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Research Article/Araştırma Makalesi

Investigation of the effects of red, green and black lentil flours on the physicochemical and technological quality of pasta

Kırmızı, yeşil ve siyah mercimek unlarının makarnanın fizikokimyasal ve teknolojik özellikleri üzerine etkilerinin araştırılması

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ABSTRACT

In this study, red lentil flour (RLF), green lentil flour (GLF) and black lentil flour (BLF) replaced wheat semolina at different (0-10%) ratios in pasta formulation. The effect of lentil types and levels of lentil flour supplementation on the physicochemical, textural characteristics and cooking quality of pasta were investigated. It was determined that BLF had the highest ash, crude fat and phytic acid contents, whereas GLF had the highest antioxidant activity (AA) and total phenolic content (TPC) among lentil varieties. The use of GLF in pasta production resulted in higher brightness ($L*$) and RLF resulted in higher redness ($a*$) and yellowness ($b*$) values. The increase in lentil flour ratio in the formulation caused the weight increase and volume increase values to decrease from 200.04% and 238.59% to 174.92% and 222.28%, respectively. Pasta samples containing GLF revealed a higher firmness value than those containing RLF and BLF. It was determined that the cooking loss value was higher in the samples containing 10% lentil flour compared to the control. The use of lentil flour in the formulation improved the pasta samples in terms of protein, ash, TPC, AA, Ca, Mg, Zn and Fe. The results show that nutritionally enriched pasta can be produced with acceptable technological quality by adding up to 10% of GLF and BLF. The successful results show that RLF can be used at rates higher than 10% in pasta production.

Key Words: Pasta, red lentil, green lentil, black lentil

ÖZ

Bu çalışmada, makarna formülasyonunda buğday irmiği ile kırmızı mercimek unu (RLF), yeşil mercimek unu (GLF) ve siyah mercimek unu (BLF) farklı oranlarda (0-10%) ikame edilmiştir. Mercimek çeşitlerinin ve mercimek unu katkı oranlarının makarnanın fizikokimyasal, tekstürel özellikleri ve pişme kalitesine etkisi araştırılmıştır. Mercimek çeşitleri arasında en yüksek kül, ham yağ ve fitik asit içeriğine BLF'nin, en yüksek antioksidan aktiviteye (AA) ve toplam fenolik madde içeriğine (TPC) ise GLF'nin sahip olduğu belirlenmiştir. Makarna üretiminde GLF kullanımı daha yüksek parlaklık ($L*$) ve RLF ise daha yüksek kırmızılık ($a*$) ve sarılık ($b*$) değerleri vermiştir. Formülasyondaki mercimek unu oranının artması ağırlık artışı ve hacim artışı değerlerinin sırasıyla %200.04 ve %238.59'dan %174.92 ve %222.28'e düşmesine neden olmuştur. GLF içeren makarna örnekleri, RLF ve BLF içeren makarnalara göre daha yüksek sertlik değeri ortaya koymuştur. %10 mercimek unu içeren örneklerde pişme kaybı değerinin kontrole göre daha yüksek olduğu belirlenmiştir. Formülasyonda mercimek unu kullanılması makarna örneklerini protein, kül, TPC, AA, Ca, Mg, Zn ve Fe açısından iyileştirmiştir. Sonuçlar, besinsel açısından zenginleştirilmiş makarnanın, %10'a kadar GLF ve BLF eklenerek kabul edilebilir teknolojik kalitede üretilebileceğini göstermektedir. Elde edilen başarılı sonuçlar RLF'nin makarna üretiminde %10'dan daha yüksek oranlarda kullanılabileceğini göstermektedir.

Anahtar Kelimeler: Makarna, kırmızı mercimek, yeşil mercimek, siyah mercimek

Introduction

Pasta is frequently preferred by people of all ages and walks of life due to its long shelf life, low cost, and ease of preparation (Melini et al., 2020). It also contributes to long-term satiety due to its lower glycemic index than bread (Atkinson et al., 2008), its compact structure, and slower digestion than other starchy foods. Wheat pasta is usually produced from refined flour/semolina, which is rich in carbohydrates and low in micronutrients, phytochemicals, and dietary fiber (Dziki, 2021). It has been recognized as a good vehicle for fortification by the FDA (Food and Drug Administration) and the WHO (World Health Organization) (Chillo et al., 2008). Recently, pasta has been the subject of many food fortification strategies to improve its functional properties and nutritional value (Dziki, 2021).

