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EFFECT OF INCORPORATION OF BIOPROCESSED LENTILS ON NUTRITIONAL AND TECHNOFUNCTIONAL PROPERTIES OF FLAT BREAD

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ABSTRACT

The present study was carried out to observe the effect of incorporation of raw and processed lentils on nutritional and technofunctional characteristics of flat bread. Lentils were processed by soaking (25 ºC for 12 hours), atmospheric boiling (25 minutes), and germination (25 ºC for 48 hours) methods. Raw and processed lentil flours were used in production of flat bread which was evaluated for rheological, compositional and color characteristics. Shelf stability studies (textural properties, water activity and free fatty acid) of flat bread were carried out by storing in food-grade LDPE bags under refrigeration (4±1 ºC) for up to 7 days. Significant ($p<0.05$) variations were observed in rheological properties which were found to be optimum upon incorporation of raw and processed lentil flour at level of 10 % for flat bread dough. Processing treatments considerably enhanced the nutritional value, with germination and boiling leading to increased protein and fiber content and decreased fat content. Color analysis also exhibited substantial changes upon incorporation of raw and processed lentil flours. There was rise in hardness, gumminess and chewiness in control and lentil incorporated flat breads upon storage. Water activity ranged between 0.85-0.92 from 0th to 7th day. Elevation in free fatty acids was observed in all the products wherein rate of increase was highest in the control sample (133 %) during storage. Based on nutrition development, functional characteristics and organoleptic acceptability of flat breads, lentil flour, raw and processed, is a potential ingredient which can be utilized in development of functional foods.

1. Introduction

Since prehistoric times, legumes have played a significant role in human diets and agricultural systems. In recent years, they have made a major contribution to solving the pressing problems of food and nutritional security. This is ascribed to legumes' high nutritional content, which includes substantial amounts of high-quality proteins, complex carbohydrates, dietary fiber, minerals and vitamins. Legumes also contain a variety of bioactive components that protect against diabetes, colon cancer, and coronary heart disease (Dhillon *and al.*, 2022; Gandhi *and al.*, 2022).

Lentil, a commonly consumed legume, is an excellent source of protein (23-31 %), dietary fiber (7-23 %) and minerals; phosphorus (57-407 mg/100g), magnesium (99-726 mg/100g), calcium (59-463 mg/100g) and potassium (285-943 mg/100g). Furthermore, it contains significant amounts of essential amino acids except methionine, which can be complemented by consuming it with cereals. However, it possesses certain antinutritional compounds (phytates, saponin, tannins) which have the ability to lower the bioavailability of nutrients like proteins and minerals. Processing techniques like soaking, boiling, autoclaving, roasting, germination, and fermentation have been reported to eliminate such compounds and thereby enhance the nutritional potential (Gandhi *and al*., 2022).

Recently, investigators have reported the utilization of raw and/or processed legume flours in the development of various food products. The investigations carried out by Alomari and Abdul-Hussain (2013), Atudorei *and al*. (2022), Bojňanská *and al*. (2021), Dhinda *and al*. (2012), Mohammed *and al*. (2012), Oskaybaş-Emlek *and al*. (2021), Sopiwnyk *and al*. (2020) and Turfani *and al*. (2017) reported the effect of utilization of flours of lentil, common bean, chickpea, red lentil and broad bean on the physicochemical characteristics of various bakery products. This could be attributed to the significant functionality of legumes which enhance the overall quality of final product. Modern research is primarily focused on enhancing bread by adding nutrient-rich and health-promoting ingredients (Olagunju *and al*., 2021). However, there is dearth of literature on the incorporation of raw and/or processed lentil flour in flat bread. Therefore, the present study was carried out to observe the effect of incorporation of raw and processed lentil on the nutritional and techno-functional characteristics of flat bread.

2. Materials and methods

2.1. Raw materials

Lentil was procured from the Punjab Agricultural University, India. Ingredients used for the preparation of flat bread were purchased from the local market of Ludhiana, India.

2.2. Processing of lentil grains

After sorting and cleaning, lentil seeds were processed using three techniques; a) soaking in distilled water for 12 hours at 25 ℃ (Rehinan *and al*., 2004); b) boiling under atmospheric conditions for 25 minutes at 100 ℃ (Yeo and Shahidi, 2017); c) germination of soaked (12 hours, 25 ℃) seeds for 48 hours at 25 ℃ (Vidal-Valverde *and al*., 2002). Following processing, seeds were tray dried (6 hours at 50 ℃) and milled to flour using domestic mill.

