

# THE EFFECT OF GREEN LENTIL FLOUR ADDITION ON THE SNACK QUALITY\*

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*Original scientific paper*

## Abstract

Enhancing the nutritional quality of plant-based food has become necessary since the research about plant-based nutrition is a trending topic. Legumes such as chickpeas, beans, and lentils are the main components for the fortifying these products. Green lentils are considered a rich source of dietary fibre and protein as well as low in fat. Therefore, it is highly preferred as a meat substitute for consumers. This study determined the influence of green lentil (*Lens culinaris* Medik.) flours (GLF) in snack formulation in terms of nutritional, physical, and sensory analysis. The lentil flour was added to the formula as a replacement of wheat flour with the ratio of 5%, 10% and 20%. According to the total phenolic content analysis results, the nutritional qualities of snacks were improved by adding green lentil flour to the formula. Physical assessment pointed out that the brightness of snacks was slightly affected by enhancement, and the yellowness of samples increased by the addition rate. Furthermore, the sensory analysis pointed out that a 10% addition of GLF into the snack formula had the highest score in terms of overall acceptability. This study showed that GLF addition can improve the quality and acceptability of the snack.

Keywords: *Green lentil flour, snack, sensory, nutrition, food*

## INTRODUCTION

The increasing rates of obesity and chronic diseases, including cardiovascular diseases, diabetes, and cancers, have raised awareness of balanced diets and lifestyle changes. As a result, some modern diets have become prominent among others (Fehér *et al.*, 2020). Plant-based diets and vegan/vegetarian diets have become more popular in recent years due to their positive effects on health. Furthermore, these diets are mostly chosen for their environmentally friendly characteristics since the crops need less land and water, resulting in less air pollution (Ewy *et al.*, 2022). However, the main drawbacks of these diets are their nutritional quality, especially the containment of lower amounts of protein. Proteins are the primary macronutrients crucial for the human body and growth;

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their essential amino acid contents measure their quality and digestibility in the human body (Lopez and Mohiuddin, 2024).

Legumes are the second most important food group after cereals, which contain high amounts of protein, carbohydrates (starch and dietary fibre), minerals and vitamins (Tiwari *et al.*, 2011). Because of those characteristics, they are highly preferred in plant-based diets for developing healthy formulas as an alternative flour substance. Lentils (*Lens culinaris*) are ancient pulses widely consumed worldwide (Khazaei *et al.*, 2019). Research on lentils showed their lowering effect on cholesterol-total lipids, colon cancer, and diabetes in humans owing to dietary fibre and bioactive contents (Roy *et al.*, 2010). Lentils are not only rich in soluble dietary fibre, but they also comprise a high amount of protein (including globulins, albumins, glutelins and prolamins), between 20.6% and 31.4%. They include low amount of sulphur-containing amino acids (Jarpa-Parra, 2018). Besides this, the digestibility is higher in lentils than other plant protein sources and the PDCASS (protein digestibility-corrected amino acid score) and DIASS (digestible indispensable amino acid score) were found to be 50.8 and 0.49, respectively, for green lentils. Due to this nutritional quality, it can be used as a functional ingredient in different formulas such as pasta (Levent *et al.*, 2023), gluten-free biscuits (Di Cairano *et al.*, 2021), gluten-free cookies (Hajas *et al.*, 2022b, Silva-Paz *et al.*, 2024), muffins (Gülhan and Karaça, 2023) and bread (Marchini *et al.*, 2021). Snacks are food, which are consumed small portions, inexpensive and ready-to eat packaged foods. These foods generally assumed as unhealthy because of including multiple processing and food additives (Hess *et al.*, 2016). Therefore, this study assessed the influence of green lentil (*Lens culinaris* Medik.) flour addition in the snack formula by developing the formulation using only plant-based substances. Furthermore, the impact of green lentil flour's replacement ratio on protein ratio also was evaluated.

## MATERIALS AND METHODS

**Materials:** Margarine, wheat flour, baking powder and salt were purchased from a local market in Bayburt Türkiye. Green lentil flour (GLF) was obtained from KB Gurme Gıda (Isparta, Türkiye) and soya lecithin was obtained from Smart Kimya (İzmir, Türkiye).