Nowadays, consumers are making changes in their eating habits due to the increase in health awareness, and the advantages of a diet rich in plant-based foods and low in animal foods, both to the body and to the environment (Messia et al., 2021). Legumes have an important place in human nutrition with low fat, high protein, dietary fiber, and micronutrient content (Sánchez-Chino et al., 2015). Legume proteins provide integrity in terms of essential amino acid balance when used with cereals (Singh and Singh, 1992). Also, legumes and products are good vitamin and mineral sources. Recently, the demand for legumes has increased, because more people, such as vegans, vegetarians or flexitarians, are looking for alternative animal protein sources (Dogan et al. 2013; Pedrosa et al. 2021). Legumes represent a component in the development of healthy diets for humans and sustainable for the environment, because they are friendly to the planet with their low water and carbon footprint (Boukid et al. 2019; Messia et al. 2021).

Lentils, peas, chickpeas, and beans are among the most consumed legumes worldwide (Boukid et al. 2019). Among legumes, the relatively short cooking times of lentils provide an additional advantage. Lentil has advantages for producers such as having high tolerance to extreme environmental conditions such as drought and high temperatures and being able to be grown without irrigation in semi-arid regions (Yadav et al. 2007). Lentils can be found in yellow, orange, green, red, brown, or black colors according to their type, seed coat, and cotyledon composition (Xu et al., 2010). It has the highest protein content after soybeans (Kamboj and Nanda, 2018). Lentils contain phytochemicals and various bioactive compounds along with protein, carbohydrates, dietary fiber, minerals, and vitamins (Rebello et al., 2014). Studies show that lentils contain much higher concentrations of phenolics (760 mg GAE/100 g) compared to other legumes, and this high polyphenolic content of lentils and excellent nutritional composition may contribute to their high antioxidant, anti-obesity, antidiabetic, anticancer and anti-inflammatory properties (Mo’ez Al-Islam, 2020; Romano et al.,2021). These nutrient contents positively affect the quality of the foods to which it is added (Migliozzi et al., 2015).

There is no report in the literature comparing the use of red lentil, green lentil, and black lentil flour in pasta quality. The aim of this research is 1) to assess the effect of three lentil species on the physicochemical, textural characteristics, and cooking quality of pasta 2) to determine the effects of lentil type and lentil flour ratio on pasta quality 3) to develop a new functional pasta formulation with improved nutritional quality.

Material and Method

Materials

Wheat semolina was kindly supplied by Golda A.Ş., Karaman, Turkiye. Red lentils and green lentils were procured from local supermarkets in Karaman, Turkiye. Red lentils and green lentils were milled with a lab grinder (MKM600, Bosch, <500 µm) and used as whole flour. Black lentil flour was obtained from Ingro Gıda Bilişim Pazarlama, Karaman, Turkiye.

Preparation of pasta samples

Pasta preparation was done according to the method stated by Ajila et al., (2010). A control sample was prepared with wheat semolina (100%) and for pasta samples containing lentil flour, red, green and black lentil flour replaced wheat semolina by 5 and 10%, separately. While preparing the pasta, the ratio of wheat semolina to water was adjusted to be approximately semolina (1000 g): water (300 ml). The moisture content of the wheat semolina+lentil flour mixture was determined by preliminary trials to produce a visually optimal dough before extrusion. A pasta machine (La Monferrina, Dolly, Italy) was used for production. To prepare the pasta, 1500 g wheat semolina was mixed with 500 ml of warm water in the rotary shaft mixer of the pilot pasta machine for 10 min until the semolina was hydrated with water. Then the mixture was extruded and cut using a pasta mold (penne). The dried samples were packaged in polypropylene bags and stored at room temperature (approximately 25-27°C) for further analysis.

Color measurements

Minolta CR-400 (Konica Minolta, Japan) device was used to determine the color values. Color readings are expressed as *L** (brightness/whiteness), *a** (redness/greenness), and *b** (yellowness/blueness). The saturation index (*SI*, vividness of color) and *hue angle* were calculated using the equations below (Francis, 1998).

$SI=(a^{*2}+b^{*2})^{1/2}$ (Eq. 1)

$Hue = \text{Arctan}\ [b^*\ a^{*-1}]) + 180$ where $a<0$ and $b>0$ (Eq. 2)

$\text{Hue} = \text{Arctan}\ [b^*\ a^{*-1}]$ where $a>0$ and $b>0$ (Eq. 3)

Chemical analysis

The moisture (method 44-19), ash (method 08-01), crude protein (method 46-12) and crude fat (method 30-25) contents of the wheat semolina, flours and pastas containing lentil flours (0%, 5% and 10) were quantified according to AACC (1990). Mineral content was assessed with ICP-OES (Agilent 720, USA) using the method used by Levent et al., (2020). The colorimetric method was used for phytic acid analysis. In this method, the sample extraction was performed by using 0.2 N HCL, and then the extract was precipitated with a ferric solution in a test tube. After heating in a boiling water bath for 30 min, and cooling in ice water for 15 min, 2.2' bipyridine solution was added and the absorbance was read at 519 nm (Haug et al., 1983).

