured by venial caliper and the average thickness and diameter of each cookies were estimated.

Spread ratio: The spread ratio was determined by measuring the spread of the cookie and dividing it by the height (AACC, 2000).

Organoleptic quality: Cookies were evaluated for top grain, appearance, texture, flavor, and overall acceptability by panel of judges on a nine-point hedonic scale as described above.

Texture analysis of cookies (hardness): Texture of the cookies was evaluated on texture analyzer (Bourne, 1982). Cookies

Treatment combinations for the cookies making

Sr. No.	Ingredients	Control (T_0)	T_1	T_2	T_3	T_4	T_5	T_6	T_7
1	Maida (wheat flour) (g)	100.0	95.0	92.5	90	87.5	85.0	82.5	80
2	Pomegranate seed flour (g)	0	5.0	7.5	10.0	12.5	15.0	17.5	20.0
3	Shortening (g)	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
4	Sugar (g)	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
5	Sodium bicarbonate (g)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	Ammonium bicarbonate (g)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7	Cardamom powder(g)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8	Vanilla powder (g)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
9	Salt (g)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10	Water/milk (mL)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
11	Vanilla essence (mL)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

subjected to a compression test to measure hardness (N). The settings used for test were pretest speed (1 mm/s), test speed (1 mm/s), post- test speed (1 mm/s), distance (15 mm) and force (50 kg).

Color measurements of cookies: The crust color of cookies was evaluated by measuring the L (100=white; 0=black), a (+, red; -, green), and b (+, yellow; -, blue) value using a Lovibond Spectrophotometer (Kimura *et al.* 1993). A piece of the cookies sheet was taken in the sample holder and the surface color was measured at three different positions.

Shelf life: Changes in moisture, textural properties, water activity and sensory properties were observed. Stored cookies were analyzed after each 15-day interval for moisture, water activity, and textural properties using standard procedures as described above.

Statistical analysis: The data collected were subjected to CRD with four repetitions of the entire experiment and single and three factorials in a fully Randomized Design (CRD) were chosen for data analysis.

Results and discussion

Baking characteristics

Effect of incorporation of pomegranate seed flour (PSF) on the baking scores of cookies: Table 1 displays the physical properties of cookies prepared with different PSF contents. The spread factor was an important characteristic for determining the quality of cookies. Cookies with higher spread ratios were considered the most desirable. An increase in PSF content significantly increased the spread ratio of the cookies till 12.5 %. Then it again decreased as the level of PSF increased, which was directly related to the height of the cookies, whereas the diameter was generally not affected. As per earlier reports (McWatters, 1978; Singh *et al.*, 1993), a decrease in spread ratio with increased protein content in the cookies was noticed.

Effect of incorporation of pomegranate seed flour (PSF) on the mean sensory scores: Table 1 represents the sensory properties (color, appearance, taste, flavor, texture and overall acceptability) of high-fiber cookies with different concentrations of PSF. According to the overall acceptability scores, the samples exhibited great acceptable sensory characteristics. Control sample was observed to have a higher level of acceptance. Nevertheless, the panelist more preferred the cookies with 15 % of PSF among all samples. The addition of more than 15 % PSF had negative effects on the colour, flavour, taste, and overall acceptability (Fig. 1). Hence, 15 % PSF incorporation was selected for further storage studies.

Proximate composition: The chemical composition of the cookies for both the control and developed treatments showed some notable differences. The developed cookies had a higher protein content (7.86%) compared to the control (7.57%) and a significantly higher fibre content (5.82% vs. 0.77%). Ash content also increased in the developed cookies (1.09% vs. 0.68%). Fat content was slightly higher in the developed cookies (27.47% vs. 26.32%), while carbohydrates decreased in the developed cookies (53.29% vs. 60.96%). Moisture content was also higher in the developed cookies (4.62% vs. 3.69%). The peroxide value was marginally higher in the developed cookies (1.25 mEq/kg vs. 1.19 mEq/kg), and energy content was slightly lower in the developed cookies (547.88 kcal/100g vs. 550.93 kcal/100g)(Table 2).

