

Effect of whole grain flours on the overall quality characteristics of mulberry pestil

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Abstract

This research aimed to determine the effects of the structural ingredients (starch, wheat flour, wheat bran and whole grain flours from oat, barley, rye and wheat) on the physical, chemical and sensorial properties of the mulberry pestil. Effects of structural ingredients and their levels were statistically significant on colour values, total dry matter, ash, pH and titratable acidity, total soluble solids, total phenolic content and sensorial evaluation results ($P < 0.01$) of pestil samples. The characteristics of mulberry pestils ranged from 7.26 to 8.53 brix for total soluble solids, 90.23–92.67% total dry matter, 2.09–3.23% ash (in dry weight), 5.67–5.81 pH, 0.40–0.73% titratable acidity. The highest total phenolic contents were determined in samples containing whole oat flour and whole barley flour, while the lowest values were determined in samples containing starch. The L^* values of the pestil samples increased with increasing barley flour and starch content whereas L^* values decreased in the pestil samples containing wheat flour, whole rye flour, whole wheat flour, whole oat flour and wheat bran. The highest a^* and b^* values were measured in samples containing 9% level of starch, and the lowest a^* and b^* colour values were determined in samples containing 9% level of wheat bran. According to the sensorial evaluation results, the pestil samples produced with oat flour were generally more appreciated by panelists.

Keywords: mulberry leather (pestil), starch, wheat bran, whole grain flour

1. Introduction

Traditional foods are foods that have been consumed by people all over the world since ancient times. They are mostly local products that express the culture, history and lifestyle of societies and reflect the cultural heritage and affect current eating patterns. Many of the traditional foods may have significant health characteristics. For this reason, the nutritional quality of these products should be improved (Trichopoulou *et al.*, 2007).

Pestil is among important traditional foods produced and consumed in many regions of Turkey (Suna *et al.*, 2014). Many fruits, such as mulberry, grape, apple, carob and apricot are used in pestil production. Pestil is produced in different ways using different materials and some pestil types are produced by using concentrated fruit juice

(mulberry syrup), starch/wheat flour and sugar in Turkey (Yıldız, 2013). In addition to these ingredients, honey and milk may also be added to pestil. In the traditional pestil production, wheat flour or starch, sugar, and concentrated fruit juice are boiled in an open vessel to increase the consistency, and the 'herle' (viscous gelatinised mixture) is then spread in a 1–5-mm thick layer onto a cloth (Tontul and Topuz, 2017a); a chewable leathery product is obtained by drying to a certain level of moisture content under the sun (Cagindi and Otlés, 2005).

The health benefits of whole grain cereals and grain bran are well-recognised and promoted widely for reducing the risk of chronic diseases (e.g. cardiovascular diseases and type 2 diabetes) and due to their high fibre contents they lower the energy density of the diet, rate and extent of starch digestion (Gujral *et al.*, 2018; Sayaslan

and Şahin, 2018; Ye *et al.*, 2012). Dietary fibre can be a food additive and has several advantages; it may influence the colour, flavour, oil- and water-holding capacity of the product. In addition, it can affect the structure, rheological characteristics, sensory properties and may modify the apparent viscosity of the product (Wang *et al.*, 2018). Barley is a rich source of dietary fibre (β -glucan) which has functional effects on human health and it is used as a binding agent with the other cereal flours in the production of cereal-based foods (Yuksel *et al.*, 2015). Oats contain soluble and insoluble fibre (e.g. β -glucans) which has a satiating effect (Ciesarová *et al.*, 2014). The nutritional value of pestil, which is often consumed by children and adolescents, is of importance in terms of nutrition. Quality characteristics of pestil could be improved with the addition of whole grain flours and grain bran because they contain high levels of bioactive compounds (e.g. fibres, essential amino acids, vitamins, phenolic compounds and minerals).

In the production of pestil, mostly wheat flour and starch are used to create a specific structure. In this study, mulberry pestil production was carried out by using wheat flour, starch, wheat bran and whole grain flour (wheat, barley, rye and oat) which are substances that improve the structure formation of the product. The aim of the present study is to investigate the effect of the structural ingredients on the physical, chemical and sensorial properties of pestil.