The colorimetric method and Folin-Ciocalteu reagent were used for TPC determination. The samples were extracted with 10 ml of solution consisting of a mixture of hydrochloric acid, methanol, and distilled water at a ratio of 1/8/1 (v/v), respectively, for 2 hours at room temperature (Beta et al., 2005; Gao et al., 2002). After centrifugation at 3000 rpm for 10 minutes, the extract (0.1 ml) was mixed with Folin-Ciocaltaeu reagent (0.5 ml, 10% diluted, v/v, water) and sodium carbonate solution (1.5 ml, 20%, w/v) and distilled water (to make up to 10 ml) in a test tube. After 2 hours in a dark place, the absorbance was read at 760 nm with a spectrophotometer (Shimadzu UV1800, Japan).

The antioxidant activities (AA) of the wheat semolina, lentil flours, and pasta were assayed as described previously by Beta et al., (2005) and Gyamfi et al., (1999). For analysis, samples were extracted according to the method used in TPC analysis. Absorbance values at 517 nm in the spectrophotometer were read at the beginning of the treatment with DPPH and after 30 minutes. AA was determined as percent inhibition according to the following equation.

$\text{Inhibition }\% = (1 - [(\text{A of sample}_{t=30})\ (\text{A of control}_{t=0})^{-1}]) \times 100$ (Eq. 4)

Cooking properties of pasta samples

Twenty grams of pasta samples were cooked in 250 ml of boiling distilled water for the optimum cooking time. The optimum cooking time was determined by squeezing the pasta samples taken from boiling water at different times between two glass slides until the white central core disappeared (Özkaya and Kahveci, 1990; Sobota et al., 2015). After cooking, the samples were drained for 2 min. Weight increase % (WI) was calculated based on the pre -and post-cooking weights of the samples. For the volume increase (VI) values, the dry and cooked samples were placed in a graduated cylinder filled with water and the amount of overflowing water was determined and the VI values were obtained from the volume of dry and cooked pasta samples. To determine the cooking loss (CL) value, the cooking waters were evaporated to a constant weight in the oven (KD-200, Nüve, Ankara, Turkey) at 135°C and the residue was weighed to determine the CL value as a percentage of the pasta weight before cooking.

Statistical analysis

The results obtained were statistically analyzed with a computer package program (SPSS, Version 22.0). Data were subjected to analysis of variance and means were compared using the Duncan multiple range test. $P<0.05$ was considered as statistically significant.

Results and Discussion

Raw material properties

The physical and chemical analysis results of wheat semolina, RLF, GLF, and BLF used in pasta formulation are given in Table 1. Wheat semolina presented higher *L** and lower *a** values than lentil types. RLF has higher *a**, *b**, and *SI* values than GLF and BLF. The moisture content of the raw materials varied between 86.0 g kg^{-1} and 127.7 g kg^{-1}, and the highest value was observed in wheat semolina. Ash contents of raw materials ranged between 7.5-42.6 g kg^{-1}. Among the lentil varieties, BLF had the highest ash content. Crude protein and fat contents of raw materials were found in the range of 124.8-267.9 g kg^{-1} and 6.8-13.8 g kg^{-1}, respectively. The chemical analysis results of raw materials are generally in agreement with previous studies reported by Rizzello et al. (2014), Piergiovanni (2021), and Yaghtini et al., (2021). RLF and BLF had significantly higher amounts of crude fat had significantly higher amounts of crude fat than wheat semolina. Lentil varieties had 1.89-2.15 times more crude protein content than wheat semolina. Bhatty (1988) reported that lentils are an excellent source of protein and amino acids that complement the amino acid pattern of cereal proteins. Due to its high protein content and reasonable price, lentils are defined as “poor man’s meat” (Samaranayaka, 2017). Lentil varieties revealed significantly higher TPC and AA values (1.54-3.03 g GAE kg^{-1}, 21.27-45.80%) than wheat semolina (0.5978 g GAE kg^{-1}, 12.80%) and GLF had the highest TPC and AA values among the raw materials. Xu and Chang (2008) reported that lentils had the highest total phenolic content and antioxidant capacity compared to chickpeas, yellow peas and green peas. Lentils contain phenolic compounds such as phenolic acids, flavonols, stilbenes, flavones, flavanones anthocyanidins and proanthocyanidins (Alshikh et al. 2015; Paranavitana et al., 2021). They have been reported to have many biological effects, including antioxidant activity (Kähkönen et al. 1999). The phytic acid content of wheat semolina, RLF, GLF, and BLF was found as 1.87 g kg^{-1}, 13.70 g kg^{-1}, 14.65 g kg^{-1} and 14.87 g kg^{-1}, respectively. Reddy et al., (1982) reported that the amount of phytic acid in cereals excluding polished rice ranged from 0.50 to 1.89 % (w/w), from 0.40 to 2.06% (w/w) in legumes, from 2.00 to 5.20% (w/w) in oilseeds excluding peanuts and soybeans evaluated in legumes.

