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The effect of soy flour and carob flour addition on the physicochemical, quality, and sensory properties of pasta formulations

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Abstract

In the present study, soy flour (SF) and carob flour (CF) were used as a substitute for wheat flour (WF) in 6 different pasta formulations. The effect of SF and CF on the quality properties of the enriched pasta formulations was investigated. With the increase in SF and CF, ash, protein, dietary fiber content of the pasta increased whereas moisture, fat, and carbohydrate contents decreased. With the increase in CF, a significant decrease was observed in the $L*$ (brightness) value and an increase in $b*$ value with an addition of SF. The addition of SF and CF reduced the amount of substance passed to the water, improving the quality of the pasta. According to the results of sensory analysis, the highest values in terms of the overall evaluation were determined in the D (80 WF: 0 SF: 20 CF) and the E (80 WF: 20 SF: 0 CF) samples, and it was determined that up to 20% SF and CF can be recommended. According to the study results, it was thought that SF and CF can be used as functional food additives in different food formulations to improve the functional and nutritional properties of food products.

Keywords: Pasta, Carob Flour, Soy Flour, Total Dietary Fiber, Functional Food

Introduction

Pasta, which is known and loved in every part of the world, is a cereal-based food produced from durum wheat (Cárdenas-Hernández et al., 2016; Tazrart et al., 2016). Pasta is an economical product, easy to prepare with a long shelf-life, and due to its nutritional properties, especially for low glycemic index (GI), it is a source of carbohydrates consumed by all ages (Bernard, 1988; Petitot et al. 2009). Pasta contains 11-15% protein, and low levels of lysine and threonine (Abdel-Aal and Hucl, 2002). Pasta quality is related to the quality of wheat used, the pasta production process, and the amount and the quality of protein effective during cooking (Feillet and Dexter, 1996; Del Nobile et al., 2005). Pasta is high in starch whereas low in dietary fiber, minerals, vitamins, and phenolic compounds (Gull et al., 2018). The growing demand for healthy foods has increased researchers and food manufacturers' interest in developing pasta products rich in minerals, vitamins, dietary fiber, and with a low glycemic index. In studies carried out to increase the nutritional value of pasta, different functional components, color pigments, high protein, and dietary fiber sources were added to the formulations (Nilusha et al., 2019; Menon et al., 2012; Bustos et al., 2013; Kaur et al., 2012; Adegunwa et al., 2012). In new functional pasta products enriched with bioactive compounds, vegetables (bean flour, sweet potato flour), fruits (carrot powder, apple peel powder, grape powder, green banana flour), legume flours (chickpea flour, fava protein), plant seeds (quinoa flour, amarant flour) (Goñi and Valentín-Gamazo, 2003; Zandonadi et al., 2012; Ginting and Yulifianti, 2015; Torres et al. 2007; Laleg et al., 2017; Bouasla et al., 2017; Lorusso et al. 2017),

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enriched durum wheat, cereal bran, cereal flours (wheat, rice, barley, oats) (Hussein et al., 2011; Kaur et al., 2012; Fuad and Prabhasankar, 2012; Fiorda et al., 2013; Chanu and Jena, 2015), for high protein content; milk and dairy products, whey protein, egg white powder, fish protein concentrates, etc. (Nielsen et al., 1980; Devi et al., 2013; Cappa and Alamprese, 2017; Xie et al., 2020) were used and the vitamin, mineral, essential amino acid, fatty acid and antioxidant contents of the pasta were enriched.