2.3. Dough rheology

Refined wheat flour was substituted with raw and processed lentil flour at different levels (0 – control, 5, 10, 15 and 20 %) to analyse the effect of incorporation on the rheological attributes. Perten doughLAB instrument (300 g capacity, Australia) working on the analytical conditions mentioned in the AACC International Method 54-21.02, was utilized to record following parameters – water absorption (%), dough development time (minutes), stability (FU) and peak energy (Wh/kg).

2.4. Preparation of flat bread

Flat bread was prepared using the procedure reported by Sharma *and al*. (1995). Refined wheat flour was substituted with raw and processed lentil flour at 0, 5, 10, 15 and 20 % levels in the flat bread. Other ingredients used were sugar (2.5 g), salt (1 g), compressed yeast (3 g), shortening (10 g), water (as per requirement) for 100 g of flour. All the ingredients were mixed to dough followed by fermentation for 60 minutes at 30 ºC and 75 % relative humidity (RH). Thereafter, dough was remixed, left for recovery time, sheeted, molded, proofed (30 minutes, 30 ºC, 75 % RH), and baked (4-5 minutes, 300 ºC). Flat bread prepared without incorporation of lentil flour was served as control sample.

2.5. Sensory evaluation

A nine-point hedonic scale ranging from 9 (Like extremely) to 1 (Dislike extremely) was adopted to evaluate prepared food products by a semi-trained panel of 25 members on the basis of appearance, texture, flavor, taste, mouthfeel, and overall acceptability. The optimum samples were selected on the basis of sensory evaluation and subjected to various physico-chemical analyses.

2.6. Proximate analysis

Standard procedures of AACC (2000) were adopted to analyse the proximate composition of flat bread samples. Moisture content was determined using hot air oven method at 130 ºC. Kjeldahl method was used for protein content estimation where in nitrogen conversion factor of 6.25 was applied. Fat content was evaluated with Soxhlet apparatus using petroleum ether (40-60 °C) as the extractant. For ash content, the samples were charred and kept in the muffle furnace at 550 ºC for 5 hours. Difference method was employed to calculate carbohydrate content by subtracting the contents of moisture, protein, fat and ash from 100. All the results were expressed as gram per 100 gram of sample (g/100 g).

2.7. Colour analysis

Hunter lab colorimeter (CR-300 Minolta Camera, Japan) was utilized to analyse the color properties. Results were expressed as L*, a* and b* values representing lightness, greenness/ redness and blueness/ yellowness, respectively.

2.8. Shelf stability

Flat bread was packed in low density polyethylene (LDPE) bags and stored for 7 days at refrigerated conditions. Samples were analysed on 0th, 3rd and 7th day for following parameters.

2.8.1. Texture analysis

TMS PRO was used for the analysis of texture profile of flat bread. Square shaped pieces of 1X1 cm^2 were placed on the platform of texture analyzer with the load cell of 100 N and probe with the diameter of 75 mm. The samples were compressed with 50 % compression. The hardness, springiness, cohesiveness, gumminess, chewiness and resilience were noted down for all the samples.

2.8.2. Water activity

The water activity was determined using a digital water activity meter (Pawkit, Decagon Devices, Inc., Pullman, Washington, USA). Water activity meter was calibrated before measuring the water activity.

2.8.3. Free fatty acid content

2 g sample and 20 mL benzene were mixed in a flask and kept for 30 minutes on shaker. Thereafter, 5 mL extract was poured into another flask and mixed with 5 mL ethanol and 5 mL benzene. 2-3 drops of phenolphthalein were added as indicator and contents were titrated against 0.02 N KOH until a light pink color appeared and persisted for 15 seconds (AACC, 2000). Titre value was noted down and results were calculated as percent (%) oleic acid.

2.9. Statistical analysis

Experiments were performed in duplicates/triplicates and final values were expressed as mean value ± standard deviation. Data sets were subjected to analysis of variance (ANOVA) at $p<0.05$ on IBM SPSS 22.0 software (SPSS Inc. Chicago II, USA).

