Erzincan Üniversitesi
Fen Bilimleri Enstitüsü Dergisi
2020, 13(3), 1317-1333
ISSN: 1307-9085, e-ISSN: 2149-4584
Araştırma Makalesi

Erzincan University
Journal of Science and Technology
2020, 13(3), 1317-1333
DOI: 10.18185/erzifbed.829149
Research Article

Chemical Compound Profile, Antioxidant Capacity and Some Physicochemical Properties of Pulp and Pestils produced from *Prunus salicina*

Memnune ŞENGÜL[1] Neva KARATAŞ[2*] Melek ZOR[3] Elif Feyza TOPDAŞ[1]

Bilal YILMAZ[4]

1 Department of Food Engineering, Faculty of Agriculture, Ataturk University, 25240 Erzurum, Turkey

2 Department of Nutrition and Dietetics, Faculty of Health Sciences, Ataturk University, 25240 Erzurum, Turkey

3 Department of Gastronomy and Culinary Arts, School of Tourism and Hotel Management, İbrahim Cecen University, 04100 Agrı, Turkey

4 Department of Analytical Chemistry, Faculty of Pharmacy, Ataturk University, 25240, Erzurum, Turkey

Geliş / Received: 20/11/2020, Kabul / Accepted: 25/12/2020

Abstract

In this study, the chemical compound profiles, antioxidant properties and some physicochemical properties of pulp, pure pestil and hazelnut added pestil of plum (*Prunus salicina*) were determined. The chemical compound profiles of the samples were detected using GC-MS (gas chromatography–mass spectrometry). The antioxidant properties were determined by the total phenolic content and DPPH and ABTS radical scavenging activity analysis. According to the results obtained, the total phenolic content of the samples varied between 130.92 mg GAE / g - 146.57 mg GAE/ g. In addition, it was determined that the concentration increase occurring in pulp and pestil production steps significantly increased the DPPH and ABTS radical scavenging activities of the samples (p <0.05). Results of the GC-MS showed that the plum pulp, pure pestil and hazelnut added pestil contained 35, 32 and 28 chemical compounds, respectively. Furans, ketones, carbohydrates and aldehydes were the most abundant compounds found in both the pulp and pestil samples. 5-hydoxymethylfurfural was the main chemical compound in all of the samples (38.52-61.61%). In addition, the dry matter value was found to be between 19.335-89.067%, ash value was between 2.08-4.15%, pH value was between 3.68-3.84, protein value was between %0.315-4.385, L* values were between 21.78-29.39, a* values were between 3.12-13.09 and b* values were between 1.45-6.93, respectively.

Keywords: Chemical compound profile, pestil, plum, *Prunus salicina.*

Prunus salicina'dan Üretilen Pulp ve Pestillerin Kimyasal Bileşen Profili, Antioksidan Kapasitesi ve Bazı Fizikokimyasal Özellikleri

Bu çalışmada, erik (*Prunus salicina*) meyvesinden üretilen pulp, sade pestil ve fındık ilaveli pestilin antioksidan özellikleri, kimyasal bileşen profilleri ve bazı fiziksel özellikleri belirlenmiştir. Örneklerinin kimyasal bileşen profilleri GC-MS (gaz kromatografisi-kütle spektrometrisi) ile tespit edilmiştir. Antioksidan

özellikler, toplam fenolik madde miktarı ile DPPH ve ABTS radikal giderme aktivite analizleri ile belirlenmiştir. Elde edilen sonuçlara göre numunelerin toplam fenolik madde miktarları 130.92 mg GAE / g - 146.57 mg GAE / g aralığında değişmektedir. Pulp ve pestil üretim aşamalarında meydana gelen konsantrasyon artışının, numunelerin DPPH ve ABTS radikal süpürücü aktivitelerini önemli ölçüde artırdığı tespit edilmiştir (p <0.05). GC-MS kompozisyonu erik pulpu, sade pestil ve fındık ilaveli pestilin sırasıyla 35, 32 ve 28 adet kimyasal bileşik içerdiğini göstermiştir. Furanlar, ketonlar, karbonhidratlar ve aldehitler hem pulp hem de pestil örneklerinde en fazla bulunan bileşiklerdir. 5-hidroksimetilfurfural tüm numunelerde ana kimyasal bileşiktir (% 38.52-61.61). Ayrıca, örneklerin kurumadde değerleri % 19.34-89.07, kül değerleri % 2.08-4.15, pH değerleri 3.68-3.84, protein değerleri % 0.32-4.39, L * değerleri 21.78-29.39, a * değerleri 3.12-13.09 ve b * değerleri 1.45-6.93 aralığında belirlenmiştir.