Soybean (*Glycine max* L.) is a plant species belonging to the *Leguminosae* family and is one of the legume products that are economically important and widely consumed worldwide (Vagadia et al., 2017). Soybean seeds contain over 40% protein, 30-35% carbohydrates, 20% fat, and it is rich in terms of dietary fiber sources, vitamins (A, B, C, and D), minerals (Ca, P), and unsaturated fatty acids (linoleic acid) (Nishinari et al., 2014; Ma et al., 2019; Rani et al., 2019; Mohajan, et al., 2018; Wang et al., 2004). It has been reported that soy protein has good components in reducing the risk of cardiovascular diseases, lowering cholesterol, in addition to having emulsifying, gelling, water, and oil holding capacity (Nishinari et al., 2014; Wietrzyk et al., 2005). Soybean and its products are used as additives, emulsifiers, vegetable oil sources, product-enrichers in the food industry and are also used as pulp in animal nutrition and as industrial substances in the manufacturing industry (Liu, 2004). Soy products, isoflavones, linolenic acid, also known as omega-3 fatty acids, and dietary fiber content are very important functional food components (Riaz, 2006; Nilüfer and Boyacıoğlu, 2008; Liu, 2004). Soy and soy products are an important source of nutrients and are preferred for increasing the nutritional and health properties of foods in product enrichment due to their seed's high content of soy protein, cholesterol-lowering properties, phytoestrogen properties, and also for reducing the risk of heart diseases and their positive effects on calcium metabolism (Jones, 2002; Wylie-Rosett et al., 2002; Garcia et al., 1997; Roccia et al., 2009; Shih et al., 2015; Zhang et al., 2020). There are studies on different cereal products in which soybean flour is used as a source of protein, dietary fiber, antioxidant, and polyphenol. It has been reported that soy flour is used in many foods including healthy drinks, soup, biscuit, bread, pasta, etc. to provide nutritional supplements and to extend the shelf-life (Mohajan et al., 2018). Several studies have been reported on the determination of the cooking properties and sensory acceptability of spaghetti, the use of soy flour with rice flour (Sereewat et al., 2015), determination of the sensory and nutritional composition properties of spaghetti enriched with soy flour (Shogren et al., 2006), effect on nutritional properties (Park et al., 2015), the effect of germinated, steamed and roasted soy flour on the physicochemical and sensory properties of bread (Shin et al., 2013), determination of structural and quality characteristics of soy-enriched functional noodles (Rani et al., 2019), lean soy flour, the effect of other flour ingredients on the quality properties of pasta (Jalgaonkar et al., 2018), lean soy flour enriched biscuits (Serrem et al., 2011; Singh et al., 2000), the use of soy flour in gluten-free bread making (Ribotta et al., 2004), use of soybean meal as a source of protein in trout feed (Bilgüven, 2006).

Carob (*Ceratonia siliqua* L.), a perennial plant belonging to the *Leguminosae* family grows widely in the Mediterranean countries (Durazzo et al., 2014). Fruit and peels of the plant are used as raw materials in different branches of the industry. It has been reported that carob is of importance for health in terms of cholesterol-lowering, blood sugar level regulating, and antimicrobial and antioxidant properties. (Chait et al., 2020; Ruiz-Roso et al., 2010; Kumazawa et al., 2002). Its milled flour form and seeds are used as a flavoring, stabilizer, thickener, and cocoa substitute in various food products (Seczyk et al., 2016; Durazzo et al., 2014; Bengoechea et al., 2008; Fadel et al., 2006; Hajaji et al., 2011). Carob flour is rich in dietary fiber, roasted in different degrees, and used in products. Carob flour attracts attention with its low-fat content, high carbohydrate, dietary fiber content (39.80%), and phenolic content (Román et al., 2017; Ortega et al., 2011). Carob flour was used for enrichment in different grain-based products. Various studies were carried out on various subjects including gluten-free bread (Tsatsaragkou et al., 2014), wheat bread enriched with lentil or carob flour (Turfani et al., 2017), pasta enriched with carob flour for improving antioxidant properties (Seczyk et al., 2016), soy and banana flour substituted cake where carob flour was substituted with cocoa (Rosa et al., 2015), pasta enriched with carob fiber (Biernacka et al., 2017), the effect of carob flour on gluten-free cakes and cookies (Roman et al., 2017), and the effect of carob powder on the sensory and physicochemical properties of the muffins (Pawlowska et al., 2018).

The present study aimed to develop pasta formulations enriched with protein-rich soy flour and dietary fiber-rich carob flour. Accordingly, pasta was produced using six different formulations (WF: SF: CF mixtures) and some physicochemical properties (moisture, ash, protein, fat, total dietary fiber, acidity, carbohydrate, energy, and color properties), quality properties (cooking properties) and sensory properties were determined in the pasta produced using these mixtures.