3.Results and discussions

3.1. Effect of lentil incorporation on the rheological properties of flat bread dough

Dough characteristics exhibited considerable ($p<0.05$) variation upon incorporation of raw and processed lentil flours (Table 1). As the concentration of the lentil increased from 5 to 20 %, the values for water absorption percentage (%), peak energy (Wh/kg), and dough development time (minutes) showed a significant rise wherein highest values were observed in dough samples containing 20 % boiled lentil flour (6.7, 93.04 and 18.9 % respectively) followed by 20 % germinated lentil flour (4.5, 77.04 and 12.03 % respectively). However, a considerable decline of 72.34 % was observed in stability (minutes) upon incorporation of 20 % soaked lentil flour.

Table 1. Effect of lentil incorporation on the rheological properties of flat bread dough^{+}

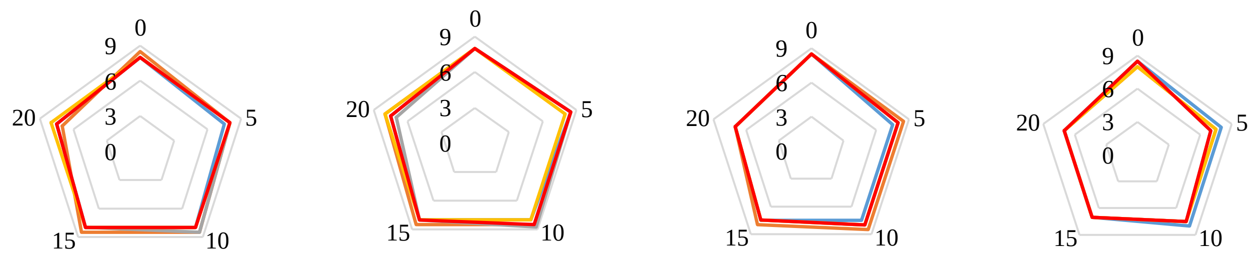
Treatment	Control	Raw				Soaked				Boiled				Germinated			
Level of Substitution (%)	100%	5%	10%	15%	20%	5%	10%	15%	20%	5%	10%	15%	20%	5%	10%	15%	20%
Water absorption (%)	60.15± 0.02^{J}	62.04± 0.02^{HIc}	63.26± 0.15^{EFb}	64.57± 0.06^{Ca}	64.84± 0.30^{Ba}	61.83± 0.14^{Id}	62.64± 0.17^{Gc}	63.52± 0.02^{Eb}	64.21± 0.36^{Da}	62.77± 0.22^{Gd}	63.06± 0.11^{Fc}	64.54± 0.13^{Cb}	65.95± 0.22^{Aa}	61.93± 0.03^{HId}	62.14± 0.08^{Hc}	64.74± 0.06^{BCb}	65.87± 0.07^{Aa}
Dough development time (minutes)	3.05± 0.03^{I}	1.50± 0.08^{Ld}	2.4± 0.07^{Jc}	4.80± 0.06^{Gb}	5.10± 0.05^{EFa}	1.50± 0.02^{Ld}	5.00± 0.04^{Fc}	5.20± 0.06^{DEb}	5.80± 0.02^{Aa}	1.70± 0.06^{Kd}	4.50± 0.08^{Hc}	5.60± 0.05^{Bb}	5.90± 0.04^{Aa}	1.50± 0.04^{Lc}	4.40± 0.12^{Hb}	5.30± 0.14^{CDa}	5.40± 0.03^{Ca}
Stability (minutes)	4.70± 0.07^{D}	6.80± 0.15^{Aa}	5.60± 0.04^{Cb}	3.60± 0.02^{Ec}	3.10± 0.07^{Fd}	6.20± 0.16^{Ba}	3.70± 0.07^{Eb}	3.20± 0.03^{Fc}	1.30± 0.14^{Id}	3.80± 0.07^{Ea}	3.30± 0.19^{Fb}	2.80± 0.04^{Gc}	2.10± 0.05^{Hd}	4.70± 0.20^{Da}	3.60± 0.02^{Eb}	3.10± 0.25^{Fc}	1.50± 0.13^{Id}
Peak energy (Wh/kg)	11.30± 0.13^{B}	8.34± 0.06^{Kd}	8.98±0. 03^{Ic}	9.44± 0.02^{GHb}	9.82± 0.04^{Fa}	8.91± 0.12^{Id}	9.34± 0.15^{Hc}	9.88± 0.17^{Fb}	10.27± 0.08^{Ea}	10.43± 0.06^{Dd}	10.87± 0.02^{Cc}	11.21± 0.01^{Bb}	13.44± 0.08^{Aa}	8.56± 0.12^{Jd}	8.98± 0.06^{Ic}	9.57± 0.14^{Gb}	9.94± 0.08^{Fa}