Storage study: Based on the overall acceptability scores, formulations developed with 15 % PSF content was selected best for the further storage study. The shelf life of cookies prepared from the selected level of 15 % PSF were analyzed for moisture, water activity, hardness, colour and sensory quality at 30±2°C temperature packed in polypropylene (PP) and aluminum laminates (AL). During the storage study, the interaction effect of packaging material

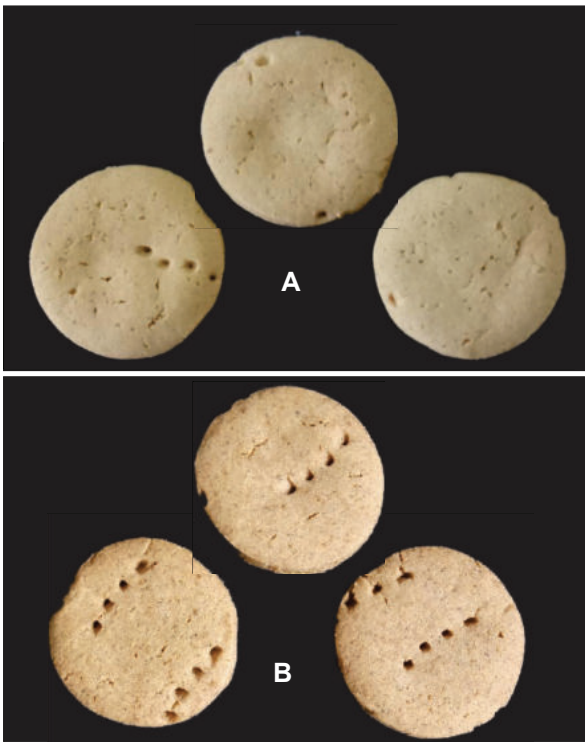

Fig. 1. Effect of incorporation of pomegranate seed flour on cookies quality. A: Control and B: PSF incorporated cookies

Table 1. Effect of incorporation of pomegranate seed flour (PSF) on the baking and mean sensory panel scores (9-point hedonic scale) of cookies

PSF (%)	Diameter (cm)	Thickness (cm)	Spread ratio	Color	Appearance	Taste	Flavor	Texture	Overall acceptability
0.0	4.63	1.47	3.15	8.33	8.20	8.50	8.33	8.67	8.13
5.0	4.69	1.51	3.11	8.00	7.90	7.93	8.03	7.97	7.83
7.5	4.66	1.47	3.18	7.67	7.67	7.77	7.77	7.50	7.80
10.0	4.71	1.48	3.18	7.20	7.80	7.60	7.27	7.83	7.50
12.5	4.80	1.43	3.36	7.73	7.37	7.57	7.13	7.60	7.77
15.0	4.63	1.42	3.26	7.97	8.40	7.97	8.00	8.07	7.93
17.5	4.63	1.40	3.31	7.27	7.00	6.97	7.53	7.43	6.97
20.0	4.60	1.45	3.18	6.27	6.33	5.93	6.67	6.53	5.87
S.Em.±	0.04	0.02	0.05	0.13	0.15	0.20	0.16	0.18	0.16
CD (0.05)	NS	0.05	0.15	0.40	0.45	0.59	0.47	0.54	0.47

Mean of four repetitions; PSF: Pomegranate seed flour

(A: PP- Polypropylene; AL: Aluminum laminates); treatments (B: Control 100 % wheat flour (control) and 15 % pomegranate seed flour (developed) incorporation were subjected for storage study.

Effect of storage period on moisture content (%) and water activity: Significant variations were observed in the moisture content of cookies prepared from pomegranate seed flour with respect to packaging materials, storage period, treatment, and interaction between packaging material with storage period and treatments with storage period (Table 3). Also, significant variations were observed in the interaction of packaging material and treatment with storage periods in the moisture content. The cookies packed in PP showed a higher rate of moisture loss than those packed in AL (Table 3). Higher moisture content was observed in cookies prepared after the incorporation of 15 % level of PSF as compared to control. Similarly, more moisture loss was found in control cookies than in cookies prepared from 15 % level PSF.

Rogers *et al.* (1988) reported that moisture content was inversely proportional to the rate of firming. Hoseney and He (1990) concluded that moisture content significantly affected bread firming. Water requirement for the growth of the microorganism was expressed in terms of available water or water activity. Statistically significant variations were observed in the water activity of cookies prepared from PSF with respect to storage period, treatment, and interaction between treatments with storage period (Table 3). The cookies which were packed in PP showed a more gain in water activity than those packed in AL (Table 3). The control sample showed more gain in water activity than the developed sample with an increasing storage period. Similar observations were reported by Breene *et al.* (1988). Labuz *et al.* (1972) reported that reducing water activity below 0.7 prevent microbial spoilage. The water activity of cookies increased with increased storage period. Similar results were observed by Frazier (1978). Water activity found more for cookies prepared from pomegranate seed flour than control cookies. Rossel *et al.* (2001) reported that the hydroxyl group of the fibre structure allows more water interaction through bonding. During storage, visible mold growth was not observed.