**Snack Production:** Snacks were produced according to the method Çetin-Babaoğlu *et al.* (2021). The snacks were prepared using wheat flour, green lentil flour, margarine, baking powder, soya lechitin, salt and water. The formulations of snacks are given in Table 1. Green lentil flour was added into the formula as flour replacement with a ratio of 5,10, and 20%. For production, all the ingredients were mixed by using a tilt-head stand mixer (Bosh, Türkiye) until it became a homogenous dough. After this, the dough was sheeted with using a rolling pin. Then the dough shaped with a cookie cutter (35 mm) and prepared doughs were baked in an electric baking oven (Arçelik, Türkiye) at 175°C for 20 min. Then, they were cooled down at room temperature and stored in polyethylene bags in dark conditions at room temperature (Çetin-Babaoğlu *et al.*, 2021). The proximate analysis of raw materials were given by the brand in Table 2. Therefore, no more analysis were applied to determine their nutritional value.

Table 1. Formulation of snacks

Formulations	Control	GLS1 (5%)	GLS2 (10%)	GLS3 (20%)
Wheat flour (%)	100	95	90	80
Green Lentil Flour (GLF) (%)	0	5	10	20
Lecithin (%)	0.3	0.3	0.3	0.3
Salt (%)	2.3	2.3	2.3	2.3
Water (%)	53.3	53.3	53.3	53.3
Margarine (%)	8.67	8.67	8.67	8.67
Baking Powder (%)	2	2	2	2

Table 2. Nutritional value of the wheat flour, green lentil flour and margarin.

Product	Carbohydrate (%)	Protein (%)	Lipid (%)
Wheat Flour	73.8	11.5	1.5
Green Lentil Flour (GLF)	62	24	1
Margarine	0.40	0.40	75

**Proximate analysis:** The moisture, total ash and fat contents of snacks were analysed according to AOAC (1995). The Bradford method was applied for the protein analysis (Moraşan et al. 2022).

**Physical Evaluation of Snacks:** Just after cooling down of the snack for 30 min, the physical properties of samples were evaluated by measuring the diameter, height, and spread ratio with digital calliper. The analysis was performed at room temperature and to determine the spread ratio, the following equation was used.

Spread ratio= Diameter of snacks / Height of snacks (Ho and Pulsawat, 2020).

The colour of snack samples was determined using Hunter Lab Chroma Meter (Minolta CR-400, Osaka, Japan) in terms of the L\* (white; black), a\* (red; green) and b\* (yellow; blue) values of the samples.

**Total Phenolic Content Determination:** Total Phenolic Content Determination: Total phenolic contents (TPC) of snacks were measured according to Zlatanovic *et al.* (2019) by using the Folin Ciocalteu method. For analysis; 100 mg grounded samples were extracted with ethanol-water (1:1, 1400 µL) at ambient temperature for 60 min. After this, mixture was centrifugated at 5000 rpm for 20 min and the supernatants were used

for analysis. Then, 0.25 mL extracts were mixed with of 1.25 mL Folin-Ciocalteu's phenol reagent and left for 6 min for reaction. Then, 1 mL of Na<sub>2</sub>CO<sub>3</sub> solution (75 g/L) was added and left for 2 h at ambient temperature in the dark. After this, the absorbance was measured at 765 nm and the results are determined as mg gallic acid equivalent/g (Zlatanović *et al.*, 2019).

**Sensory Analysis:** The sensory analysis was conducted according to Rajagukguk *et al.* (2022) and the analysis was carried out with 20 untrained panelists (staff and students of the Faculty of Health Sciences, Bayburt University). The sensory characteristics of snacks were evaluated using a 7-point hedonic scale. The fresh snacks samples were presented to pannellist and they assessed the snacks in terms of their appearance, flavour, taste, texture, after taste, and overall acceptability (Rajagukguk *et al.*, 2022).

**Statistical Analysis:** Obtained results were compared by ANOVA including post hoc comparison Tukey's test, at the probability level  $p = 0.05$  using IBM SPSS Version 22 for Windows.