Table 1. Color values and chemical properties of raw materials[1]

	Wheat semolina	Red lentil flour	Green lentil flour	Black lentil flour
Color				
*L**	88.76±0.28[a]	79.11±0.34[b]	80.23±0.30[b]	72.10±0.42[c]
*a**	-1.71±0.08[c]	16.03±0.11[a]	-0.50±0.06[b]	-2.24±0.08[d]
*b**	23.56±0.16[c]	34.44±0.27[a]	24.77±0.30[c]	19.03±0.35[d]
SI	23.62±0.40[b]	37.99±0.17[a]	24.78±0.30[b]	19.16±0.35[c]
Hue	94.15±0.28[b]	65.04±0.40[d]	91.16±0.21[c]	96.71±0.14[a]
Moisture (g kg^{-1})	127.7±2.5[a]	86.0±1.6[c]	99.8±1.0[b]	94.6±1.8[b]
Ash (g kg^{-1})	7.5±0.7[c]	19.4±0.6[b]	21.1±0.4[b]	42.6±0.8[a]
Crude protein (g kg^{-1})	124.8±2.1[c]	264.2±1.0[a]	236.0±2.8[b]	267.9±2.7[a]
Crude fat (g kg^{-1})	6.8±0.8[c]	10.4±0.6[b]	7.3±1.0[c]	13.8±0.4[a]
TPC (g GAE kg^{-1})[2]	0.598±0.01[d]	1.54±0.01[c]	3.03±0.01[a]	2.53±0.01[b]
AA (Inhibition%)[3]	12.80±0.28[d]	21.27±0.30[c]	45.80±0.65[a]	38.55±0.21[b]
Phytic acid (g kg^{-1})	1.87±0.03[d]	13.70±0.07[c]	14.65±0.04[b]	14.87±0.07[a]
Minerals (g kg^{-1})				
Ca	0.26±0.006[d]	1.35±0.003[a]	1.28±0.003[b]	1.20±0.002[c]
Fe	0.016±0.0008[c]	0.066±0.001[b]	0.064±0.001[b]	0.081±0.001[a]
Mg	0.29±0.002[d]	0.95±0.002[b]	0.88±0.001[c]	1.05±0.001[a]
Mn	0.015±0.0006[ab]	0.016±0.0004[ab]	0.014±0.001[b]	0.0175±0.0007[a]
Zn	0.017±0.0008[c]	0.034±0.0003[b]	0.0311±0.001[b]	0.053±0.0006[a]

[1]Means followed by the different letters within a raw are significantly different (P<0.05). Based on dry matter (except moisture). [2]TPC: Total phenolic content. [3]AA: Antioxidant activity.

As expected all lentil varieties had higher Fe, Ca, Zn, and Mg content than wheat semolina. Among the raw materials, Mg, Fe, and Zn content of BLF were found to be richer. Iqbal et al., (2006) studied the composition of chickpeas, lentils, cowpeas and peas and reported that all four legumes were better suppliers of mineral substances, particularly K, P, Ca, Cu, Fe, and Zn. The accumulation of mineral elements in plants varies depending on soil characteristics, cultivation and fertilization system, climate, as well as plant characteristics (Juknevicius and Sabiene, 2007).