2. Material and methods

Materials

Mulberry syrup (*pekmez*) used in the production of pestil was obtained from a commercial company in Malatya which was producing it at a national level. Initial total soluble solids (TSS) of mulberry syrup were measured as 72 °brix. In this study, two different levels (6 and 9%) of corn starch, wheat flour, whole grain flours (wheat, barley, rye and oat) and wheat bran were used as structural

ingredients. Wheat, oat, barley, rye, wheat flour, wheat bran and corn starch were supplied from the local market. Wheat, barley, rye and oat were milled thoroughly in the Bühler type mill to obtain whole grain flour. The properties of materials used in the pestil production are given in Table 1.

Production of pestil

In the production of pestil, the initial TSS of mulberry syrup were diluted with drinking water to decrease the value from 72 °brix to 20 °brix and the formulations were prepared by adding two different levels (6 and 9%) of whole grain flours (rye, barley, oat and wheat), wheat flour, wheat bran and starch. The best results in preliminary sensorial texture tests were obtained from 6 to 9% level of pestils with added whole grain flour. This is because whole grain flour can absorb more water. Heat-treatment was applied with constant stirring in an open environment (boiler). Heat-treatment was continued for 12 min after boiling (100–103 °C). Overall heat-treatment was carried out for 15 min. 'Herle' were spread on the special pestil cloths in equal thickness (6 mm) and dried in an oven at 50 °C for 10 h. The air velocity of the oven was 1.5 m/s, the relative humidity was determined as 15–20% using a hygrometer depending on the drying temperature. The mulberry leather was sealed in a stretch film and stored at room temperature. Preparations of the mulberry pestil were conducted in three replications.

Methods

Total dry matter, total soluble solids and total ash analysis

Total dry matter (TDM) was determined according to the work of Cemeroglu (1992) and results were expressed as percentages. TSS were measured by using an Abbe refractometer (Phimpharian *et al.*, 2011). For analysis of total ash, 3 g of the pestil samples was weighed and dried at 100–120 °C in an oven and then burned at 500–600 °C

Table 1. Ash, titratable acidity, pH and colour intensity values of structural ingredients and mulberry syrup (*pekmez*).

Ingredients	L*	a*	+b [†]	Ash (%)	pH	Titratable acidity (%citric acid)
MS	20.99 ± 0.01	5.88 ± 0.01	2.29 ± 0.02	2.10 ± 0.02	5.36 ± 0.03	1.78 ± 0.02
S	99.95 ± 0.05	-1.62 ± 0.01	4.15 ± 0.14	0.10 ± 0.01	4.33 ± 0.03	0.5 ± 0.05
WF	97.03 ± 0.01	-0.72 ± 0.01	10.67 ± 0.01	0.80 ± 0.01	6.12 ± 0.01	1.58 ± 0.01
WWF	90.09 ± 0.06	1.89 ± 0.01	10.10 ± 0.02	1.61 ± 0.04	6.37 ± 0.02	2.08 ± 0.07
WBF	92.86 ± 0.13	0.55 ± 0.00	9.94 ± 0.03	2.52 ± 0.01	5.94 ± 0.02	3.59 ± 0.12
WRF	89.76 ± 0.03	1.08 ± 0.01	9.54 ± 0.01	1.76 ± 0.05	6.45 ± 0.03	2.37 ± 0.09
WOF	89.75 ± 0.06	0.72 ± 0.00	10.53 ± 0.00	2.72 ± 0.02	5.92 ± 0.03	9.97 ± 0.06
WB	82.17 ± 0.05	3.62 ± 0.01	13.14 ± 0.06	4.61 ± 0.03	6.40 ± 0.04	6.71 ± 0.01

MS, mulberry syrup, S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

in a muffle furnace for about 6 h. The results were calculated as g/100 g (Uylaşer and Başoğlu, 2011).

pH, titratable acidity and colour intensity analysis

The pH measurements of the samples were performed using an INOLAB pH of 720 pH meter (Torley *et al.*, 2008).

Measurements of titratable acidity (TA) of the samples was conducted according to Cemeroglu (2007). About 5 g of the pestil sample was weighed and then finely blended with 50 ml distilled water, and the mixture was titrated with 0.1 N NaOH up to pH = 8.1 and the result was expressed as percent citric acid (INOLAB pH 720; WTW, Weilheim, Germany). The colour intensity measurements were carried out using the HunterLab colorimeter device and the results were evaluated according to the International Commission on Illumination (CIE Lab) (Minolta CR-200; Minolta, Osaka, Japan). This formula is based on a three-dimensional colour measurement; L^* (lightness, 0 = black 100 = white), a^* (+ indicates redness, and – greenness) and b^* (+ indicates yellowness, and – blueness) (Alpaslan and Hayta, 2006).

