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Gluten-free lentil crackers: Technological and sensory characteristics

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Abstract

Lentils (*Lens culinaris* Medik.), including red-, green-, and black-colored varieties, are one of the most commonly consumed pulses. They are characterized by their great quantity of proteins, fibers, folic acid, minerals, and phenolics. To enhance the nutritional quality of gluten-free crackers, lentils are a functional and inexpensive option. This study examined the impacts of different colored lentil varieties on the technological (color, diameter, thickness, spread ratio, and puffiness) and sensory (color, taste, odor, appearance, crispness, and overall liking) quality of gluten-free crackers. Results showed that the color profile of gluten-free crackers was affected by lentil varieties. The highest *L** and *hue* values were obtained in the control crackers, while the highest *b** and *SI* values were observed in crackers made with red lentil. Lentil crackers elicited a greater diameter than the control. However, the use of lentil varieties did not change the thickness values of crackers compared to the control. The spread ratio value of black lentil crackers was lower than that of red and green lentil crackers. Compared to other lentil varieties, the use of black lentils resulted in the greatest puffiness in crackers. Regarding sensory evaluation, gluten-free crackers prepared from green and black lentils revealed comparable color, taste, odor, appearance, crispness, and overall liking scores to the control. The data obtained in this study illustrated that lentils, especially green- and black-colored varieties, can be promising ingredients for gluten-free products.

Key Words: *Lentils, Gluten-free, Crackers, Functional foods, Technological quality*

Introduction

Lentils (*Lens culinaris* Medik.) are one of the leguminous crops, which are cultivated in different regions of the world, from Asia to Africa. Canada (44%) is the greatest producer of lentils, followed by India (18%), Australia (8%), and Türkiye (Kaale et al., 2023). Lentils are known as a protein-rich crop, align with their high fiber, mineral (especially Fe), vitamin (B-complex), and phytochemical contents. The seed coat color of lentils varies from yellow to black, which is associated with their secondary metabolite content, such as polyphenols (Jackson et al., 2021). A nutrient-dense profile of lentils can provide advantages in improving human health by reducing the risks of cardiovascular diseases, cancer, obesity, hypertension, and diabetes (Faris et al., 2013; Zhang et al., 2018; Dhull et al., 2023).

Compared to their traditional counterparts, gluten-free foods are characterized by their lower protein, fiber, vitamin, mineral, and polyphenol content. Hence, nutritional deficiencies in available gluten-free foods should be compensated for with nutritive ingredients like lentils (Di Cairano et al., 2018). According to Hajas et al. (2022), lentil flour can improve the nutritional quality and antioxidant activity of gluten-free cookies without a detrimental impact on the sensory properties. Bisson et al. (2025) also stated that incorporating a legume blend containing lentil flour increased protein and resistant starch content of gluten-free snacks with comparable textural quality.

To the best of my knowledge, this is the first report on the inclusion (100%) of three different colored lentil varieties into gluten-free cracker formulation. Therefore, this study aims to develop gluten-free cracker formulations with red, green, and black lentils, and to characterize and compare their technological and sensory properties.

Materials and Methods

Materials

Red lentil, green lentil, black lentil, corn starch, rice flour, shortening, salt, sugar, baking powder, and yeast were procured from a store in Konya, Türkiye. Xanthan gum was supplied from Smart Kimya (İzmir, Türkiye).

Methods

Control gluten-free cracker samples were produced using 200 g gluten-free flour (corn starch:rice flour, 100:100, w/w), 40 g shortening, 3.2 g salt, 3 g sugar, 3 g baking powder, 2 g xanthan gum, 2 g yeast, and water. After kneading for 5 min, the dough was fermented at 35 °C for 2 h. Following that, the sheeted and shaped dough was baked (Kumtel, Kayseri, Türkiye) at 175 °C for 7 min. In lentil crackers, gluten-free flour was fully replaced with red/green/black lentil flour.

Color *L**, *a**, and *b** values were determined via a PCE-CSM 2 colorimeter (Meschede, Germany), calibrating with a white tile. $(a^{*2}+b^{*2})^{1/2}$ equation was used to determine the saturation index (*SI*) values. *Hue* angle was calculated using *a** and *b** values [arctan (*b**/*a**)].