Materials and Method

Material

In the present study, soy flour was obtained from Doğasan Ltd. (Ankara) while carob flour was obtained from Global Gıda-Haşhaşcızade (Afyonkarahisar). Wheat flour was obtained from Bandırma Has Un (Toru Un) Factory and salt was obtained from local markets. Moisture, ash, fat, protein, titratable acidity, and total dietary fiber values in durum wheat flour (WF) were determined to be 14.8%, 1.15%, 2.04%, 13.9%, 0.03%, 2.93%, respectively. The durum wheat flour farinograph analysis was carried out at the Bandırma Toru Flour factory to determine the water-holding properties. In soy flour (SF) and carob flour (CF), moisture, ash, oil, protein, titratable acidity and total dietary fiber values were SF: 7.04%, 7.61%, 2.04%, 59.16%, 0.36%, 18.38%, CF: 7.57%, 3.09%, 0.31%, 6.03%, 0.27%, 32.87%, respectively.

Pasta Production

In the production of home-type pasta, laboratory-type pasta dough forming machine was used to prepare and shape the pasta dough. The formulations used in pasta production are given, respectively: (A: 100 WF: 0 SF: 0 CF), (B: 90 WF: 5 SF: 5 CF), (C: 80 WF: 10 SF: 10 CF), (D: 80 WF: 0 SF: 20 CF), (E: 80 WF: 20 SF: 0 CF), (F: 60 WF: 20 SF: 20 CF).

According to six different formulations to be used in pasta production, mixtures of durum wheat flour (WF), soy flour (SF), and carob flour (CF) (WF: SF: CF) were formed. Also, 0.5% salt was added to the mixtures. An average of 50-55 ml of water was added to the mixture at the rate determined by farinograph (Brabender, Germany) preliminary tests (ICC, 1992) according to the water holding capacity of the flour and the mixture was kneaded for10 minutes. After kneading, the dough was left to rest for 30 minutes. The pasta was passed through a thinning roller to be shaped as spaghetti (Ampia Machine, Italy). Spaghetti-shaped pasta was dried in the oven (Binder) at 50-55 ^{o}C for 5-6 hours. After the moisture content of the pasta samples decreased to 11%, they were preserved in polyethylene packages until they were analyzed. Pasta samples were passed through a grinder (IKA A 11 Basic) and prepared for analysis.

Physicochemical Analyses

In pasta samples, moisture (AACC Method No: 44-15A), ash (AACC Method No: 08-01), protein (using the Kjeldahl method AACC Method No: 46-11A (AACC, 1990), fat (using the Soxhlet system, AACC Method No: 30-25.01) were made according to AACC (1990). Titratable acidity (in terms of acetic acid) AACC Method No. was determined according to 02-31 (AACC, 2000).

The total dietary fiber amount was determined enzymatically (with alpha-amylase, amyloglucosidase, and protease enzymes) by the AOAC 985.29 method. Velp raw cellulose analyzer was used in the filtration processes. (Anonymous, 2007).

Carbohydrate and energy values in pasta samples were determined according to FAO (2003) (Anonymous 2003). It was calculated using the Atwater general factor system. It was calculated by the formula given below (the relevant model is given in Equations 1 and 2).

$$Carbohydrate\ \% = 100- (Moisture\% + Ash\% + Protein\% + Fat\%)\ (1)$$

$$Energy\ (kcal) = (9 \times Fat\%) + (4 \times Protein\%) + 4 \times (Carbohydrate\% - Dietary\ Fiber\%)\ (2)$$

The colors of pasta samples were determined by using the Minolta CM 3600d model color measurement device. In the triple scale consisting of CIE Color Values (L^*, a^*, b^*) L^*=100 was evaluated as white, L^*=0 as black; high positive a^* as red, high negative a^* as green; high positive b^* as yellow, and high negative b^* as blue.

Quality Analyses

Pasta samples were examined in terms of cooking quality, optimum cooking time, the amount of substance passing to the water (cooking loss-CL), weight gain (water absorption-WA), and volume expansion (VE).

The optimum cooking time of pasta samples was determined according to AACC (2000). Cooked pasta samples obtained from the analysis of "cooking duration" were filtered and weighed. The weight value of the same amount of uncooked pasta was subtracted from the weight value of cooked pasta and the difference after cooking was determined as % (AACC, 2000). Similar to the weight gain, the water level in cooked and uncooked pasta during the applied processes was determined using the formula for determining the percentile overrun in the water level (AACC, 2000). 250 ml distilled water was placed in a 400 ml beaker and boiled. Then 10 g pasta sample was added and cooked. The filtrate obtained at the end of cooking was placed in glass Petri dishes which were previously tared at a fixed weight. The sample was kept at 98 ^{0}C for 24 hours in an oven. It was then transferred to a desiccator, cooled, and weighed. It was calculated according to the formulation and stated in %. (AACC, 2000).