Total phenolic contents

The total phenolic content was determined by using the Folin–Ciocalteu method (Gülcin *et al.*, 2002) with some modification. For the extraction process, 46 ml of distilled water was added to 0.1 g of the pestil sample. Subsequently, the whole of the filtrate obtained by filtering through the Whatman no: 1 filter paper was filtered and mixed with 1 ml of Folin–Ciocalteu solution. After 3 min, 3 ml of Na_2CO_3 (2%) was added, then the mixture was stirred with a magnetic stirrer for 2 h at 22 °C. The absorbance was measured at 760 nm in an ultraviolet-visible (UV-VIS) spectrophotometer (Shimadzu UV-160; Kyoto, Japan). The total phenolic content was calculated on the basis of the calibration curve of gallic acid and expressed as gallic acid equivalents (μg GAE/mg sample).

Texture analysis

Hardness of pestil samples that were stored (in room temperature for 24 h) was measured at 20 °C by an uniaxial compression test using a TA.XT Plus Texture Analyser (Stable Micro Systems, Godalming, UK) equipped with a 30 kg load cell and a P/35 probe. Pestils were cut into cylinders with 23.5 mm of diameter and 2 mm height. The cylindrical pestil samples were compressed at the speed of 2.00 mm/s to a strain of 30% and then the hardness (N) was recorded.

Sensory analysis

Sensorial properties of pestils were evaluated according to the method proposed by Alpaslan and Hayta (2006) with slight modifications. The panel was formed in the Laboratory of Atatürk University Faculty of Agriculture Department of Food Engineering. The panellists were selected from the lecturers of the Department of Food Engineering and graduate/doctoral students, 10 male and 10 female, between the ages of 25 and 40. The pestil samples were cut into 15 cm × 3 cm × 2 mm sizes, then three-digit number codes were assigned to each sample, presented with drinking water on plastic plates, and evaluated sensibly. All the pestil samples that were produced were given to be presented after 24 h storing at room temperature. Pestil samples were evaluated for their taste, aroma, texture and general acceptability properties. Panellists were required to rate samples of pestil on a 9-point (1: dislike intensely, 5: neither dislike nor like, 9: like intensely) traditional hedonic scale (Villanueva and Da Silva, 2009).

Statistical analysis

All the experiments were carried out in triplicate and in two different trials. The data obtained from the study were subjected to analysis using Statistical Package for the Social Sciences (SPSS) (a completely randomised design procedure by SPSS; SPSS; Chicago, IL, USA) packet program and differences between data were tested using Duncan's range test ($P < 0.05$, $P < 0.01$). The result were expressed as mean \pm standard error.

3. Results and discussion

TSS, TDM, ash, pH and TA values of mulberry pestil significantly changed with the addition of structural ingredients (Table 2). The highest value for TSS was found in the samples added 6% level of wheat flour, while the lowest value was found in the samples added 9% level of oat flour. It was also observed that the TSS values decreased with increase in the structural ingredient addition level in all samples. The reason for a decrease in TSS value could be due to the presence of water-insoluble components (insoluble fibre) that increase proportionally in the formulation and basically reduce the amount of soluble components from the mulberry syrup. While the highest value for TDM was determined in samples containing 9% level of starch, the lowest value was determined in samples containing 6% level of oat flour. When ash contents of pestil samples were analysed, it was seen that the pestil samples with wheat bran had the highest value and the ones containing starch had the lowest value. However, the addition of bran caused a significant increase in the ash content of the samples. This may be explained by the fact that wheat bran has more ash content than mulberry

Table 2. Proximate composition and physicochemical properties of pestil samples.