## RESULTS AND DISCUSSION

Results of the proximate analysis are given in Table 3. The differences between samples were not significant statistically in terms of ash, which indicates the importance of the addition ratio. Moisture content ranged found between  $4.94 \pm 0.03$  and  $10.90 \pm 0.11\%$ . Addition of GLF increased the moisture content of samples since dried lentil flour absorbs water more quickly than wheat flour (Nonogaki *et al.*, 2010). As the snack samples were evaluated regarding lipid content, there was a significant difference between samples ( $p < 0.05$ ). The control sample has the highest ratio since green lentil flour includes less lipid than wheat flour. However, the lipid ratio was the smallest for the samples with 5% GLF added, and the lipid proportion slightly increased as the GLF replacement ratio rose in the formulation. Polat *et al.* (2020) reported the similar results even though they found that the ash amount is higher with an increasing ratio of green lentil. The protein ratio increased with the higher in snack formulation ratio of GLF. Although there were no significant differences between GLS2 and GLS3, the protein amount in the control sample was significantly lower than in the fortified samples. Similar results were obtained by Levent *et al.* (2023) for pasta samples and Yaver (2022) for snacks, including GLF and carob flours.

Table 3. Results of proximate analysis of the snacks

Samples	Ash (%)	Moisture (%)	Protein (%)	Lipid (%)
Control	$3.41 \pm 0.05^a$	$4.94 \pm 0.03^c$	$11.04 \pm 0.83^b$	$7.30 \pm 0.35^a$
GLS1	$3.67 \pm 0.08^a$	$10.90 \pm 0.11^a$	$11.58 \pm 0.10^{ab}$	$5.50 \pm 0.15^c$
GLS2	$3.44 \pm 0.04^a$	$10.40 \pm 0.38^{ab}$	$13.80 \pm 0.88^a$	$6.67 \pm 0.03^b$
GLS 3	$3.16 \pm 0.50^a$	$10.26 \pm 0.16^b$	$13.86 \pm 1.52^a$	$6.94 \pm 0.01^{ab}$

\* Different superscript letters (a,b,c) in the same columns indicate significant differences ( $p < 0.05$ ), ( mean $\pm$ standard deviation of triplicate analysis).

The total phenolic content (TPC) of the samples is given in Table 4. The values varied between 0.521 to 0.340 mg GAE/ g, and the differences were obtained as statistically significant. Although the TPC ratio increased with the increasing ratio of GLF in snack formulation, the control sample was still higher than fortified snacks. Previous studies were found to be quite the opposite of the results of this study. Di Stefano *et al.* (2020), Levent *et al.* (2023), Yaver *et al.* (2022), Polat *et al.* (2020) found that the TPC ratio increased with the addition of GLF in the formula (Di Stefano *et al.*, 2020; Levent *et al.*, 2023; Yaver, 2022; Polat *et al.*, 2020).

Table 4. Total phenolic content (TPC) of snacks

Samples	TPC (mg GAE /g snack)
Control	0.521 ± 0.01 <sup>a</sup>
GLS1	0.340 ± 0.01 <sup>c</sup>
GLS2	0.378 ± 0.03 <sup>bc</sup>
GLS 3	0.422 ± 0.00 <sup>b</sup>

\* Different superscript letters (a,b,c) in the same columns indicate significant differences (p<0.05), ( mean±standard deviation of triplicate analysis).

The thickness, weight and spread ratio of fortified samples were found to be between 1.26 and 1.66 cm, 2.76 and 2.93g, and 1.68 and 2.32, respectively. Despite not observing the significant differences between the control and GLS1 in terms of thickness, weight and spread ratio, a significant difference was found between samples GLS2 and GLS3 (p<0.05). Yaver (2022) also stated that both carob flour and green lentil flour did not show any different effect on the thickness, diameter and spread ratio of the enhanced snacks (Yaver, 2022), it can be seen that the spread ratio increased with the increased GLF ratio. A similar situation was observed by Portman *et al.* (2020) and Hajas *et al.* (2022a) as they added lentil flour to the cookie formula (Portman *et al.*, 2020; Hajas *et al.*, 2022a).