Sensory Analyses

The sensory analysis of pasta was carried out by 20 panelists aged 21-60. All the sensory evaluations were carried out using a 1-5 hedonic scale (5 points) by Aydın (2009) with modifications, on a tasting form containing the sensory quality criteria of the pasta samples (5 points: Very Good, 4 Points: Good, 3 Points: Acceptable, 2 Points: Non-satisfactory, 1 Point: Poor). The sorting test was applied to evaluate the appreciation and acceptability of the pasta containing soy flour and carob flour. In the evaluation of sensory properties of cooked pasta samples, the evaluations were carried out in terms of color, odor, aroma, appearance, flavor, hardness, stickiness, chewiness, mouthfeel, and overall acceptability. Statistical analyzes were carried out by taking the average of the scores given by each panelist for different pasta formulations.

Statistical Analysis

As a substitute to wheat flour in pasta production, carob and soy flour were added in different proportions in 6 different formulations and all the analyzes were carried out in 3 replications. The data obtained as a result of the analyzes were statistically analyzed using the SAS Enterprise 5.1 software and the differences from the addition of carob flour and soy flour to pasta were evaluated. Significant differences in mean values, the LSD (Least Significant Difference) test was used to determine the statistical difference between the mean values ($P<0.05$).

Result and Discussion

Physicochemical properties of pasta formulations

The effect of the addition of soy flour (SF) and carob flour (CF) at different ratios to durum wheat flour (WF) flour on some chemical properties of pasta formulations is given in

Table 1a and Table 1b. Compared to the control samples, a significant decrease (P <0.05) was observed in the moisture content of the pasta whereas a significant increase was observed in the ash values of the samples due to the increase in the soy flour and carob flour ratio in the formulations. The highest ash value was determined in the F example in which SF and CF were substituted with WF in equal ratios (60 WF: 20 SF: 20 CF) with 3.41% (P <0.05). The highest ash values in pasta containing SF and CF positively affect the mineral content (Baysal, 2009). Similar results were reported in the studies on wheat bread with added chickpea flour (Sabanis et al., 2006), wheat bread with lentil, and carob flour (Turfani, 2017).

The fat value determined in the C example in which SF and CF were substituted with WF at equal ratios (80 WF: 10 SF: 10 CF) was found to be significantly higher than those of other samples (P <0.05). In the E sample in which only SF was used as the additive (80 WF: 20 SF: 0 CF), protein value (25.56%) was statistically higher (P<0.05) compared to that of the control sample. This was associated with the fact that the amount of soy protein (53.16%) in soy flour was quite high. Similar study results were found in studies on enriching different foods with soy protein and soy flour (Tang et al., 2006; Li et al., 2013; Rinaldoni et al., 2014; Lamacchia et al., 2010; Limroongreungrat and Huang, 2007; Baiano et al., 2011). In a study, in which 25-35-50%soybean flour was added in pasta production, it has been reported that the protein values of pasta increased (Shogren et al., 2006). In pasta studies with different legume flours, when working with pea flour, bean flour, and bean flour, an increase in protein amounts were observed, similar to that determined in the present study (Petitot et al., 2010). Soy flour addition to wheat flour has been reported to increase the protein content and digestibility of biscuit (Vitali et al., 2009).

There were no statistically significant differences between the titratable acidity of the pasta samples (P> 0.05). The highest carbohydrate value was determined in the D (80 WF: 0 SF: 20 CF) sample whereas the lowest was determined in the E (80 WF: 20 SF: 0 CF) sample, and the differences were statistically significant (P <0.05). When only CF (the D sample) was used in the flour mixture and as the additive rate increases, fat and energy values decrease compared to the control sample whereas acidity, total carbohydrate, ash, and total dietary fiber values (TDF) increased. In the formulation in which SF was solely used (the E sample), ash, protein, total dietary fiber increased whereas fat, total carbohydrates, and energy values decreased significantly. In the F sample in which SF and CF were used equally at 20% (60 WF: 20 SF: 20 CF), compared to the control sample, moisture, fat total carbohydrate, and energy values decreased whereas ash, protein, total dietary fiber values increased significantly (P<0.05). Similar to the present study, it has been reported that the dietary fiber value increased whereas the energy value decreased significantly compared to the control sample in pasta samples in which carob fruit pulp flour was added at 5%, 7.5%, or 10% ratios (Umay, 2019).