Color measurement results of pasta

Color values of pasta samples were discussed according to two main factors (lentil type and lentil flour ratio) (Table 2). According to the lentil type factor, the highest *L** value was obtained in the pasta samples containing GLF. The lowest *L**, *b**, and *SI* values were determined in pasta containing BLF, while pasta samples containing RLF had the highest *a**, *b** and *SI* values. According to the raw material analysis results, RLF had the highest *a**, *b** and *SI* values among the raw materials (Table 1). The color characteristics of the raw material may affect the color of the pasta. Bae et al., (2016) reported that in noodles enriched with red lentil flour, as the amount of red lentil powder increased, the *L* value of the noodles decreased and the *a* and *b* values increased. In the study conducted by Teterycz et al., (2020) green pea, red lentil and grass pea flours were included in the pasta formulation and it was reported that all legume flours affected the color of the pasta and the most intense color was obtained with red lentil flour. It was determined that the most suitable coloring component in all examined legume flours was red lentil flour (Figure 1).

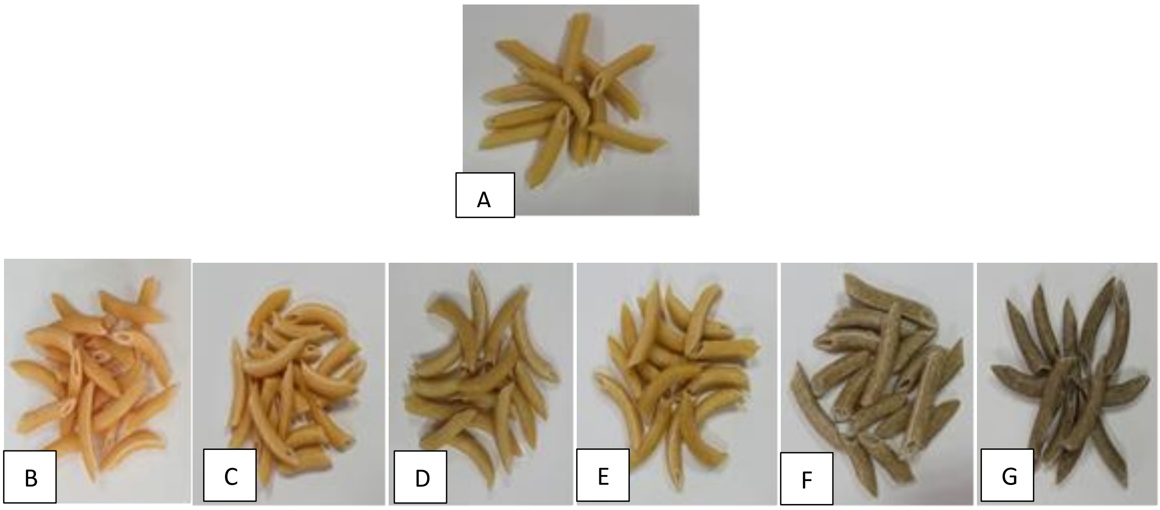

Figure 1: Pasta samples prepared with red lentil flour (RLF), green lentil flour (GLF), and black lentil flour (BLF) (A:Control, B: 5% RLF, C: 10% RLF, D: 5% GLF, E: 10% GLF, F: 5% BLF, G: 10% BLF)

Table 2. Color values of pasta samples[1]

	n	*L**	*a**	*b**	*SI*	*Hue*
Lentil type						
RLF	6	82.55±1.76[b]	2.94±3.39[a]	22.41±1.76[a]	22.82±1.61[a]	82.21±8.52[b]
GLF	6	83.75±0.61[a]	-0.41±0.60[b]	21.67±2.28[b]	21.60±2.20[b]	90.92±1.35[a]
BLF	6	79.24±5.21[c]	-0.37±0.74[b]	18.68±4.52[c]	18.65±4.47[c]	90.79±2.08[a]
Lentil flour ratio (%)						
0	6	84.47±0.31[a]	-1.17±0.06[a]	24.47±0.28[a]	24.40±0.17[a]	92.68±0.26[a]
5	6	82.09±1.65[b]	1.03±2.11[b]	19.32±2.0[b]	19.44±2.09[b]	87.24±5.89[b]
10	6	78.97±4.75[c]	2.29±3.08[a]	18.95±3.34[b]	19.24±3.67[b]	84.00±7.59[c]

[1]Means followed by the different letter within a column are significantly different (P<0.05). RLF: Red lentil flour, GLF: Green lentil flour, BLF:Black lentil flour.

The increased lentil flour ratio in the formulation significantly decreased the *L** and Hue values and increased the *a** values of pasta samples (p<0.05). The *b** and *SI* values of pasta samples containing lentil flour (5 and 10%) were lower than the control, but they were not significantly different from each other. For good pasta quality, a translucent bright yellow colored smooth surface is preferred. Carotenoid pigments in durum wheat semolina give the desired yellow color intensity on the pasta surface (Demir and Bilgiçli, 2020). The use of the increasing ratio of lentil flour in the formulation caused dilution of yellow pigment from semolina and loss of yellow color in pasta samples.