Effect of storage period on hardness of cookies: The individual effect of treatments on the hardness of cookies was found to be highly significant (Table 3). The interaction of storage period and treatments on the hardness of cookies was found to be significant. The hardness of cookies increased with the storage period. More increase in the hardness of cookies was found in control as compared to the selected sample. Cookies packed in AL packaging material showed a smaller increase in hardness compared to those packed in PP packaging material. As a result, cookies packed in AL maintained a softer texture than those packed in PP.

Effect of storage period on color (L & b-value) of cookies: The effect of the incorporation of pomegranate seed flour on color properties of cookies are discussed in Table 4. The individual effects of packaging materials, treatments and storage period on the L-value of cookies were found to be significant.

The interaction of packaging material with treatments, treatments with storage period and storage period with packaging materials on L-value of cookies were found to be significant. Also, the interaction of packaging materials treatments with the storage period was found to be significant. The lightness of cookies increased with increasing storage period (Table 4). More increase in lightness of cookies was found in control as compared to the selected sample. Cookies packed in AL packaging material showed less increase in L-value than cookies packed in PP packaging material. Cookies packed in AL remained lighter in color than cookies packed in PP.

Table 2. Chemical composition of cookies

Treatment	Protein (%) ±SD	Ash (%) ±SD	Fat (%) ±SD	Fibre (%) ±SD	Moisture (%) ±SD	Carbohydrates (%) ±SD	Peroxide value (mEq/kg) ±SD	Energy kcal/100g±SD
Control	7.57±0.06	0.68±0.03	26.32±0.72	0.77±0.02	3.691±0.15	60.96±0.78	1.19±0.04	550.93±3.81
Developed	7.86±0.12	1.09±0.07	27.47±0.57	5.82±0.14	4.62±0.12	53.29±0.64	1.25±0.06	547.88±5.58

Mean of four repetitions; ±SD: Standard deviations

Table 3. Effect of storage period on moisture content (%), water activity and textural properties of cookies prepared by adding pomegranate seed flour packed in PP and AL

Days	Moisture content (%)				Water activity				Hardness (kg)			
	PP		AL		PP		AL		PP		AL	
	Control	Developed	Control	Developed	Control	Developed	Control	Developed	Control	Developed	Control	Developed
0	3.69	4.62	3.69	4.62	0.338	0.379	0.338	0.379	0.023	0.017	0.023	0.017
15	3.77	4.34	3.74	4.62	0.357	0.393	0.354	0.383	0.028	0.027	0.023	0.020
30	3.58	3.97	3.69	4.35	0.367	0.430	0.357	0.416	0.032	0.032	0.030	0.023
45	3.28	3.89	3.55	4.22	0.397	0.451	0.373	0.434	0.040	0.038	0.032	0.027
60	2.77	3.59	3.43	3.96	0.444	0.458	0.412	0.440	0.048	0.040	0.040	0.040
75	2.35	3.37	2.94	3.64	0.530	0.480	0.471	0.488	0.058	0.044	0.048	0.053
90	2.30	3.20	2.64	3.50	0.562	0.504	0.519	0.488	0.063	0.057	0.052	0.054
Factors		CD (0.05)	S.Em.±			CD (0.05)	S.Em.±			CD (0.05)	S.Em.±	
A		0.054	0.019			0.011	0.004			0.004	0.002	
B		0.054	0.019			0.011	0.004			NS	0.002	
A×B		NS	0.027			NS	0.005			NS	0.002	
C		0.101	0.036			0.02	0.007			0.08	0.003	
A × C		0.143	0.051			NS	0.010			NS	0.003	
B × C		0.143	0.051			0.028	0.010			0.009	0.004	
A × B × C		0.203	0.071			NS	0.014			NS	0.005	

Mean of three repetitions; NS: Non-significant; A: Packaging material (PP- Polypropylene; AL: Aluminum laminates); B: Treatment (Control; Developed- 15 percent pomegranate seed flour); C: Storage period

Table 4. Effect of storage period on L-value (%), b-value and overall acceptability of cookies prepared by incorporating pomegranate seed flour packed in PP and AL