Ingredient (structural)	Level (%)	TSS (^o Brix)	TDM (%)	Ash (%)	pH	TA (%citric acid)
S	6	7.73 ± 0.03 ^d	91.41 ± 0.21 ^{def}	2.23 ± 0.05 ^f	5.75 ± 0.01 ^{cd}	0.45 ± 0.01 ^f
	9	7.53 ± 0.03 ^e	92.67 ± 0.12 ^a	2.09 ± 0.01 ^g	5.81 ± 0.01 ^a	0.40 ± 0.01 ^g
WF	6	8.53 ± 0.03 ^a	92.16 ± 0.00 ^{ab}	2.36 ± 0.00 ^e	5.78 ± 0.01 ^b	0.46 ± 0.01 ^{ef}
	9	8.03 ± 0.03 ^c	92.02 ± 0.33 ^{bc}	2.21 ± 0.00 ^f	5.77 ± 0.01 ^b	0.44 ± 0.02 ^f
WWF	6	8.51 ± 0.01 ^a	90.96 ± 0.15 ^{fg}	2.51 ± 0.00 ^d	5.77 ± 0.00 ^b	0.48 ± 0.01 ^{de}
	9	8.01 ± 0.01 ^c	91.58 ± 0.08 ^{bcd}	2.43 ± 0.00 ^{de}	5.74 ± 0.00 ^d	0.48 ± 0.01 ^{de}
WBF	6	8.51 ± 0.01 ^a	91.45 ± 0.07 ^{cdef}	2.67 ± 0.01 ^{bc}	5.68 ± 0.00 ^e	0.57 ± 0.01 ^c
	9	8.01 ± 0.01 ^c	91.39 ± 0.11 ^{def}	2.66 ± 0.01 ^{bc}	5.67 ± 0.00 ^e	0.55 ± 0.01 ^c
WRF	6	8.25 ± 0.01 ^b	91.37 ± 0.04 ^{def}	2.60 ± 0.01 ^c	5.74 ± 0.01 ^d	0.50 ± 0.00 ^d
	9	8.01 ± 0.01 ^c	91.81 ± 0.32 ^{bcd}	2.37 ± 0.05 ^e	5.78 ± 0.01 ^b	0.49 ± 0.01 ^{de}
WOF	6	8.26 ± 0.01 ^b	90.23 ± 0.21 ^h	2.73 ± 0.05 ^b	5.67 ± 0.01 ^e	0.68 ± 0.01 ^b
	9	7.26 ± 0.01 ^f	90.54 ± 0.24 ^{gh}	2.72 ± 0.02 ^b	5.69 ± 0.01 ^e	0.69 ± 0.01 ^b
WB	6	8.01 ± 0.01 ^c	91.19 ± 0.04 ^{ef}	3.14 ± 0.02 ^a	5.76 ± 0.02 ^{bcd}	0.73 ± 0.01 ^a
	9	7.51 ± 0.01 ^e	91.03 ± 0.07 ^{efg}	3.23 ± 0.05 ^a	5.77 ± 0.01 ^{bc}	0.73 ± 0.02 ^a
P-value		**	**	**	**	**

Values are mean ± Standard Error (SE). Different letters in the same column are significantly different (* $P < 0.05$; ** $P < 0.01$).

S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

syrup and other ingredients. It was also found that the pestil samples produced from ingredients with high initial ash content had higher ash content. Elgün and Ertugay (2012) stated that the bran layer of the cereal grains is very rich in mineral matter.

Pestil samples had an acidic pH. The pH of the pestil is mostly dependent on the fruit pulp, juice, the ingredients used in its formulation and the process conditions such as heat treatment and drying techniques (Tontul and Topuz, 2017b). For example, formation of acidic compounds due to non-enzymatic browning reaction during heat treatment may affect the pH of products. The pH value of pestil samples ranged between 5.67 and 5.81. The lowest pH values were measured in pestil samples containing oat and barley flour while the highest pH values were determined in samples containing 9% level of starch. Similar results were reported by Tontul and Topuz (2017b); the pH of the traditional pestil produced with wheat starch was higher than that produced with hydrocolloid (locust bean gum and pre-gelatinised starch) added to the formulation and temperature increases for the same drying technique did not affect the pH of the pestil, except during hot air drying. On the other hand, the TA values of the pestil samples increased with the increase in the amount of structural ingredients. The highest TA value was found in the samples containing wheat bran, whereas the lowest value was found in the samples containing 9% level of starch.

In products such as pestil and fruit juice, colour is one of the most important quality criteria significantly influencing consumer preferences. Colour in fruit juice is principally attributed to the presence of various carotenoids,

betalains and anthocyanins, which are water-soluble diglycosides (Maskan *et al.*, 2002a; Tiwari *et al.*, 2009). Browning reactions occurred during the boiling process and water-soluble diglycosides have a great effect on the colour formation of pestil (Maskan *et al.*, 2002a). The colour properties of the structural ingredients (Table 1) reflected in the pestil samples (Figure 1). In Figure 2, an increase in the level of structural ingredient added to the formulation resulted in an increase in the L^* value of the samples with barley flour and starch added; however, it decreased the L^* value in samples containing the wheat flour, whole rye flour, whole wheat flour, whole oat flour and wheat bran. It was also determined that samples containing starch had colour values close to samples containing wheat flour. The highest L^* colour value was found in the samples containing 6% level of wheat flour, whereas the lowest L^* colour value was found in the samples containing wheat bran. As expected, the wheat flour led to an increase in the L^* colour values of the pestil samples, while the addition of wheat bran decreased the L^* colour values.