Dietary fibers are the edible parts of plants that can be partially or completely fermented in the large intestine by resisting digestion in the small intestine and defined as carbohydrate polymers consisting of components with many health benefits including hemicellulose, cellulose, lignin, pectin, gums, etc. (Dülger and Sahan, 2011; Jakobek and Matic, 2019; Li et al., 2017). According to Table 1b, CF and SF additions were found to cause a significant increase in TDF values compared to the control sample. The highest TDF value was determined in the F (60 WF: 20 SF: 20 CF) sample. Since SF (TDF:18.38% and CF (TDF: 32.87%) additions were rich in TDF, TDF values increased in the pasta samples. Evaluating the results in terms of energy values, all formulations were found to be significantly lower than the control sample. Production of formulations with high total dietary fiber and low fat resulted in a decrease in energy values, and therefore, a healthier product. Zunft et al. (2003) have reported that carob pulp with high water-insoluble fiber decreased the amount of LDL (serum cholesterol) in humans and the consumption of functional foods prepared with this fiber will be effective in the treatment of diseases. Ortega et al. (2011) have reported that the soluble nutrient fibers in carob flour increase the biological acceptability of phenols. Sebecic et al. (2007), in the study examining the dietary fiber content of biscuits enriched with different flour additives, carob flour has been reported to yield the highest TDF value by increasing the TDF value of biscuits by 42%. Similarly, some studies use the gum of the carob seed to increase the dietary fiber ratio in bread (Ktenioudaki and Gallagher, 2012).

Color properties are one of the important factors affecting consumer preferences (Mamat et al., 2010). The color values of the pasta samples are given in Table 2. Pasta formulations (SF and CF ratios) were found to have a significant (P<0.05) effect on the color values. The highest L* brightness value was in the control sample containing only wheat flour (*L**: 68.71), followed by the E sample containing 20% SF (*L**: 60.56). The *L* * (brightness) value (37.11) of the F formulation prepared with the addition of 20% CF showed a significantly lower value (P<0.05) than those of the other samples. The unique dark color of the CF ad an effect on this result. It has been reported that roasted carob flour yielded a darker color value than cocoa color (Yousif and Alghzawi, 2000). Also, it has been stated that as the amount of protein and ash increases in food products, the *L** value decreases (Feillet et al., 2000). With the increase in SF, a significant decrease was observed in the *L** (brightness) value, and the darkening of the color was observed whereas yellow color was dominant due to the significant increase in *b** value with an increase in SF addition. Increasing the ratio of CF and SF in the pasta samples increases *a** (redness) values significantly (P <0.05). In *b* *, which is another color property of pasta, E formulation containing 20% SF yielded the highest *b** value (*b**: 20.00). Sereewat et al. (2015) have reported that using 15% non-fat soy flour in the production of rice pasta where they used lean soy flour, *a** and *b** values increased whereas *L** value decreased (62.3-49.6). It has been reported that the increase in protein and ash decreases the *L** value (Feillet et al., 2000). Similar results were obtained in the present study.

Table 1a. The effect of soy flour and carob flour addition on some chemical properties of pasta formulations*

Sample	Formulation	Moisture (%)	Ash (%)	Fat (%)	Protein (%)
A	100 WF: 0 SF: 0 CF	11.50±0.5[a]	1.71±0.24[e]	0.41±0.01[b]	18.98±0.11[d]
B	90 WF: 5 SF: 5 CF	10.05±0.35[b]	2.24±0.28[d]	0.39±0.01[c]	19.51±0.07[d]
C	80 WF: 10 SF: 10 CF	10.35±0.21[b]	2.66±0.02[c]	0.55±0.01[a]	21.37±0.50[c]
D	80 WF: 0 SF: 20 CF	10.00±0.00[b]	2.14±0.01[d]	0.34±0.01[d]	14.71±0.13[e]
E	80 WF: 20 SF: 0 CF	9.70±0.40[b]	3.08±0.01[b]	0.09±0.01[f]	25.56±0.40[a]
F	60 WF: 20 SF: 20 CF	8.94±0.13[c]	3.41±0.03[a]	0.10±0.01[e]	24.01±0.10[b]
Min-Max		8.94-11.50	1.71-3.41	0.09-0.55	14.71-25.56

*Calculated using the dry matter value.
* The mean values indicated with different letters in the same column are significantly different (P <0.05).