Anahtar Kelimeler: Kimyasal bileşen profili, pestil, erik, *Prunus salicina.*

1. Introduction

Plums, which belong to the Prunus genus, are widely consumed around the world (Özçağıran et al., 2011). Depending on the taxonomist, there are approximately 400 species of trees and subspecies (Ayanoğlu et al., 2007; Özçağıran et al., 2011). However, the most economically significant species are the European plum (Prunus domestica L.) and Japanese or Asian plum (Prunus salicina Lindell) (Birwal and Saurabh, 2017; USDA, 2019; Walkowiak–Tomczak, 2008). In general, the Japanese plums (Prunus salicina L.) are grown for fresh consumption (Srinivasan et al., 2005).

The plum fruit is rich in phenolic acids, anthocyanins, carotenoids, flavanols, organic acids such as citric and malic acids, pectin, tannins, aromatic substances, enzymes, carbohydrates, potassium, phosphorus, sodium, iron and vitamins A, B1, B2, B3, B6, C and E. Due to these bioactive components, plums have been found to have positive effects on liver, heart and kidney diseases, digestive system disorders and rheumatism (Kalkışım and Özdemir, 2012; Özbek, 2010; Tunalıoğlu and Keskin, 2004; Usenik et al., 2008).

The shelf life of the plum fruit is short because of its short harvest season, high water content, and the fact that it cannot be stored for a long period of time under refrigerator conditions. Plums can be dried or processed as fruit juice, concentrate, compote, jam, paste, pulp, marmalade and wine to extend their storage period and ensure their consumption in all seasons (Özgüven et al., 2000).

Pestil is a traditional Turkish food that is natural and widely consumed (Sengul et al., 2010). It is obtained by concentrating the juice or pulp of a fruit and then spreading it out on cloths to dry (Cagindi and Otles, 2005; Chowdhury et al., 2011; Gökçe, 2015; Raab and Oehler, 2000; Kara and Küçüköner, 2019; Yildiz et al., 2011). Pestil can be produced from a variety of fruits such as apples, grapes, mulberries, cornelian cherries, plums, apricots, bananas, cherries, oranges, strawberries, pears, pineapples, peaches, carobs (locust bean) and figs (Sengul et al., 2010; Yildiz, 2013; Kara and Küçüköner, 2019; Ünver, 2019). However, plum is the most commonly used fruit to produce pestil in Turkey.

Pestil is a good source of carbohydrates, energy, antioxidants, minerals and fiber (Nas and Gökalp, 1993; Batu et al., 2007; Çakir, 2009; Yildiz, 2013). Honey and various nuts including walnuts can also be added to the pestil during the production process in order to make it rich in iron minerals (Özbek, 2010; Kara and Küçüköner, 2019). Features

such as having a long shelf life, being a dried light snack and easy consumption in all seasons have made the dried fruit pulp a popular product (Kara and Küçüköner, 2019).

The literature reviews showed that there were a few studies conducted on the physical and chemical properties of plum pestil and that there were none regarding its mineral substance content and detailed chemical composition. The present study aimed to determine the chemical compounds and mineral content in plum pulp, pure plum pestil and hazelnut added plum pestil.