In the samples containing starch and wheat flour, the a^* (+ indicates redness, and – greenness) colour value was quite high compared to the other samples. The lowest a^* colour value was measured in pestil samples containing 9% level of wheat bran. Taking into consideration the consumer liking, it is stated that the a^* colour value is not desired to be very high and pestils with lower a values are preferred, because it is considered to be related to the extent of heat treatment applied in the pestil production and is a result of excessive caramelisation of sugars (Maskan *et al.*, 2002b; Yıldız, 2013). Boz *et al.* (2016)

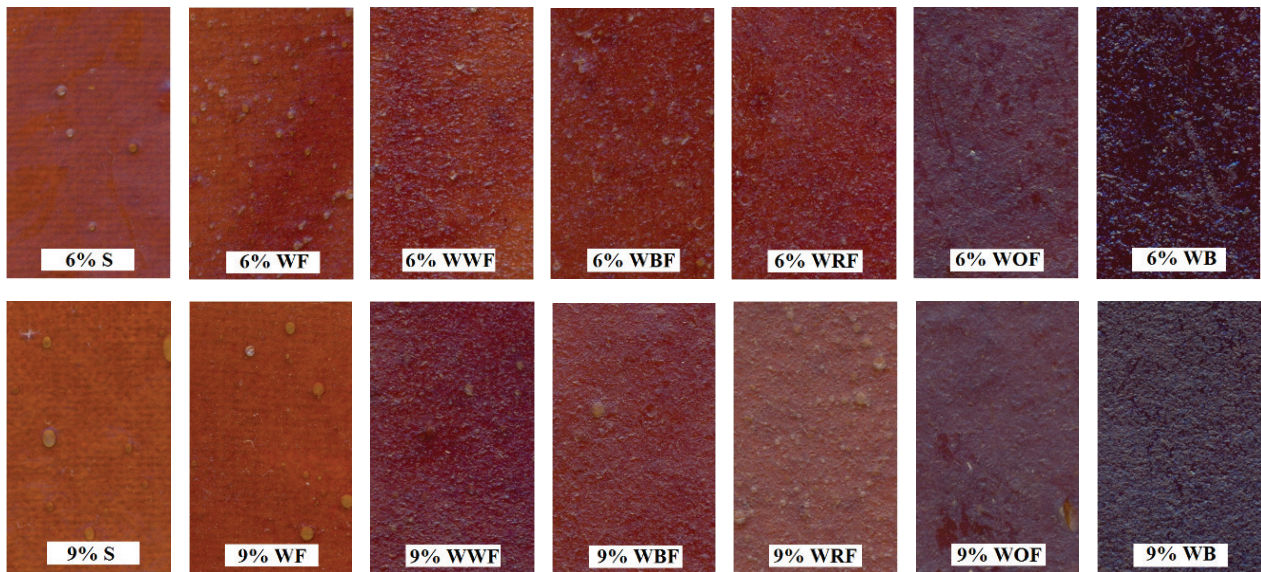


Figure 1. Produced pestil samples.

S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

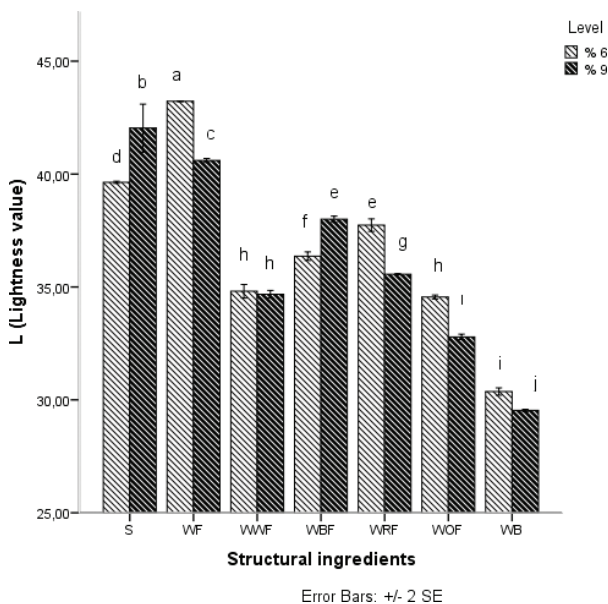


Figure 2. L (Lightness value) colour variation in mulberry pestil according to type and level of added structural ingredients.