Table 1b. The effect of soy flour and carob flour addition on some chemical properties of pasta formulations*

Sample	Formulation	Titratable acidity (TA)	Total Carbohydrates (%)	Total Diet Fiber (%)	Energy (kcal)
A	100 WF: 0 SF: 0 CF	0.02±0.00[a]	69.97±0.16[b]	2.74±0.18[e]	339.61±1.64[a]
B	90 WF: 5 SF: 5 CF	0.09±0.55[a]	69.99±0.25[b]	5.40±0.42[d]	332.07±0.17[a]
C	80 WF: 10 SF: 10 CF	0.09±0.01[a]	67.65±0.28[c]	9.28±0.09[b]	314.59±0.57[b]
D	80 WF: 0 SF: 20 CF	0.12±0.01[a]	74.50±0.12[a]	9.35±0.97[b]	316.58±3.90[b]
E	80 WF: 20 SF: 0 CF	0.12±0.02[a]	64.35±0.70[e]	7.45±0.34[c]	320.75±3.03[b]
F	60 WF: 20 SF: 20 CF	0.18±0.01[a]	65.92±0.18[d]	11.09±0.15[a]	313.84±7.38[b]
Min-Max		0.02-0.18	64.35-74.50	2.74-11.09	313.84-339.61

*Calculated using the dry matter value.
* The mean values indicated with different letters in the same column are significantly different (P <0.05).

Table 2. The effect of soy flour and carob flour addition on the color properties of pasta formulations*

Sample	Formulation	*L**	*a**	*b**
A	100 WF: 0 SF: 0 CF	68.71±1.18[a]	-0.57±0.13[d]	17.95±0.14[b]
B	90 WF: 5 SF: 5 CF	54.02±1.40[c]	4.6±0.42[b]	16.42±0.42[c]
C	80 WF: 10 SF: 10 CF	39.16±1.47[e]	7.61±0.20[a]	17.01±0.13[c]
D	80 WF: 0 SF: 20 CF	42.73±1.38[d]	7.30±0.12[a]	17.92±0.36[b]
E	80 WF: 20 SF: 0 CF	60.56±0.25[b]	2.66±0.25[c]	20.00±0.84[a]
F	60 WF: 20 SF: 20 CF	37.11±1.08[e]	7.30±0.48[a]	16.73±0.31[c]
Min-Max		37.11-68.71	-0.57-7.61	16.42-20.00

* The mean values indicated with different letters in the same column are significantly different (P<0.05).

Cooking properties of pasta formulations

The effect of soy flour and carob flour addition on the cooking quality characteristics of pasta formulations is given in Table 3. The water absorption (WA), volume expansion (VE), and the amount of the substance passing to the water (CL) were found to be significantly higher (P <0.05) in the control sample compared to other samples. Similar to the present study, it has been reported that as the additive ratio increased in pasta samples produced with different leguminous flours such as broad bean flour and pea flour, water holding capacity increased (Petitot et al., 2010). In a study in which carob fiber and pea fiber were used in bread production, fiber addition changed the water absorption values and the highest water absorption capacity was determined in the samples containing pea fiber and carob fiber (Wang et al. 2002). Cooking weight values in the present study were similar to those reported by Grant et al. (2004) for pasta (284% -305%) and to those by Edwards et al. (1993) for weight gain in cooked pasta (261% -280%). Hotsa (2012) in noodle samples with 30% pea flour and 30% chickpea flour additions have reported the amount of substance passing to water, water absorption, VE values as 8.70-10.63%, 169.26-181.66%, and 140-190%, respectively. In the present study, CL values were found lower, whereas VE and WA values were higher. Examining the level of substances passing to the water values, this value was found higher in the control sample compared to other samples. The addition of SF and CF to pasta formulations has increased the quality by decreasing the amount of substance passing to the water. Cook loss <6 = good; 6-8 = moderate; > 10 = poor pasta quality (Hummel, 1966; AACC, 2000).