$^{+}$Data is presented as mean± standard deviation.
Different letters from A, B, C to L indicate statistical differences by Tukey test ($p<0.05$) among different treatments.
Different letters from a, b to d indicate statistical differences by Tukey test ($p<0.05$) among different replacement levels for a single treatment.

According to Bojňanská *and al.* (2021), incorporating bean, lentils, and chickpea flours in bread led to an increase in water absorption capacity and development time, but a decline in dough stability. The higher water-holding capacity of legume flour can be attributed to the higher protein and pentosan (ribose and deoxyribose) contents which could change the water dynamics and distribution of the dough. The increased dough development time may be attributed to protein interactions causing a reduction in dough hydration and therefore dough development (Dhinda *and al*., 2012). The variations observed upon the addition of boiled lentil flour can be attributed to the denaturation and unfolding of proteins which exposed the hydrophilic regions, leading to increased water absorption. Gelatinization of starch after boiling also aided in increasing the water absorption (Aguilera *and al*., 2009). Shahzadi *and al*. (2005b) also noted a comparable decrease in dough stability attributing it to decrease in the content of wheat gluten. Similar observations have been reported by Turfani *and al*. (2017) who also found that lentil flour notably reduced stability and raised dough development time in bread due to the weakening of the protein (gluten) network. Additionally, germination of lentil flour can lead to proteolysis causing increase in low molecular weight proteins and exposure of the hydrophilic regions of the protein chains thereby increasing its water absorption capacity (Gandhi *and al*., 2022). However, proteolysis also impacted the strength of gluten and decreased the stability of the dough. Similar results were observed for flat bread incorporated with sprouted oats which was attributed to the action on the wheat proteins upon sprouting (Sergiacomo *and al*., 2024).

3.2. Effect of lentil incorporation on the sensory attributes of flat bread

The overall acceptability scores were highest for all the flat breads incorporated with 10 % processed lentil flours (Figure 1). Incorporation of lentil flour improved mouthfeel and aroma of the flat breads, however score for appearance declined. At higher substitution levels, an adverse impact on the final product's hardness, shape, color, and crumb elasticity was observed. Kohajdová *and al*. (2013) reported similar observations that baked rolls prepared with 10 % legume flour were most acceptable. Based upon the sensory evaluation, all the flat breads incorporated with 10 % raw and processed lentil flours were further subjected to physical-chemical analysis and shelf stability studies.



(a) **(b)** **(c)** **(d)**

Figure 1. Effect on the sensory attributes (— appearance, — mouthfeel, — taste, — aroma, — overall acceptability) of flat bread upon substitution with lentil flours – a) raw, b) soaked, c) boiled and d) germinated – at 0 (control), 5, 10, 15 and 20 % replacement levels