The AACC method 10-54 was used to determine the diameter and thickness values of gluten-free crackers (AACC, 2010). Following this, the spread ratio was obtained by taking the quotient of the diameter and the thickness. Puffiness was measured using the following equation:

Puffiness = [(Thickness after baking - Thickness before baking)/Thickness before baking]*100 (1)

A group of nine panelists used a nine-point scale (1=dislike extremely, 9=like extremely) to assess sensory characteristics such as color, taste, odor, appearance, crispness, and overall liking for gluten-free cracker samples. Each cracker was assigned a distinct code composed of three randomly generated numerical digits.

Statistical Analysis

The one-way analysis of variance (ANOVA) was carried out to determine significant differences ($p<0.05$) using the Tukey HSD test. The mean values were presented with standard deviation.

Results and Discussion

Color influences consumer perception and acceptance of food products (Millar et al., 2017). Color values of cracker samples are reported in Table 1. The highest *L** and *hue* values were observed in the control gluten-free crackers. The use of lentil flours in cracker formulations reduced *L** and *hue* values of gluten-free crackers compared to the control, probably due to the natural colors of lentil flours. Gluten-free crackers made with red lentils had the greatest *a**, *b**, *and SI* values. The changes in color values could be attributed to natural colors of lentils and Maillard reactions as a result of increasing free amino acids with the addition of lentils (Monnet et al., 2019; Bisson et al., 2025). Similar results were also found for gluten-free green and red lentil crackers by Han et al. (2010).

Table 1. Color values of gluten-free lentil crackers.

Crackers	*L**	*a**	*b**	*SI*	*Hue*
Control	77.88±0.56^{a}	1.71±0.24^{d}	20.72±0.37^{c}	20.79±0.39^{c}	85.29±0.46^{a}
Red lentil	63.26±0.47^{b}	29.70±0.38^{a}	42.26±0.59^{a}	51.65±0.60^{a}	54.91±0.58^{d}
Green lentil	58.93±0.68^{c}	9.37±0.30^{b}	31.73±0.56^{b}	33.09±0.55^{b}	73.55±0.44^{b}
Black lentil	39.78±0.44^{d}	6.62±0.36^{c}	14.67±0.59^{d}	16.10±0.36^{d}	65.73±0.36^{c}

The significant ($p<0.05$) variations between means are indicated by distinct letters in every column.

The diameter values of gluten-free crackers ranged from 46.84 mm to 50.91 mm (Table 2). Lentil crackers showed a greater diameter than the control crackers. This may be attributed to a reduction in starch content and an increase in protein content as a result of lentil addition (Esen et al., 2025). Thickness values of crackers changed between 1.38 mm and 1.81 mm, but the changes in thickness values were found to be statistically insignificant ($p>0.05$) (Table 2).

Table 2. Technological characteristics of gluten-free lentil crackers.

Crackers	*Diameter (mm)*	*Thickness (mm)*	*Spread ratio*	*Puffiness (%)*
Control	46.84±0.47^{b}	1.38±0.25^{a}	33.94±0.27^{a}	15.00±0.28^{d}
Red lentil	50.55±0.44^{a}	1.49±0.30^{a}	33.93±0.32^{a}	24.17±0.33^{c}
Green lentil	50.91±0.54^{a}	1.64±0.27^{a}	31.04±0.29^{b}	36.67±0.26^{b}
Black lentil	50.53±0.41^{a}	1.81±0.31^{a}	27.92±0.34^{c}	50.83±0.29^{a}

The significant ($p<0.05$) variations between means are indicated by distinct letters in every column.

As shown in Table 2, the spread ratio of red lentil crackers was similar to that of the control crackers. However, the use of green or black lentils reduced the spread ratio of crackers. The decrease may be due to the higher dietary fiber contents of green and black lentils (Göncü and Çelik, 2020). The lowest puffiness was obtained in the control, while black lentil crackers showed the greatest puffiness (Table 2). The change in cracker composition due to the use of protein- and fiber-rich lentils may be responsible for these results (Bisson et al., 2025).