Table 3. The effect of soy flour and carob flour addition on the cooking properties of pasta formulations*

Sample	Water absorption (WA) (%)	Volume expansion (VE) (%)	Optimum Cooking Time (Min.)	Cooking loss (CL) (%)
A	281.62±1.91[a]	368.63±0.18[a]	7	11.15±0.21[a]
B	223.10±0.10[b]	275.30±0.42[c]	7	5.40±0.03[b]
C	223.75 ±0.20[b]	275.15±0.21[c]	7	3.50±0.28[d]
D	218.50±0.28[c]	275.45±0.65[c]	7	5.38±0.20[b]
E	212.30±0.42[d]	300.20±0.28[b]	7	3.15±0.35[d]
F	183.25±0.4[e]	275.25±0.35[c]	6	4.31±0.27[c]
Min-Max	183.25-281.62	275.15-368.63	6-7	3.15-11.15

* The mean values indicated with different letters in the same column are significantly different (P<0.05).

Sensory properties of pasta formulations

Cooked pasta formulations with the addition of SF and CF are given in Figure 1 and the sensory properties of cooked pasta formulations are given in Figure 2 with a radar chart. Cooked pasta samples were evaluated by sensory analysis by 20 panelists. Evaluating the overall sensory analysis results, significant differences (P <0.05) were observed in the sensory properties of the pasta compared to the control sample. The most favored sample in terms of aroma and odor was the D sample with 20% CF addition while the most favored sample in terms of appearance was the E sample with 20% SF addition, which received the closest score of the control group (P <0.05). Mouthfeel score of SF and CF-added pasta formulations were determined to be higher compared to the control sample, and the highest score was in the F sample. The highest values in terms of overall evaluation scores were observed in pasta formulations D (4.80) and E (4.75) (P <0.05). The panelists gave higher sensory scores to the samples containing 20% sole soy flour or carob. All SF and CF-added formulations received scores 4 and above in terms of overall acceptability scores and were found to be acceptable in terms of aroma and taste. Similar to the present study, according to the results of sensory analysis, there are studies in which 20% carob flour addition was recommended in biscuits and the carob fiber improves the sensory properties of pasta (Aydın, 2012; Sęczyk et al., 2016). It has been reported that the soybean flour also changed the acceptable additive value ratios between 10-15% in terms of the sensory properties of products such as bread and biscuits (Islam et al., 2007; Awasthi et al., 2012; Taghdir et al., 2017).