3.3. Effect of lentil incorporation on the proximate composition of flat bread

Results obtained for proximate composition are summarized in Table 2. Incorporation of boiled lentil flour significantly ($p<0.05$) enhanced the moisture content of flat breads, that was in agreement with the findings of Dostalova *and al*. (1998) attributing it to the increment in the water holding capacity of legume flour after boiling. A significantly ($p<0.05$) higher protein content was recorded in all the lentil flour (both raw and processed) incorporated flat breads owing to the higher protein content of legume (Kohajdová *and al*., 2013). Furthermore, germinated lentil flour resulted in highest increment in the protein content of the flat bread which might be due to the substantial reduction in the other constituents of the flour during the germination process leading to relative compositional variations (Xu *and al*., 2019). Conversely, flat bread prepared with soaked lentil flour exhibited lower ($p<0.05$) protein content. As explained by Agume *and al*. (2017), the breakdown as well as solubilization of proteins during soaking resulted in lower values. In context to ash content, flat bread prepared with lentil flours exhibited significantly ($p<0.05$) elevated values attributing to the higher content of minerals in legumes, as reported by Gandhi *and al*. (2022). Amongst lentil flours, highest increment in ash content was observed with raw lentil flour followed by germinated, soaked and boiled. It was believed that, during germination, the enzymatic activity caused relative compositional changes whereas leaching of minerals during boiling and soaking resulted in lower ash content (Gandhi *and al*., 2022). Fat content was found to reduce significantly ($p<0.05$) upon lentil incorporation which can be attributed to its low fat content as compared to wheat flour (Shahzadi *and al*., 2005a). Moreover, Gandhi *and al*. (2022) showed that soaking and boiling of lentils led to reduced fat content attributing this to the diffusion of the lipid bodies into processing water. Germination was demonstrated to decrease the fat content due to the utilization of lipid bodies as energy source for sprouting. Carbohydrate content of the flat bread substantially ($p<0.05$) reduced with addition of lentil flours owing to the lower carbohydrate content of the legumes (Kohajdová *and al*., 2013). Moreover, the incorporation of processed lentil flours in the flat bread led to reduction in carbohydrate content wherein lowest values were observed for boiled lentil flour followed by germinated and soaked. Dhull *and al*. (2023) observed leaching of sugars during hydrothermal treatments resulted in lower carbohydrates values. In context to germination, Fouad and Rehab (2015) highlighted that, the decline in carbohydrate content upon processing was due to the conversion of complex carbohydrates into simple sugars by α-amylase.

3.4. Effect of lentil incorporation on the color properties of flat bread

Color values (L*, a* and b*) of the flat bread exhibited substantial variations with the incorporation of processed lentil flour (Table 2). Significant ($p<0.05$) decrease of 4.77-9.45 % in L* values were recorded in raw and processed lentil flour incorporated flat breads implying decrease in lightness. Huang *and al*. (2017) reported similar observations upon addition of whole green lentils to bread which led to reduction in the L* value (darker coloration) by 10.31 % attributing it to the high phenolic content of lentils. However, a* and b* values were found to increase upon incorporation of raw and processed lentil flours. This color change can be explained by the Maillard reaction which caused the natural dark pigmentation of bread (Alomari and Abdul-Hussain, 2013). Flat bread incorporated with boiled lentil flour exhibited reduction in L*, a* and b* values which may be due to degradation of color pigment and water-soluble phenolic compounds during boiling (Monalisa *and al*., 2020).

3.5. Effect of lentil incorporation on the shelf stability of flat bread

3.5.1. Texture profile analysis

Texture profile analysis was used to evaluate hardness, cohesiveness, chewiness, springiness, gumminess, and resilience of the prepared flat breads (Table 3). During storage studies, the hardness, gumminess, and chewiness of the flat breads were significantly ($p<0.05$) increased till the 7th day of storage to 9.19 N (in germinated), 9.47 N (in soaked), and 62.4 J (in boiled) respectively. However, the values of springiness, cohesiveness, and resilience showed a considerable ($p<0.05$) decline to 6.26 (in germinated), 0.24 (in raw), and 0.14 (in germinated) respectively on the 7th day. The values of hardness showed highest elevation in raw lentil flour flat breads during storage. Atudorei *and al*. (2022) also found similar trends in the texture profile attributes during the preparation of bread from lentil flour due to higher fiber content and a more compact bread structure. It was also explained that a decrease in the strength of the gluten network may be caused due to the higher water-binding capacity of dietary fibers. The dilution of the gluten resulting from the flour addition caused by a reduction in the strength of the gluten network and the result of a change in the nature of starch may be responsible for the reduction in the values of springiness, cohesiveness, and resilience. The increase in hardness upon storage in all the samples was attributed to moisture loss and starch retrogradation (Lin *and al*., 2013).