S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

reported that an increase in cooking time reduced L values of mulberry pestil samples. Aksu *et al.* (1997) have reported that increases in the browning of sugary foods generally correlated well with decreases in L^* value.

The highest b^* (+ indicates yellowness, and – blueness) value was measured in samples containing 9% level of

starch and the closest value to samples containing starch was measured in pestil samples that added 6% level of wheat flour. The lowest b^* value was measured in samples containing 9% level of wheat bran. The level of ingredient added to the formulation and ingredients significantly ($P < 0.01$) affected colour values (L^* , a^* and b^*) in pestil samples. In Figures 2–4, the increase in the level of ingredient added to the formulation increased the L^* , a^* and b^* values in the samples with starch and whole barley flour added, whereas it generally decreased these values in samples containing wheat flour, whole wheat flour, whole rye flour, whole oat flour and wheat bran.

Phenolic compounds are mostly produced by plants and have strong antioxidant properties (Tokbas, 2009). While total phenolic content of pestil samples produced by using starch, whole wheat flour, whole barley flour, whole rye flour and whole oat flour decreased with increasing addition level, it increased in pestil samples containing wheat flour and wheat bran (Figure 5). The decrease in the amount of phenolic compounds may be considered normal due to the increase in the amount of structural ingredient added to the formulations. The amount of mulberry syrup with a high phenolic content was reduced as according to the amount of structural ingredient added. The highest phenolic content values were measured in samples containing 6% level of whole barley and whole oat flour and the lowest value was measured in pestil sample that had 9% level of starch added. Cereals, such as oat and barley contain important phenolic compounds. Axtell and Baik (2006) found the phenolic compound content of grains, expressed as catechin equivalent (CE). Phenolic

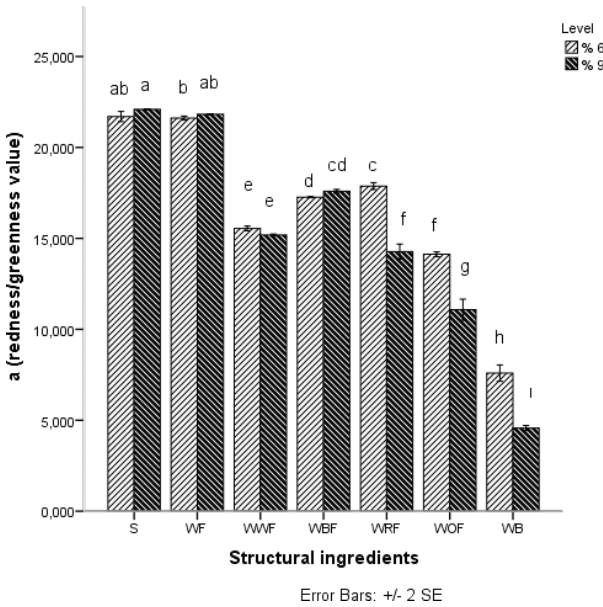


Figure 3. a (redness/greenness value) colour variation in mulberry pestil according to type and level of added structural ingredients.

S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

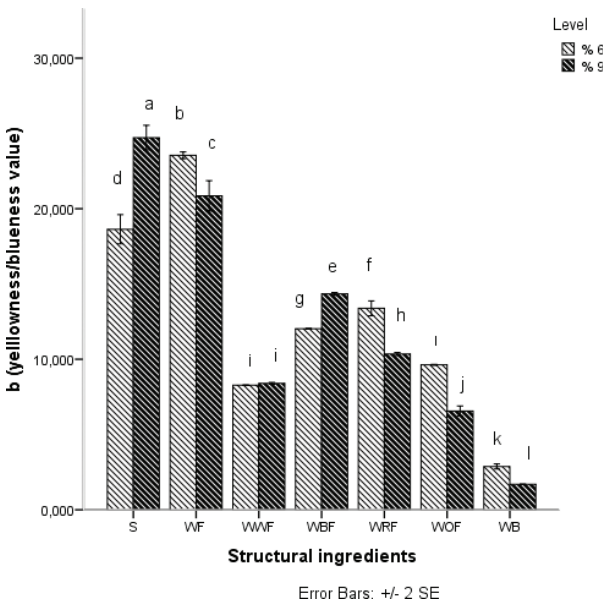


Figure 4. b (yellowness/blueness value) colour variation in mulberry pestil according to type and level of added structural ingredients.