Days	L-value (%)				b-value				Overall acceptability			
	PP		AL		PP		AL		PP		AL	
	Control	Developed	Control	Developed	Control	Developed	Control	Developed	Control	Developed	Control	Developed
0	58.88	51.51	58.88	51.51	24.34	22.33	24.34	22.33	8.36	8.44	8.36	8.44
15	59.42	51.40	59.18	50.22	25.55	22.17	24.96	22.08	8.21	8.24	8.15	8.26
30	60.25	51.27	59.60	49.20	25.91	21.88	25.47	21.96	8.23	8.48	7.97	8.33
45	61.53	51.41	60.60	47.94	26.32	21.56	25.89	21.61	7.46	7.46	7.64	8.42
60	62.88	51.32	61.77	47.12	26.63	20.92	26.23	21.30	6.44	6.49	7.34	7.63
75	64.49	50.76	62.66	46.63	27.32	20.21	26.31	21.19	5.27	5.35	5.85	7.02
90	67.65	49.20	63.44	45.40	28.02	19.94	26.73	20.67	ND	ND	ND	ND
Factors		CD (0.05)	S.Em.±			CD (0.05)	S.Em.±			CD (0.05)	S.Em.±	
A		0.47	0.17			NS	0.22			0.07	0.03	
B		0.47	0.17			0.61	0.22			0.07	0.03	
A × B		0.66	0.23			NS	0.31			0.10	0.04	
C		0.87	0.31			NS	0.41			0.12	0.04	
A × C		1.24	0.44			NS	0.57			0.17	0.06	
B × C		1.24	0.44			1.63	0.57			0.17	0.06	
A × B × C		NS	0.62			NS	0.81			0.24	0.08	

Mean of three repetitions; NS: Non-significant; A: Packaging material (PP- Polypropylene; AL: Aluminum laminates); B: Treatment (Control; Developed- 15 percent pomegranate seed flour); C: Storage period

The individual effect of treatments was found significant for the b-value of cookies. The interaction effect of packaging materials and storage period on the b-value of cookies was found to be non-significant (Table 4). The interaction of treatments with storage period was found to be non-significant during storage study. The interaction of packaging material with treatments and storage period with packaging materials on b-value of cookies was found to be non-significant during storage. Also, the interaction of packaging materials treatments with the storage period was found to be non-significant. The b-value for control cookies increased with increasing storage period and decreased with increasing storage period for developed sample. Cookies packed in PP material showed more increase in b-value than cookies packed in AL material.

Effect of storage period on overall acceptability scores: The effect of incorporation of pomegranate seed flour on overall acceptability of cookies is presented in Table 4. The individual effect of packaging materials, treatments, and storage period on overall acceptability of cookies was found to be significant. The interaction of packaging material with treatments, treatments with storage period, and storage period with packaging materials on the overall acceptability of cookies was found to be significant. Also, the interaction of packaging materials treatments with the storage period was found to be significant. The overall acceptability of cookies decreased with increasing storage period. A greater decrease in the overall acceptability score of cookies was found in control cookies as compared to developed cookies. Cookies packed in AL packaging material showed less decrease in overall acceptability score as compared to cookies packed in PP packaging material. Cookies packed in AL remained more acceptable than cookies packed in PP over the storage period.

Cookies made from developed formulations and packed in PP and AL packaging materials were slightly liked by the sensory panelists, while those made from control formulations were moderately disliked. The cookies from the developed formulations were accepted by the sensory panelists up to 75 days of storage in AL packaging material and 60 days in PP packaging material. Control cookies received acceptance until day 60 but the extended storage period made them too hard due to dryness. The sensory evaluation of cookies from the developed formulations became impossible after 75 days of storage. The laboratory analysis revealed no signs of growth among either control or developed formulations that used PP or AL packaging (Table 4).

The sensory panel chose cookies containing 15% PSF because they obtained a superior baking score together with better color, appearance, texture, flavor, taste and overall acceptability results. The combination of 15% PSF made cookies achieved optimal results for baking properties and sensory qualities so researchers selected them for additional shelf-life investigations. The moisture content reduction in cookies packed in both PP and AL materials led to dryness that resulted in unacceptability. The water activity levels in control cookies exceeded those of PSF-incorporated cookies. The developed formulations of cookies maintained their acceptance quality throughout 75 days under ambient conditions yet control cookies gained unacceptable status at 60 days. Overall acceptability decreased over time as the cookies became harder due to moisture loss and changes in texture. Cookies made with 15% PSF showed no visible growth up to 90 days of storage, but their sensory properties began to change after 75 days.