Table 2 Effect of lentil incorporation on the physico-chemical properties of flat bread^{+}

Treatments	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrates (%)	Color analysis		
						L*	a*	b*
Control	32.69± 0.13^{C}	12.46± 0.01^{D}	10.26± 0.02^{A}	0.5± 0.01^{E}	74.85± 0.31^{D}	85.56± 0.58^{A}	3.63± 0.16^{D}	16.47± 0.20^{C}
Raw	31.75± 0.08^{E}	15.00± 0.07^{B}	10.23± 0.04^{AB}	0.88± 0.03^{A}	80.36± 0.02^{B}	80.92± 0.30^{C}	4.81± 0.07^{A}	17.53± 0.05^{B}
Soaked	32.85± 0.09^{B}	14.71± 0.12^{C}	10.09± 0.04^{C}	0.75± 0.02^{C}	80.78± 0.03^{A}	79.76± 0.33^{D}	4.30± 0.06^{C}	18.40± 0.23^{A}
Boiled	34.78± 0.06^{A}	14.99± 0.23^{B}	10.03± 0.04^{C}	0.67± 0.02^{D}	80.68± 0.04^{A}	77.47± 0.11^{E}	3.16± 0.22^{E}	11.66± 0.07^{D}
Germinated	32.38± 0.04^{D}	15.46± 0.05^{A}	10.18± 0.05^{B}	0.83± 0.03^{B}	79.86± 0.12^{C}	81.48± 0.17^{B}	4.51± 0.05^{B}	17.34± 0.13^{B}

$^{+}$Data is presented as mean± standard deviation.
Different letters from A, B to E indicate statistical differences by Tukey test ($p < 0.05$) among different treatments.

3.5.2. Water activity

The water activity for the flat breads made from different processed lentil flours showed significant ($p<0.05$) variation upon storage (Table 3). However, a slight rise in water activity was seen from the 0th to the 3rd and 3rd to the 7th day under refrigeration conditions. Increase in water activity upon storage can lead to quality degradation in relation to hydrolytic rancidity and organoleptic attributes like texture. Tiwari *and al*. (2011) also reported that the packaging material and storage conditions may be the cause of moisture absorption by the product since it acts as medium for microbial growth and can reduce the shelf by causing development of off-flavour thereby affecting its shelf life.

3.5.3. Free-fatty acid content

The values of free fatty acid content on the 0th day varied from 0.24-0.36 % oleic acid for the flat breads prepared from raw and processed flours. The free fatty acid content showed a significant ($p<0.05$) increase from day 0 to day 7 (Table 3). Due to enzymatic (lipase action) or non-enzymatic activities at high temperatures, triglycerides are hydrolyzed to produce free fatty acids (Tiwari *and al*., 2011). Surekha *and al*. (2013) reported the same results related to free fatty acid levels after a storage examination of cookies produced from barnyard millet. The considerable ($p<0.05$) rise in free fatty acids can be related to the presence of moisture in flat breads, as well as the use of low-density polyethylene material for packaging, which shows a higher water vapor transmission rate. However, it was also observed in the current study that the rate of increase of free fatty acid was higher in the control sample as compared to the flat breads prepared with raw and processed lentils which can be attributed to their antioxidant activity.

Table 3 Effect of lentil incorporation on the storage stability of flat bread[+]