Cooking quality of pasta samples

The cooking properties of pasta samples are shown in Table 3. According to the lentil type factor, WI, VI, and CL values of pasta samples varied in the range of 181.60-190.94%, 218.72-246.06%, and 6.58-6.60%, respectively. Control pasta had the highest WI values (200.04%) followed by pasta containing 5% lentil flour (186.72%) and pasta containing 10% lentil flour (174.92%), respectively. In a study conducted by Bahnassey and Khan, (1986) pasta samples were prepared by supplementing semolina with navy, pinto, and lentil flours and their protein concentrates, and a decrease was observed in the cooked weights of fortified samples as the fortification level increased. Similar results were also reported by Doxastakis et. Al., (2007). This effect may be due to the weakening of the gluten matrix by the addition of gluten-free legume flours (Teterycz et al., 2020).

Table 3. Cooking properties and firmness values of pasta samples[1]

	n	Weight increase (%)	Volume increase (%)	Cooking loss (%)	Firmness (g)
Lentil type					
RLF	6	181.60±15.97[b]	243.71±10.44[a]	6.58±0.19[a]	248.71±19.99[b]
GLF	6	189.13±9.40[a]	218.72±24.75[b]	6.60±0.26[a]	303.17±96.72[a]
BLF	6	190.94±8.96[a]	246.06±8.99[a]	6.58±0.24[a]	257.78±21.26[b]
Lentil flour ratio (%)					
0	6	200.04±1.72[a]	238.59±2.05[b]	6.41±0.12[b]	236.79±12.62[b]
5	6	186.72±6.51[b]	247.62±14.77[a]	6.57±0.15[ab]	247.94±12.10[b]
10	6	174.92±7.61[c]	222.28±27.12[c]	6.78±0.20[a]	324.94±80.09[a]

[1]Means followed by the different letters within a column are significantly different (P<0.05). RLF: Red lentil flour, GLF: Green lentil flour, BLF: Black lentil flour.

The use of different lentil varieties in pasta production did not cause a significant difference between CL values (p>0.05). The lowest WI and VI values were obtained at a 10% lentil ratio. CL value was determined as 6.41% in the control sample that did not contain any type of lentil flour. This result is in agreement with Manthey and Schorno (2002) who reported that the CL value in pasta made from semolina was around 6.5%. Increasing the lentil flour ratio in the pasta formulation increased the CL value and a higher CL value (6.78%) was obtained in the highest lentil flour ratio (10%) compared to the control. A similar trend was also observed by Zhao et al., (2005) who used milled flours of lentil, chickpea, yellow pea, and green pea (5-30%) in spaghetti production. They reported that CL increased with the increase in the legume flour ratio in the formulation.

Gluten can form a protein network, which is responsible for the low CL value and good textural properties in wheat pasta (Laleg et al., 2017; Matsuo and Irvine, 1970). The use of non-gluten flours in pasta formulation diluted the gluten strength and weakened the structure of the product. This may cause more solids from the pasta samples to seep into the cooking water, resulting in higher cooking loss (Rayas-Duarte et al., 1996). Legume proteins (albumins and globulins) do not form an elastic network like durum wheat proteins (gliadins and glutenins) (Rosa-Sibakov et al., 2016). Pasta cooking quality is determined by the physical competition between protein coagulation into continuous network (I) and starch swelling (II) during cooking. If the first (I) predominates, starch particles are retained in the network causing the cooked pasta to increase in firmness, while if the second (II) predominates, the protein coagulates into discrete masses devoid of a continuous framework, starch granules swell easily and some of the starchy material passes into the cooking water and the pasta exhibits softness and often stickiness (Marti and Pagani, 2013; Resmini and Pagani, 1983). In addition, the use of legume flour in the form of whole flour and its higher ash content than semolina may weaken the gluten network and increase dry matter losses (Table 1) (Teterycz et al., 2020).

The firmness values of the pasta samples containing red, green, and black lentil flour were determined as 248.71 g, 303.17 g, and 257.78 g, respectively (Table 3). As the lentil flour ratio increased in the pasta formulation, the firmness values increased partially, and a higher firmness value was obtained at the 10% lentil flour ratio. Bahnassey and Khan (1986) and Zhao et al. (2005) found similar results. They reported that the use of legume flours (navy, pinto, green pea, yellow pea, chickpea, and lentil) and protein concentrates in pasta formulation caused an increase in firmness values. Also, it was reported that firmness values of fortified pasta samples increased with the level of fortification. Similarly, in a study by Teterycz et al. (2020), it was determined that preparation of the pasta with 15-20% red lentil flour and 5-15% green pea flour increased the firmness values, significantly.