Table 5. Physical properties of snacks

Samples	Thickness (cm)	Weight (g)	Spread Ratio
Control	1.66 ± 0.05 <sup>a</sup>	2.80 ± 0.00 <sup>b</sup>	1.68 ± 0.05 <sup>c</sup>
GLS1	1.57 ± 0.05 <sup>a</sup>	2.87 ± 0.05 <sup>ab</sup>	1.83 ± 0.09 <sup>bc</sup>
GLS2	1.26 ± 0.05 <sup>c</sup>	2.93 ± 0.05 <sup>a</sup>	2.32 ± 0.15 <sup>a</sup>
GLS 3	1.41 ± 0.02 <sup>b</sup>	2.76 ± 0.05 <sup>b</sup>	1.95 ± 0.04 <sup>b</sup>

\* Different superscript letters (a,b,c) in the same columns indicate significant differences (p<0.05), ( mean±standard deviation of triplicate analysis).

The colour of the snack samples and the GLF were analysed with a Hunter colourimeter, and the results are shown in Table 6, the image of the samples was given in Figure 1. As it was seen from the figure 1, the surface colours were very similar for all analysed

samples. However, the measurements were performed by grounding the samples. Thus, the colour of the inner part was also taken into account.



Figure 1. Image of the snack samples

The brightness of samples indicated that the addition of GLF into the formula increased the brightness, and the differences between samples were significant ( $p < 0.05$ ). Although the wheat flour used for snack production was refined, the brightness of GLF was also higher, which was reflected in the  $L^*$  value. The  $a^*$  values ranged between 0.21 and 5.24, with significant differences between all samples. The most yellowness was found for the GLF, and the highest was recorded as a control sample. Hajas *et al.* (2022a) and Oskaybaş-Emlek *et al.* (2021) found that the brightness was decreased by increasing of GLF replacement ratio (Hajas *et al.*, 2022a; Oskaybaş-Emlek *et al.*, 2021). However, both studies examined the effect of GLF on cookies; but the lower brightness was obtained probably because of the high sugar content in the formulation, which might lead to more caramelisation. Therefore, the brightness of the cookies was observed to be darker than in this study.

Table 6. Colour properties of the snacks

Sample	$L^*$	$a^*$	$b^*$
(GLF)	$87.05 \pm 0.02^a$	$0.21 \pm 0.01^e$	$23.76 \pm 0.04^d$
Control	$77.98 \pm 0.09^c$	$5.24 \pm 0.02^a$	$27.67 \pm 0.14^b$
GLS1	$81.14 \pm 0.01^b$	$2.99 \pm 0.01^d$	$25.29 \pm 0.61^c$
GLS2	$79.51 \pm 0.09^c$	$3.98 \pm 0.05^c$	$27.37 \pm 0.34^b$
GLS 3	$78.82 \pm 0.02^d$	$4.51 \pm 0.01^b$	$29.20 \pm 0.13^a$

\* Different superscript letters (a,b,c) in the same columns indicate significant differences ( $p < 0.05$ ), ( mean $\pm$ standard deviation of triplicate analysis).

The sensory analysis was performed to determine the potential consumer acceptability of the snacks on a small scale, and the data are given in Figure 2. The data did not vary considerably from each other ( $p < 0.05$ ). Except for texture scores, other sensory parameters such as appearance, flavour, taste, after taste and overall acceptability showed that these fortified snacks had potential positive responses from the consumer. Since the average hedonic scale was found to be around 5, it can be considered that the snacks were liked slightly. According to overall acceptability, GLS2 had the highest

score among samples as well as taste and after taste. This sample had also the highest spread ratio. The lowest overall acceptability was noticed in the GLS1, which had the lowest scores for taste and texture, the darkest colour, the lowest fat and phenolic compounds content and the highest moisture content. Because of that the GLS2 and the GLS1 could be considered as the most preferable and the least preferable samples. On the hand, Yaver (2022) stated that overall acceptability had been found for the least added GLF in the snack formulation with carob flour.