Sensory evaluation of gluten-free crackers is illustrated in Figure 1. Color scores of crackers formulated with green and black lentils were close to the control. The use of red lentils reduced the color scores of crackers compared to the control.

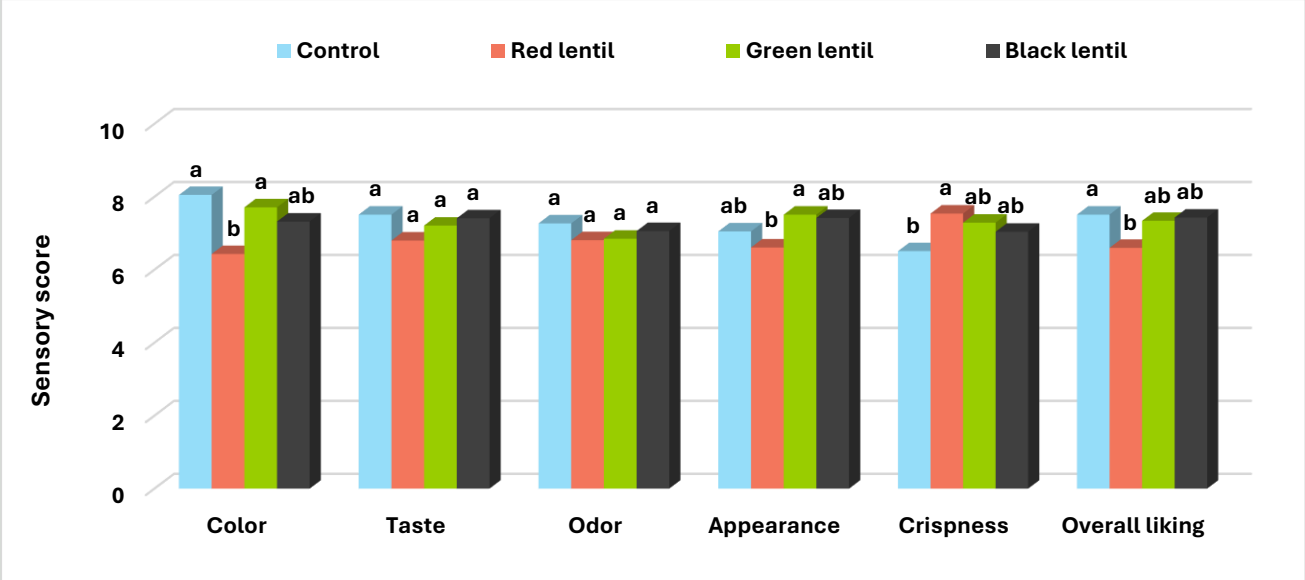

Figure 1. Sensory characteristics of gluten-free lentil crackers.

Lentil type did not show a considerable impact on the taste and odor scores of gluten-free crackers. In terms of the appearance parameter, all lentil varieties elicited similar scores to the control. Furthermore, the crispness score of red lentil crackers was higher than that of the control. Regarding the overall liking parameter, red lentil slightly reduced the score of crackers, but green and black lentils showed similar scores to the control.

Conclusion

The data obtained in the current study revealed that different colored lentils (especially green and black) had a good potential as a functional ingredient in gluten-free crackers. Lentil crackers showed lower L^* and higher a^* values than those of the control crackers. Lentil varieties did not demonstrate a notable impact on the diameter and thickness of crackers. However, the use of green and black lentil flours reduced the spread ratio of crackers compared to the control and red lentil crackers. All lentil crackers had higher puffiness values than the control. Regarding the sensory perspective, crackers formulated with green and black lentils had comparable scores to the control. Further research should be focused on the nutritional and anti-nutritional characteristics of lentil crackers.

Declarations

Author Contribution Statement

Elif Yaver: Data collection, investigation, formal analysis, conceptualization, methodology, writing the original draft, review and editing.

Conflict of Interest

The author declares no conflict of interest.

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