Chemical characteristics of pasta samples

Moisture, ash, crude protein and crude fat and crude protein contents of pasta samples containing red, green, and black lentil flours were found in the range of 8.0-9.3 g kg^{-1}, 8.1-9.6 g kg^{-1}, 132.8-133.4 g kg^{-1} and 8.2-9.1 g kg^{-1}, respectively (Table, 4). In the samples containing 10% lentil flour in the formulation, there was an increase of 21.5%, 8.4%, 10.9%, 39.3%, and 24.8% in ash, fat, protein, TPC, and AA values, respectively, compared to the samples without lentil flour in the formulation. Bayomy and Alamri (2022) reported that fortification of durum wheat flour with yellow lentil flour (25%) increased the protein, crude fat, and ash content of the control sample from 12.79%, 2.62%, and 1.47% to 15.84%, 3.21%, and 1.93%, respectively. In a study by Bae et al., (2016) red lentil powder was used (15-45%) in the noodle formulation and it was reported that the antioxidative activities of the noodles increased significantly as the red lentil powder ratio increased ($p<0.05$).

There was no significant difference between moisture, crude protein, and crude fat contents of pasta samples according to lentil type ($p>0.05$). Higher ash and phytic acid values were determined in pasta samples prepared using BLF compared to those containing RLF and GLF. According to the raw material analysis results, it was determined that the ash and phytic acid content of BLF was more remarkable than other lentil varieties (Table 1). From these results, it can be said that raw material properties are reflected in the final product.

Table 4. Chemical properties of pasta samples[1]

	n	Moisture (g kg^{-1})	Ash (g kg^{-1})	Crude protein (g kg^{-1})	Crude fat (g kg^{-1})	Phytic acid (g kg^{-1})	TPC[2] (g GAE kg^{-1})	AA Inhibition(%)[3]
Lentil type								
RLF	6	8.0±1.2[a]	8.1±0.5[b]	132.8±5.8[a]	8.6±0.7[a]	1.92±0.54[b]	0.689±0.007[c]	15.59±1.10[c]
GLF	6	8.2±1.3[a]	8.3±0.5[b]	133.4±6.6[a]	8.2±0.5[a]	2.02±0.65[b]	0.800±0.166[a]	17.23±2.37[a]
BLF	6	9.3±2.3[a]	9.6±1.6[a]	133.0±7.7[a]	9.1±0.8[a]	2.16±0.74[a]	0.705±0.082[b]	16.41±1.56[b]
Lentil flour ratio (%)								
0	6	7.5±1.1[a]	7.9±0.3[b]	126.2±2.9[c]	8.3±0.5[a]	1.34±0.06[c]	0.608±0.007[c]	14.38±0.27[c]
5	6	8.4±1.6[a]	8.4±0.7[b]	133.0±2.2[b]	8.6±0.7[a]	1.97±0.11[b]	0.739±0.065[b]	16.90±1.11[b]
10	6	9.6±1.8[a]	9.6±1.6[a]	140.0±3.0[a]	9.0±1.0[a]	2.78±0.22[a]	0.847±0.099[a]	17.95±1.21[a]

[1]Means followed by the different letters within a column are significantly different ($P<0.05$). Chemical properties except moisture are based on dry matter. RLF: Red lentil flour, GLF: Green lentil flour, BLF: Black lentil flour, [2]TPC: Total phenolic content, [3]AA: Antioxidant activity.

Phytic acid forms a complex with minerals such as Ca, Cu, Fe, Mg, and Zn, which are necessary for human nutrition and reduces their bioavailability (Bilgiçli, 2002). Therefore, phytic acid is considered as an antinutrient. For all that, phytic acid has positive effects on health such as having an antioxidant, and anti-cancerous effect, lowering serum cholesterol and triglyceride, reduction of apoptosis, and preventing foodborne pathogens (Kumar et al., 2021). With the use of lentil flours in pasta formulation, it was determined that the amounts of all minerals (except Mn) examined in pasta samples increased significantly ($p<0.05$). It can be said that the increase in the amount of minerals with the use of lentil flour can compensate for the undesirable effects of phytic acid.