2. Materials and Methods

2.1. Raw Material

In this study, the plum (*Prunus salicina*) fruit (F), its pulp (PP), pure plum pestil (PS) and hazelnut added plum pestil (HNAPS) were used as the materials. The hazelnut and fresh fruits were purchased from a market in the province of Erzurum. The fruits were stored at -20°C until the analyses were conducted and the pulp were produced. The PP, PS and HNAPS were kept at 4±2°C until conducting the analyses.

2.2. Sample production

Fresh plum fruits were purified from stalk, rotten parts and stones. Then, the fruits were crushed using a blender and concentrated by being carefully mixed on a stove at 92°C up to 20 Brix for the pulp production. The pulp produced was divided into two parts. Ground hazelnut was added to the first part. Hazelnut added pulp and pure pulp were spread out on special cloths and dried at 25±2ºC. The schema of the pestil production is given in Figure 1.

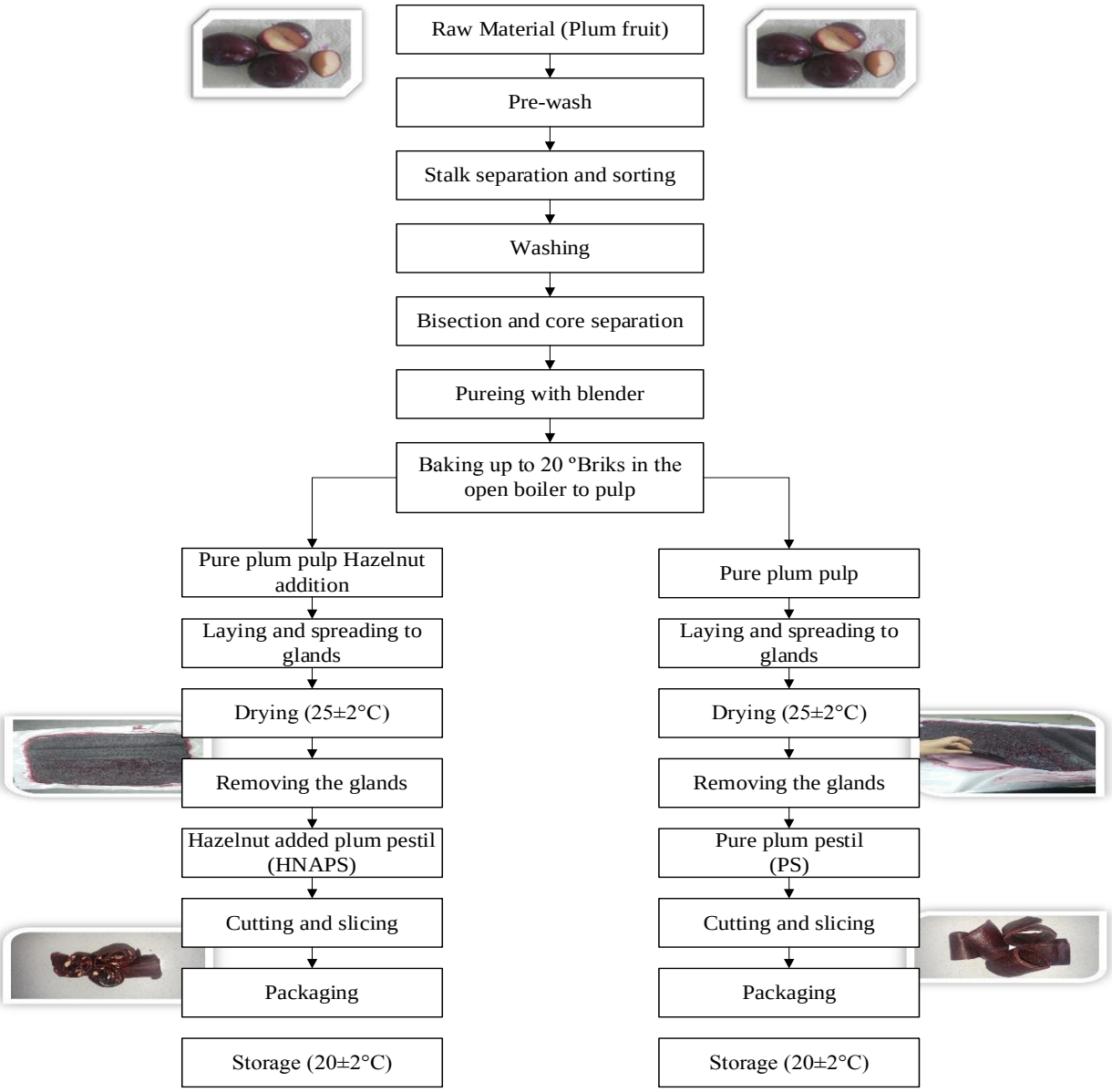

Figure 1. Pestil production flow chart

2.3. Physicochemical analysis

The dry matter, ash and pH values of the samples were determined by the procedure performed by Cemeroğlu (2013). The amount of protein in the samples was calculated by multiplying the total amount of nitrogen determined by the Kjeldahl method with a factor of 6.25 (Kurt et al 1999). Color intensity was measured with a minolta colorimeter (Chroma Meter, CR-200, Japan) device (Luo 2006).

2.4. Chemical compounds profile

The chemical compounds were detected using an Agilent 7820A gas chromatography device, a 5977-mass spectroscopy detector, a 7673 series autosampler and ChemStation (Agilent Technologies, Palo Alto, CA) software. The PP, PS and HNAPS were weighed 5 g and vortexed (Heidolph Reax Top, D-91126 Schwabach, Germany) with 50 mL of methanol to obtain a homogeneous

mixture and dissolved in a magnetic stirrer (Orbital Shaker SSL1, UK) for 12 hours. After mixing and thawing, samples were filtered with Whatman filter paper and put into 1.5 mL glass vials through a 0.22 µm micro filter through disposable syringes. The compounds were separated on an HP-5 MS column with a film thickness of 0.25 µm (30 m