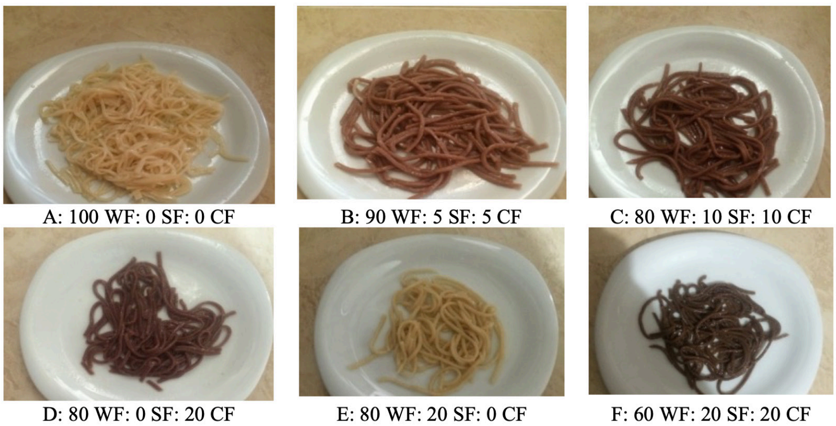

Figure 1. Cooked pasta formulations containing SF and CF

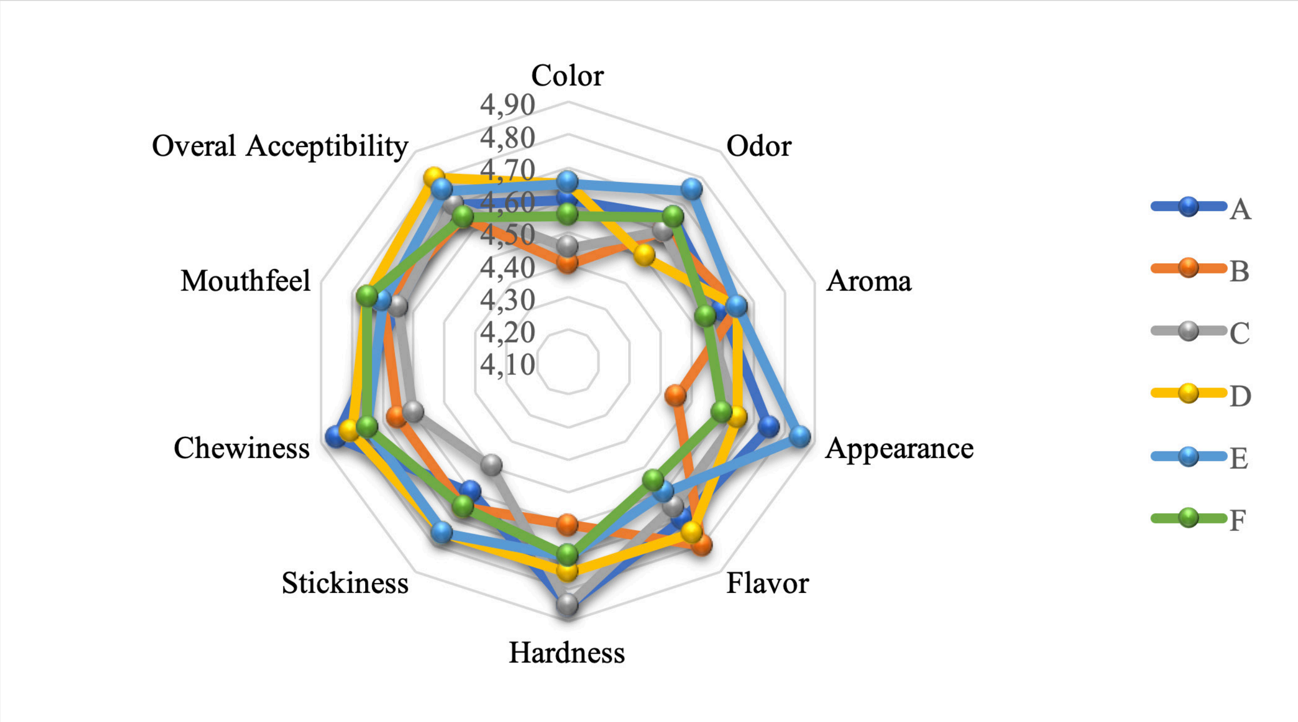

Figure 2. The effect of SF and CF addition on the sensory properties of pasta formulations

Conclusion

In the present study, physicochemical properties, cooking properties, and sensory properties of the pasta containing SF and CF at different substitution rates to wheat flour, and it was determined that the addition of SF and CF increased protein, ash, total dietary fiber whereas decreased the energy values. Functional pasta formulations with low fat and calorie content and high fiber and protein content were produced. According to the results obtained, the use of both additives has reduced the amount of the substance passing to the water and positively affected the cooking quality. There was a significant decrease in L^* (brightness) value of the pasta formulations in the samples with higher CF addition ratios. The dominant dark color of CF compared to CF has affected the color values of pasta formulations. According to the results of sensory analysis, the pasta formulations scored 4 and above in terms of the overall evaluation were the pasta formulations with 20% CF (D) and 20% SF (E), 10% CF + 10% SF (C) and these samples yielded the highest values, respectively. According to the sensory analysis results, it can be suggested that CF and SF can be evaluated by adding appropriately up to 20% in pasta as a substitute for wheat flour. Evaluating the results in general, carob flour, and soy flour with functional and nutritious properties can be evaluated in the food industry in the development of new and healthy food formulations as an alternative functional component.

Compliance with Ethical Standards

Conflict of interest

The authors declare that for this article they have no actual, potential, or perceived conflict of interests.

Author contribution

Dilek Dülger Altıner contributed as the thesis supervisor in conducting analyzes, statistical analyses of data, writing the article, and writing-review-proofreading-publishing procedures. The Master's thesis student Şeyma Hallaç carried out the preparation of samples, analyses, reporting, and writing and correction of literature sources. The authors have read and approved the final version of the article. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Not applicable.

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Data availability

Not applicable.

Consent for publication

Not applicable.

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