S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

compound contents of grains have been found as 24.3 µg/mg for barley, 17.6 µg/mg for oat, 10.2 µg/mg for wheat and 8.9 µg/mg for rye. In a study on pestils

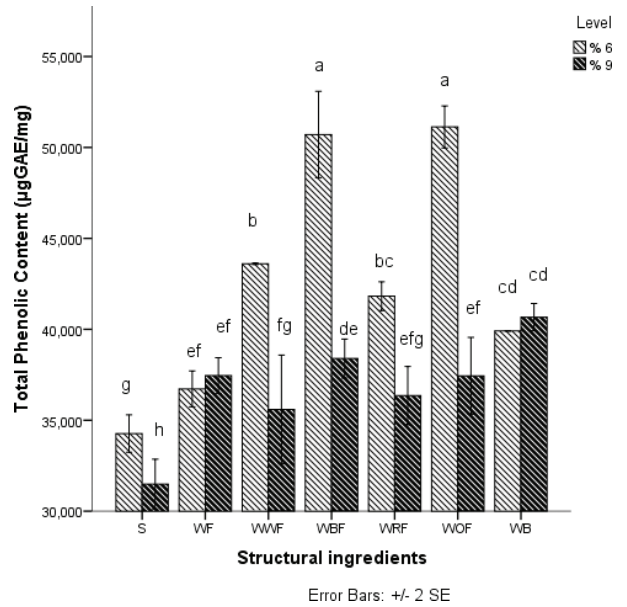


Figure 5. Total phenolic content variation in mulberry pestil according to type and level of added structural ingredients.

S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

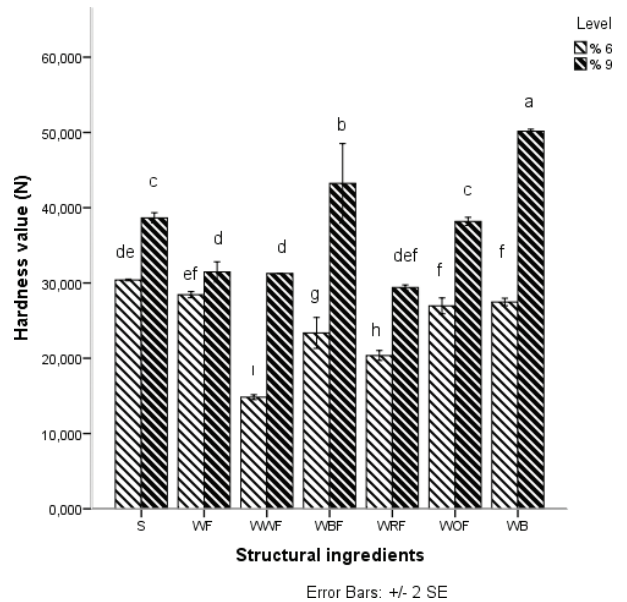


Figure 6. Hardness variation in mulberry pestil according to type and level of added structural ingredients.

S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

produced from mulberry, cornelian cherry and plum total phenolic content that was reported ranged from 4.79 to 28.36 µgGAE/mg sample. In addition, it was stated that plum pestil (28.36 µgGAE/mg) from pestils had the highest content of total phenolic content and

Table 3. Sensory analysis results of pestil samples.