x 0.25 mm inner diameter, USA) using 1 µl splitless injection mode with 1 ml/minute flow rate and 70 eV ionization energy using helium as the carrier gas. The temperature conditions were as follows: the initial temperature was set to 50℃, and it was raised to 100℃ after one minute at a rate of 20℃/minute and kept at this temperature for a minute, then raised to 180℃ at a rate of 10℃/minute and kept at this temperature for a minute, then raised to 220℃ at a rate of 5℃/minute and kept at this temperature for five minutes and lastly it was raised to 300℃ at a rate of 10℃/minute and kept at this temperature for five and a half minutes. The identification of chemical compounds was carried out using the National Institute of Standards and Technology (NIST) gas chromatography–mass spectrometry (GC-MS) library and reference standard substances.

2.5. Antioxidant properties

Samples were stored at -20 °C until $DPPH^{\bullet}$ (2,2-diphenyl-1-pcyrylhydrazyl) and $ABTS^{\bullet+}$ (2,2'-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) scavenging activities and total phenolic compounds analyses. To determine the total amount of phenolic compounds, 25 g of each sample was mixed with 75 ml of ethanol-water (90:10, v/v) using a magnetic stirrer for 6 h in the dark. Then the mixture was filtered through Whatman No. 1filter paper, the filtrate was evaporated at 50 °C, the solution was completed to 25 ml with distilled water, and the stock solution was prepared. Total phenolic compounds were measured using the modified version of the procedure described by Slinkard & Singleton (1977). Briefly, 46 ml of distilled water and 1 ml of Folin & Ciocalteau's phenol reagent were added to 1 ml of the stock solution, mixed thoroughly, and the mixture was left to stand for 3 min. Then, 3 ml of 2% sodium carbonate solution was added to the mixture and the mixture was stirred for 2 h in the dark. The sample absorbances were measured spectrophotometrically at 760 nm in triplicate. Total phenolic content was determined as µg gallic acid equivalents (GAE) per mg sample with the help of the standard curve prepared by different concentrations of gallic acid.