The AA and TPC values of pasta samples varied from 15.59% to 17.23% and from 0.689 g GAE kg^{-1} to 0.800 g GAE kg^{-1}, respectively. Pasta samples containing GLF presented the highest TPC and AA, followed by pasta samples containing BLF and RLF. In legumes, total phenolic compounds are mostly found in the seed coats, so seeds with more color pigments within each species have higher contents than their pale or white-coated counterparts (Piergiovanni, 2021). In a study by Durazzo et al. (2013), the highest TPC and antioxidant capacities measured by means of FRAP were obtained with green lentils in both aqueous-organic extract and residue when compared to red lentils, chickpeas and sweet chestnuts. A recent study by Paranavitana et al. (2021) found that both black and green lentils were found to have potent antioxidant properties, as determined by in vitro antioxidant activity and radical scavenging capacity assays. Xu et al. (2007) studied the phenolic compounds and antioxidant activities of legumes (peas, lentils, beans, soybeans, and chickpea) produced in the USA and reported that lentils had the highest phenolic compounds concentrations and antioxidant activities. In addition, antioxidant activities measured with DPPH, FRAP and ORAC methods were highly correlated (r =0.94, 0.96, and 0.89, respectively) with TPC ($p<0.01$).

Table 5 represents the mineral contents of pasta containing lentil flour. Pasta prepared with RLF revealed higher Ca content than BLF, while those containing BLF revealed higher Fe content. The substitution of lentil flour in the pasta formulation at a 10% ratio, resulted in 1.26-, 1.29-, 1.29-, and 1.15-fold increases in the amounts of Ca, Fe, Mg, and Zn, respectively. According to the lentil flour ratio, the increase in the amount of Mn was not found significant ($p>0.05$). Kaya et al. (2018) used pea, lentil, and faba bean hulls in noodle formulation. It was reported that a general trend of increasing Mg and Ca contents of noodles was observed with legume hull substitution. Göncü and Çelik (2020) used red, green and yellow lentil whole flour in tarhana formulation and reported that the K, Zn and Cu content of samples increased significantly ($p<0.05$) compared to control tarhana prepared with wheat flour.

Table 5. Mineral contents of pasta samples (g kg^{-1})[1]

	n	Ca	Fe	Mg	Mn	Zn
Lentil type						
RLF	6	0.41±0.05^{a}	0.018±0.002^{b}	0.0028±0.00032^{a}	0.0114±0.0003^{a}	0.0155±0.0008^{a}
GLF	6	0.40±0.04^{ab}	0.019±0.002^{ab}	0.0027±0.00025^{a}	0.0110±0.0003^{a}	0.0152±0.0010^{a}
BLF	6	0.40±0.04^{b}	0.021±0.003^{a}	0.0028±0.00034^{a}	0.0113±0.0006^{a}	0.0166±0.0018^{a}
Lentil flour ratio (%)						
0	6	35.83±0.24^{c}	0.017±0.0008^{b}	0.0024±0.0007^{c}	0.0111±0.0004^{a}	0.0147±0.0005^{b}
5	6	40.37±0.61^{b}	0.019±0.0011^{b}	0.0027±0.007^{b}	0.0112±0.0004^{a}	0.0158±0.0012^{ab}
10	6	45.06±1.0^{a}	0.022±0.0024^{a}	0.0031±0.01^{a}	0.0114±0.0005^{a}	0.0169±0.0013^{a}

[1]Means followed by the different letters within a column are significantly different ($P<0.05$). RLF: Red lentil flour, GLF: Green lentil flour, BLF: Black lentil flour.

Conclusion

In this study, lentil flours (red, green, and black) were used at different ratios (0-10%) in pasta formulation. While the highest *L** value was obtained in the pasta containing GLF, the *L** and *Hue* values of the pasta samples decreased as the lentil flour ratio increased. The use of GLF in the pasta formulation revealed a lower volume increase and higher firmness values compared to other pasta samples. The highest firmness value was obtained at the highest usage ratio of lentil flour. Lentil flours (10%) significantly increased crude protein, ash, AA, TPC, Ca, Fe, Mg, and Zn content of pasta samples ($p<0.05$). Pasta containing GLF had the highest AA and TPC values among pasta samples. When the physicochemical, textural properties and cooking quality of uncooked and cooked pasta samples were evaluated together, it was concluded that GLF and BLF could be used up to 10% in pasta production and that usage ratios higher than 10% of RLF should be investigated. The results showed that the use of lentil flour in pasta production will be of great importance as it meets our nutritional needs more without significantly affecting its technological properties.

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