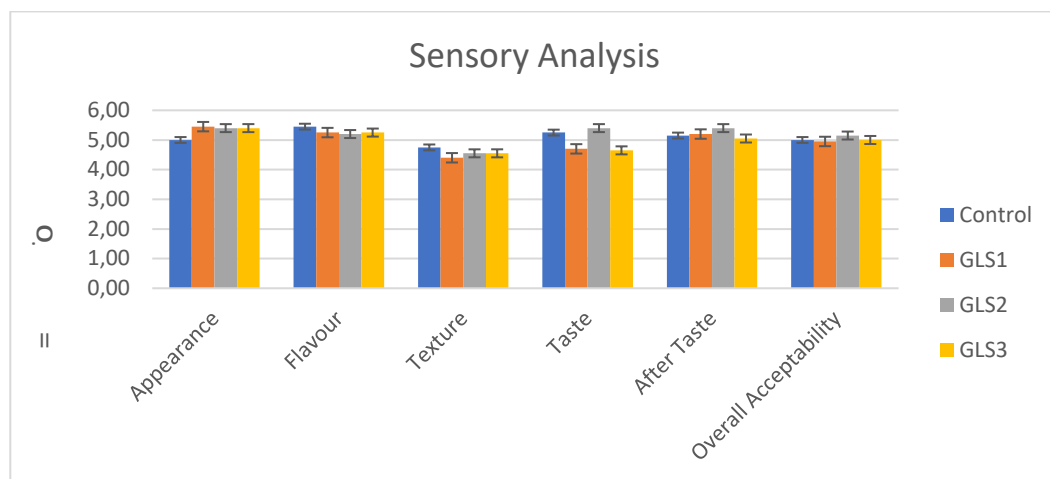


Figure 2. Sensory analysis results of snacks

## CONCLUSION

In conclusion, this study showed that GLF can be used as a fortification and functional agent for plant-based snack products. However, to improve the protein ratio, the replacement ratio needs to be increased, but an increased ratio of GLF might lead to unwanted lentil flavour and might negatively affect the dough systems. Therefore, the formulations can be improved for future studies to enhance the formulation and sensory scores.

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## UTJECAJ ADITIVA SERVOMYCES® NA KVASCE RAZLIČITIH GENERACIJA TIJEKOM VRENJA PIVA

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Izvorni znanstveni rad – *Original scientific paper*

### Rezime

Pivo se procesom alkoholnog vrenja proizvodi iz slada, hmelja, vode i pivskog kvasca. U proizvodnji piva koriste se odabrani sojevi pivskog kvasca vrste *Saccharomyces uvarum* za tzv. lager piva (piva donjeg vrenja), dok se za proizvodnju ale piva (piva gornjeg vrenja) koristi vrsta *Saccharomyces cerevisiae*, a mogu se koristiti i različiti hibridi tih kvasaca. U toku vrenja kvasac razlaže šećere iz sladovine na alkohol i CO<sub>2</sub>. Proizvodi njegova metabolizma su i nusproizvodi kao što su vicinalni diketoni koji značajno utječu na aromu i kvalitetu piva. Posebna se pažnja posvećuje procesu propagacije kvasca. Servomyces® jedan je od aditiva koji je proizveden kao dodatak za potrebe pivarske industrije. Cilj ovoga rada bio je utvrditi učinak na kvasce 1., 2. i 3. generacije, te utvrditi eventualne razlike između piva kojemu je pri kraju procesa kuhanja dodan aditiv Servomyces®, u odnosu na pivo koje je proizvedeno standardnim postupkom. U tu svrhu, tijekom procesa vrenja praćeni su prividni ekstrakt i koncentracija vicinalnih diketona, a na kraju vrenja izmjeran je stupanj prevrelosti i postotak mrtvih stanica kvasca. Redukcija vicinalnih diketona se pratila 6 - 9 dana nakon završetka vrenja. Utvrđeno je da je redukcija vicinalnih diketona brža uz dodatak Servomycesa®, te da je udio prividnog ekstrakta ustaljen nakon šestog dana. Broj mrtvih stanica kvasca bio je manji u kvascu s dodatkom Servomycesa®. Stupanj prevrelosti bio je znatno niži u uzorcima kojima je dodan Servomyces®.

Ključne riječi: *pivo, kvasac, aditivi, vicinalni diketoni, vrenje*

### UVOD

Pivo je osvježavajuće gazirano piće s malim udjelom alkohola. U proizvodnji piva velika se pažnja posvećuje kvascu koji se koristi za naciepljivanje pivske sladovine. Koriste se odabrani sojevi vrste *Saccharomyces uvarum* i *Saccharomyces cerevisiae* (Marić i Navodnik, 1995). U toku vrenja kvasac razlaže šećere iz sladovine na alkohol i CO<sub>2</sub>. Kvasac tijekom uzgoja proizvodi i druge spojeve osim CO<sub>2</sub> i etanola, primjerice

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