$DPPH^{\bullet}$ radical scavenging activity is widely used in screening antioxidants such as polyphenols and anthocyanins in fruits and fruit products. $DPPH^{\bullet}$ is scavenged by polyphenols and anthocyanins through the donation of hydrogen, forming the reduced DPPH-H*. The colour changes from purple to yellow after reduction can be quantified by its decrease of absorbance at wavelength 517 nm. As the IC_{50} value decreases, the free radical-scavenging activity increases (Yang and Zhai 2010).

$ABTS^{\bullet+}$ assay has attracted much interest because it enables high-throughput screening of potential antioxidant activity of single compounds and biological matrices such as plasma and food components, food extracts or beverages. This assay is based on the antioxidant's ability to react with $ABTS^{\bullet+}$ radical cation

generated in the assay system (Gliszczyńska-Świgło 2006; Gulcin 2005).

2.6. Statistical analysis

The analyzes were carried out on samples with 3 replications. All the data were evaluated statistically using IBM SPSS Statistics Version 20.0 package program. Results are given as average±std deviation and the Duncan of Multiple Comparison Tests were applied.

3. Resarch Findings

3.1. Physicochemical properties

The antioxidant and some physicochemical properties of *P.salicina* fruit used in pestil production are shown in Table 1.

Table 1. Some physicochemical and antioxidant properties of *Prunus salicina* (F)

Properties	***P.salicina***
Total dry matter (%)	19.34±0.29
Ash (%)	2.32±0.05
pH	3.80±0.03
Protein (%)	0.32±0.07
L*	29.39±0.35
a*	+13.09±0.52
b*	+6.93±0.08
DPPH (IC_{50}, µg/ml)	67.14±0.86
ABTS (IC_{50}, µg/ml)	25.44±0.65
Total phenolic content (mg	130.92 ±1.72

The total dry matter, ash, pH and protein values of plum fruit used in pulp production were determined as 19.34 ± 0.29%, 2.32 ± 0.05%, 3.80±0.03, 0.32 ± 0.07, respectively. The color values of the fruit were measured as L * 29.39 ± 0.35, a * + 13.09 ± 0.52, b * + 6.93 ± 0.08. In addition, the DPPH and ABTS radical scavenging activities (IC_{50}) of the fruit were 67.14 ± 0.86 and 25.44 ± 0.65 µg / ml, respectively, while the total phenolic content was 130.92 ± 1.72 mg GAE / g.

Table 2. Some physicochemical properties of pulp and pestil samples

Properties	PP	PS	HNAPS
Total Dry matter (%)	21.67±0.14^{a}	88.15±0.42^{b}	89.67±0.83^{c}
Ash (%)	2.08±0.06^{a}	4.15±0.02^{c}	3.66±0.06^{b}
pH	3.81±0.07^{ab}	3.68±0.08^{a}	3.84±0.04^{b}
Protein (%)	0.67±0.09^{a}	1.25±0.10^{b}	4.39±0.14^{c}
L*	27.77±0.66^{c}	21.78±0.12^{a}	26.94±0.04^{b}
a*	11.15±0.71^{c}	4.48±0.47^{b}	3.12±0.01^{a}
b*	5.33±0.33^{c}	2.18±0.06^{b}	1.45±0.03^{a}

*Values are given as mean ± standard deviation (n = 3). Statistical analysis for each column was made within itself and the different letters in the same column are significantly different at p <0.05 level.

Some physicochemical properties of PP, PS and HNAPS are given in Table 2. The total dry matter amount was determined as 21.67±0.14%, 2.08±0.06% ash, pH 3.81±0.07, protein 0.67±0.09% in the pulp. The total dry matter was determined as 88.15±0.42% in PS and 89.67±0.83 in HNAPS (Table 2). Ash was determined as 3.66±0.06%-4.15±0.02% in PS and HNAPS, respectively. The pH values of pestil samples were determined as 3.68±0.08 and 3.84±0.04 (Table 2). L* value of PP was determined as 27.77±0.66, a* value as +11.15±0.71 and b* value as +5.33±0.33, respectively. The L* value of the pestil samples were found between 21.78±0.12-26.94±0.04; a* values were between (+3.12±0.01)-(+ 4.48±0.47) and b* value between (+1.45±0.03)-(+ 2.18±0.06), respectively (Table 2).