The study indicated that the The cookies containing 15% pomegranate seed flour (PSF) achieved the best baking results and sensory scores thus becoming the most acceptable option. The cookies containing pomegranate seed flour maintained their quality throughout 75 days of storage but regular cookies became unacceptable before day 60 due to drying out. The cookies received better texture and flavor after PSF addition and both formulations remained free from microbial growth throughout storage. The 15% PSF cookies presented the most suitable option for long-term storage because their sensory quality started deteriorating after 75 days.

References

AACC, 2000. *Approved Methods of American Association of Cereal Chemists*. 10th ed. The Association St. Paul, MN.

Akhtar, S., T. Ismail, D. Fraternale and P. Sestili, 2015. Pomegranate peel and peel extracts: Chemistry and food features. *Food Chem*., 174: 417-425.

Anonymous, 2019. Indian Bakery Market: Industry Trends, Share, Size, Growth, Opportunity and Forecast 2019-2024.

Aruna, P., D. Venkataramanamma and K.A. Singh, 2016. Health Benefits of Punicic Acid: A Review. *Comprehensive Rev. Food Sci. Food Saf.*, 15: 16-27

Bourne, M.C. 1982. Principles of objective texture measurement. In Food Texture and Viscosity: Concept and Measurement. Academic Press, San Diego. pp 114-17.

Breene, W.M., P.S. Taoukis and T.P. Labuza, 1998. The role of water activity in foods. *Adv. Cereal Sci. Technol.,* 9: 91-94.

Dalimov, D.N., G.N. Dalimova and M. Bhatt, 2003. Chemical composition and lignins of tomato and pomegranate seeds. *Chem. Nat. Compounds,* 39: 37-40.

Frazier, W.C. and D.C. Westhoff, 1978. *Food Microbiology*. pp181-2 Tata McGraw-Hill.

Hosney, R.C. and H. He, 1990. Changes in bread firmness and moisture during long-term storage. *Cereal Chem*., 67: 603-605.

Kimura, T., K.R. Bhattacharya and S.J. Ali, 1993. Discoloration characteristics of rice during parboiling. *J. Soc. Agric. Structure,* 24: 23-30.

Labuza, T.P., L.D. Mc Naly, J. Gallaghar, I. Hawkes and F. Hurdato, 1972. The stability of intermediate moisture food. 1. Lipid Oxidation. *J. Food Sci.,* 37: 154.

Larmond, E. 1970. *Method of Sensory Evaluation of Food*. Canadian Department of Agriculture Publications. 1284.

McWatters, K.H. 1978. Cookie baking properties of defatted peanut, soybean and field pea flours. *Cereal Chem*., 55(6): 853-863.

Rogers, D.E., C.S. Zeleznak and R.C. Hoseney, 1998. Effect of native lipids, shortening and bread moisture on bread firming. *Cereal Chem*., 65: 398-401.

Rossel, C.M., J.A. Rojaz and B.D. Benedito, 2001. Influence of hydrocolloids on dough rheology and bread quality. *Food Hydrocolloid,* 15: 75-78.

Schubert, S.Y., E.P. Lansky and I. Neeman, 1999. Antioxidant and eicosanoid enzyme inhibition properties of pomegranate seed oil and fermented juice flavonoids. *J. Ethnopharmacol.,* 66: 11-17.

Simsek, N., A. Karadeniz and A.G. Bayraktaroglu, 2009. Effects of L-carnitine, royal jelly and pomegranate seed on peripheral blood cells in rats. *J. Faculty Vet. Med. Kafkas. Univ.,* 15: 63-69.

Singh, B., M. Bajaj, A. Kaur, S. Sharma and J. Sidhu, 1993. Studies on the development of high-protein biscuits from composite flour. *Plant Foods Hum. Nutri.,* 43(2): 181-189.

Syed, D.N., F. Afaq and H. Mukhtar, 2007. Pomegranate-derived products for cancer chemoprevention. *Semin Cancer Biol.,* 17(5): 377-385.

Vroegrijk, I.O., J.A. Van Diepen, S. Van Den Berg, I. Westbroek, H. Keizer and L. Gambelli, 2011. Pomegranate seed oil, a rich source of punicic acid, prevents diet-induced obesity and insulin resistance in mice. *Food Chem. Toxicol.,* 49: 1426-1430.

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