Treatment	Days	Texture analysis						Water activity	Free fatty acid (% oleic acid)
		Hardness (N)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (J)	Resilience		
Control	0	5.43±0.14^{Oc}	12.27±0.02^{Ba}	0.70±0.02^{Aa}	1.86±0.03^{Kc}	12.40±0.03^{Nc}	0.67±0.01^{Ba}	0.85±0.01^{Eb}	0.24±0.02^{Fc}
	3	7.18±0.03^{Hb}	10.53±0.05^{Cb}	0.64±0.07^{Ba}	2.48±0.02^{Jb}	14.29±0.04^{Mb}	0.53±0.03^{Cb}	0.85±0.01^{Eb}	0.36±0.02^{Eb}
	7	10.27±0.03^{Aa}	7.86±0.04^{Jc}	0.47±0.02^{Db}	4.65±0.03^{Fa}	17.80±0.08^{La}	0.28±0.02^{Fc}	0.92±0.01^{ABa}	0.56±0.01^{BCa}
Raw	0	6.28±0.02^{Lc}	10.32±0.03^{Da}	0.56±0.02^{Ca}	3.45±0.03^{Hc}	35.85±0.02^{Fc}	0.68±0.02^{Ba}	0.90±0.01^{CDb}	0.26±0.01^{Fc}
	3	6.76±0.03^{Jb}	9.04±0.02^{Hb}	0.41±0.02^{EFb}	4.61±0.07^{FGb}	42.43±0.05^{Eb}	0.51±0.02^{CDb}	0.91±0.01^{BCb}	0.45±0.04^{Db}
	7	8.2±0.04^{Ea}	7.63±0.04^{Kc}	0.24±0.04^{Hc}	6.35±0.02^{Ca}	61.59±0.39^{Ba}	0.26±0.03^{Fc}	0.92±0.01^{ABa}	0.58±0.01^{Ba}
Soaked	0	5.68±0.03^{Nc}	12.69±0.04^{Aa}	0.66±0.01^{ABa}	4.55±0.05^{Gc}	28.72±0.08^{Ic}	0.74±0.01^{Aa}	0.91±0.01^{BCa}	0.35±0.01^{Ec}
	3	6.86±0.02^{Ib}	9.31±0.07^{Gb}	0.44±0.02^{DEb}	6.24±0.03^{Db}	32.34±0.09^{Hb}	0.47±0.05^{Db}	0.91±0.01^{BCa}	0.44±0.03^{Db}
	7	8.43±0.02^{Da}	6.92±0.07^{Mc}	0.33±0.04^{Gc}	9.47±0.06^{Aa}	51.58±0.04^{Da}	0.36±0.02^{Ec}	0.91±0.01^{BCa}	0.53±0.03^{Ca}
Boiled	0	6.06±0.01^{Mc}	10.19±0.06^{Ea}	0.57±0.02^{Ca}	3.28±0.02^{Ic}	21.00±0.23^{Kc}	0.48±0.01^{Da}	0.91±0.01^{BCa}	0.36±0.03^{Ec}
	3	7.57±0.03^{Gb}	8.64±0.02^{Ib}	0.37±0.01^{FGb}	5.86±0.02^{Eb}	32.44±0.02^{Hb}	0.34±0.03^{Eb}	0.91±0.01^{BCa}	0.47±0.01^{Db}
	7	8.87±0.03^{Ca}	6.91±0.09^{Mc}	0.28±0.03^{Hc}	6.87±0.06^{Ba}	62.40±0.16^{Aa}	0.24±0.05^{Fc}	0.93±0.01^{Aa}	0.63±0.02^{Aa}
Germinated	0	6.66±0.01^{Kc}	9.48±0.04^{Fa}	0.53±0.01^{Ca}	3.49±0.04^{Hc}	23.19±0.03^{Jc}	0.38±0.03^{Ea}	0.89±0.01^{Dc}	0.35±0.03^{Ec}
	3	7.94±0.05^{Fb}	7.44±0.03^{Lb}	0.36±0.02^{Gb}	4.58±0.09^{FGb}	34.67±0.05^{Gb}	0.25±0.02^{Fb}	0.91±0.01^{BCb}	0.46±0.03^{Db}
	7	9.19±0.12^{Ba}	6.26±0.12^{Nc}	0.25±0.01^{Hc}	6.26±0.03^{Da}	56.40±0.07^{Ca}	0.14±0.03^{Gc}	0.92±0.01^{Aba}	0.54±0.02^{Ca}

[+]Data is presented as mean± standard deviation.
Different letters from A, B, C to O indicate statistical differences by Tukey test ($p<0.05$) among different treatments.
Different letters a, b and c indicate statistical differences by Tukey test ($p<0.05$) among different days for a single treatment.

Saeed *and al*. (2020) also observed that the formation of free fatty acids content in black gram incorporated biscuits was low as compared to control samples and indicated this to the capability of the antioxidants present in the former samples.

4. Conclusion

Incorporation of raw and processed lentil flour in flat bread dough at 10 % level led to optimum rheological properties. The overall palatability of the flat bread containing 10 % processed lentil flour was observed to be enhanced in comparison to the control. Processing techniques significantly improved the nutritional value; boiling and germination resulted in higher protein and lower fat levels; potentially making it a healthier choice. Significant variations in color and textural characteristics (hardness, gumminess, and chewiness) were also observed after adding both processed and raw lentil flours. The water activity and free fatty acid values were in the optimum ranges for lentil incorporated flat bread. This comprehensive study on the application of processed lentil flour in the making of flat bread resulted in significant knowledge regarding the physical, chemical, sensory, and rheological characteristics.

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