3.2. Chemical compounds profile

The chemical compounds in the methanolic extract of the PP, PS and HNAPS were investigated using GC-MS in accordance with the external calibration method. These compounds were characterized on the basis of the Mass Spectral Library Search Program and the data available in the literature. The chemical profile, retention times and relative peak area of the compounds are summarized in Tables 3-5. It was found that the PP, PS and HNAPS contain 35, 32 and 28 chemical compounds, respectively.

The GC-MS analysis of the PP revealed the presence of 35 chemical compounds, which were composed of epoxide, alchene-alcohol, carboxylic acid, ketone, hydrazide, ether- alcohol, diether- nitrile, carbohydrate, aldehyde, diazopirol-ketone, ester, furan, ether, phenol, alcohol, saccharide, amide, steroid. The extract of the PP was primarily composed of the 5-hydoxymethylfurfural (HMF) (38.52%), pyranone (14.02%), epoxyoleic acid (7.87%), 1,2-cyclohexane dicarboxylic acid diisononyl ester (6.75%), 6-acetyl-β-d-mannose (5.80%), furfural (3.37%), isosorbide (2.13%), 8-Oxa-1,3-diazaspiro[4.5]decane-2,4-dione (2.07%), oleic acid amide (1.61%), 2-furanmethanol (1.60%), butane, 1,2:3,4-diepoxy-(±) (1.42%), 2,4-dihydroxy-2,5-dimethyl-3(2h)-furan-3-one (1.39%), levulinic acid (1.13%), melibiose (1.09%) and D-Mannose (1.02%). The other compounds were found in low concentrations (represented less than 1% of total) (Table 3).

A total of 32 compounds were detected in the PS. These compounds were 1 polyester, 1 ester, 2 epoxides, 3 aldehydes, 6 ketones, 1 hydroxamate, 3 monosaccharides, 1 pyridine derivative, 2 carboxylic acid, 1 ether, 2 furan, 1 trisaccharide, 1 oxazole, 1 phenol, 1 saccharide, 1 amide, 3 steroid and 1 alkene. The most abundant compound in the pestil extract was HMF with a total percentage of 59.24 (Table 4).

As shown in Table 5, a total of 28 chemical compounds were detected in the HNAPS. The GC-MS analysis of the HNAPS showed that furans, ketones, carbohydrates and aldehydes were the most represented classes of compounds in this pestil, accounting for up to 91.07% of its total chemical compound. 5-hydroxymethylfurfural (HMF) was determined as the main compound in all of the samples (38.52-61.61%) (Table 3, 4 and 5).