Ingredient (structural)	Level (%)	Taste	Aroma	Texture	General acceptability
S	6	6.83 ± 0.17 ^{ab}	6.75 ± 0.25 ^{abc}	5.79 ± 0.21 ^{bcd}	5.71 ± 0.71 ^{cd}
	9	6.81 ± 0.19 ^{ab}	6.23 ± 0.23 ^{cde}	4.67 ± 0.67 ^e	6.03 ± 0.03 ^c
WF	6	6.13 ± 0.13 ^c	6.13 ± 0.13 ^{de}	5.11 ± 0.11 ^{cde}	6.10 ± 0.10 ^{bc}
	9	6.08 ± 0.08 ^c	5.83 ± 0.17 ^e	5.21 ± 0.21 ^{cde}	5.92 ± 0.08 ^c
WWF	6	6.03 ± 0.03 ^c	6.21 ± 0.21 ^{cde}	6.06 ± 0.06 ^{bcd}	6.21 ± 0.21 ^{bc}
	9	6.11 ± 0.11 ^c	6.13 ± 0.13 ^{de}	4.64 ± 0.64 ^e	6.10 ± 0.10 ^{bc}
WBF	6	6.92 ± 0.08 ^{ab}	6.54 ± 0.04 ^{bcd}	6.72 ± 0.08 ^b	6.83 ± 0.17 ^{ab}
	9	6.00 ± 0.00 ^c	6.12 ± 0.08 ^{de}	4.58 ± 0.58 ^e	5.98 ± 0.03 ^c
WRF	6	6.00 ± 0.00 ^c	5.92 ± 0.08 ^e	6.17 ± 0.17 ^{bc}	6.04 ± 0.04 ^c
	9	6.15 ± 0.15 ^c	6.13 ± 0.13 ^{de}	5.08 ± 0.08 ^{cde}	5.78 ± 0.22 ^{cd}
WOF	6	7.17 ± 0.17 ^a	7.18 ± 0.18 ^a	7.83 ± 0.17 ^a	7.21 ± 0.21 ^a
	9	6.72 ± 0.08 ^b	7.02 ± 0.02 ^{ab}	6.77 ± 0.23 ^b	6.98 ± 0.02 ^a
WB	6	5.21 ± 0.21 ^d	5.17 ± 0.17 ^f	5.77 ± 0.24 ^{bcd}	5.92 ± 0.08 ^c
	9	5.13 ± 0.13 ^d	4.38 ± 0.38 ^g	5.00 ± 0.00 ^{de}	5.08 ± 0.08 ^d
	<i>P</i> -value	**	**	**	**

Values are mean ± SE. Different letters in the same column are significantly different (**P* < 0.05; ***P* < 0.01).

S, starch; WF, wheat flour; WWF, whole wheat flour; WBF, whole barley flour; WRF, whole rye flour; WOF, whole oat flour; WB, wheat bran.

was followed by mulberry with walnut (24.08 µgGAE/mg) (Şengül *et al.*, 2010).

According to instrumental analysis results, the hardness values of the samples increased with an increase in structural ingredient level (Figure 6). The most hard pestils were samples containing wheat bran. Pestil is desired to be folded and bent. High hardness value is not required because moisture losses during shelf life will be unavoidable. Phimpfarian *et al.* (2011) reported for pineapple pestil produced by adding three different levels of pectin (0.5, 1.0 and 1.5%) that an increase in the pectin concentration resulted in an increase of hardness of pestil.

The sensory properties are among the most important properties of food products. Sensory texture refers to the determination of structural, mechanical and surface properties of foods based on vision, hearing, touch and kinesthetic observation (Szczeniak, 2002). As shown in Table 3, the highest taste, aroma, texture and general acceptability values were determined in the samples of whole oat flour. The lowest taste, aroma and general acceptability values were found in samples containing wheat bran. The lowest texture values were determined in samples containing starch, whole wheat flour, whole barley flour and wheat bran. Lowest overall acceptability value was determined in pestil samples containing wheat bran. Samples containing wheat bran were not preferred due to their more fibrous structure compared to other samples. This fibrous structure negatively influenced the mouthfeel properties of the pestil samples.

4. Conclusion

This study revealed that physical, chemical and sensorial properties of mulberry pestil were influenced when whole grain flours and wheat bran were used instead of adding wheat flour and starch during pestil production. According to the result, the characteristics of mulberry pestils ranged from 7.26 to 8.53 °brix for TSS, 90.23–92.67% TDM, 2.09–3.23% ash, 5.67–5.81 pH, 0.40–0.73% TA. The highest values for total phenolic content were determined in samples containing whole oat flour and whole barley flour. In general, the colour properties of the structural ingredients reflected the change in colour values of the pestil samples. According to the overall sensorial parameters, the pestils produced using oats were more appreciated by panelists. Pestil is among the most important traditional foods produced but is not a well-known product and few studies related to it have been published. The use of whole grain flour instead of ingredients such as starch in order to improve the functional properties of pestil may have a positive impact on consumer health. The results of this study could be used in the development of traditional foods.

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Conflict of interest

We are declaring no conflicts of interest with respect to the research, authorship and/or publication of this article.

Compliance with ethical standards

This article followed all ethical standards for a research without direct contact with human or animal subjects.

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