Table 3. Chemical compounds detected in the methanolic extract of the PP

Peak Number	Compound class	Compound	Retention time (min)	Relative peak area (%)
1	Epoxide	Butane, 1,2:3,4-diepoxy-(±)	3.22	1.42
2	Alchene-Alcohol	2 propane, 1 hydroxy-	3.28	0.37
3	Carboxylic acid	D-(-)-3 acetyl thio isobutyric acid	3.36	0.35
4	Ketone	5-furan methanol	3.42	0.41
5	Hydrazide	1-pyrrolidin-2-one, N-carbohydrazide	3.45	0.29
6	Ketone	Furfural	3.523	3.37
7	Furan	2-furanmethanol	3.78	1.60
8	Diether- nitrile	4,4-Ethylenedioxy-pentanenitrile	3.96	0.17
9	Monosaccharide	D-arabinose	4.280	0.55
10	Epoxide	6-oxa-bicyclo [3.1.0] hexan-3-one	4.37	0.82
11	Aldehyde	2-furaldehyde, 5-methyl-	4.71	0.60
12	Keton	2,4-dihydroxy-2,5-dimethyl-3(2h)-furan-3-one	4.901	1.39
13	Carboxylic acid	Levulinic acid	5.74	1.13
14	Ketone	Furaneol	5.89	0.69
15	Diazopirol-Ketone	8-Oxa-1,3-diazaspiro[4.5]decane-2,4-dione	6.18	2.07
16	Ketone	Pyranone	7.17	14.02
17	Saccharide	6-acetyl-β-d-mannose	7.37	5.80
18	Ester	3-trifluoro acetoxydodecane	7.58	0.41
19	Ketone	Hydroxymaltol	7.70	0.63
20	Disaccharide	Melibiose	7.91	1.09
21	Furan	5-hydroxymethylfurfural	8.47	38.52
22	Trisaccharide	D-Melezitose	8.92	0.55
23	Ether	İsosorbide	9.26	2.13
24	Trisaccharide	Melezitose	9.48	0.13
25	Disaccharide	Maltose	9.63	0.82
26	Phenol	2,4-di-tert-butylphenol	11.96	0.98
27	Carboxylic acid	β-hydroxydodecanoic acid	12.88	0.20
28	Trisaccharide	D-(+)Melezitose	14.44	0.55
29	Alcohol	Hexadecanoic acid	18.65	0.64
30	Alcohol	1-hexadecanol, 2-methyl	20.71	0.35
31	Monosaccharide	D-Mannose	21.57	1.02
32	Amide	Oleic acid amide	26.74	1.61
33	Ester	1,2-cyclohexane dicarboxylic acid diisononyl ester	31.69	6.75
34	Epoxide	Epoxyoleic acid	32.56	7.87
35	Steroid	Ethyl iso-allocholate	35.87	0.78

Table 4. Chemical compounds detected in the methanolic extract of the PS

Peak Number	Compound class	Chemical Compound	Retention time (min)	Relative peak area (%)
1	Polyester	Butane dioic acid, 2,3-bis (acetyloxy)-	3.15	0.04
2	Ester	Carbonocyanidic acid, ethyl ester	3.24	0.18
3	Epoxide	Levoglucosenone	3.37	0.31
4	Aldehyde	Furfural	3.48	4.22
5	Furan	2-furanmethanol	3.64	1.58
6	Ketone	4-cyclopentene-1,3-dione	3.89	0.60
7	Hydroxamate	Hexanohydroxamic acid	4.12	0.38
8	Epoxide	6-oxa-bicyclo [3.1.0] hexan-3-one	4.27	0.46
9	Monosaccharide	DL-arabinose	4.42	0.37
10	Pyridine derivative	4-Hydroxypyridine 1-oxide	4.55	0.43
11	Aldehyde	2-furaldehyde,5-methyl-	4.66	0.69
12	Ketone	2,4-dihydroxy-2,5-dimethyl-3(2h)-furan-3-one	4.83	1.03
13	Ketone	2-(3-hydroxy-propyl)-cyclohexane 1,3 dione	5.09	0.57
14	Carboxylic acid	Levulinic acid	5.72	1.89
15	Ether	Cyclohexylmethane,1,1-dioldiacetate	6.12	2.67
16	Ketone	Pyranone	7.31	9.80
17	Ketone	5-hydroxymaltol	7.79	0.43
18	Aldehyde	5-acetoxymethyl-2-furaldehyde	8.20	0.34
19	Furan	5-hydroxymethylfurfural	8.68	59.24
20	Monosaccharide	6-acetyl-β-d-mannose	9.15	3.41
21	Trisaccharide	Melezitose	9.69	5.33
22	Oxazol	n-nitroso-2,4,4-trimethyl oxazolidine	9.83	3.19
23	Phenol	2-4-di-tert-butylphenol	11.97	0.23
24	Carboxylic acid	n-hexadecanoic acid	18.65	0.07
25	Ketone	1-gala-1-ido-octanoic lactone	21.57	0.15
26	Saccaride	Desulphosinigrin	22.08	0.10
27	Monosaccaride	D-Mannose	22.44	0.09
28	Amide	Oleic acid amide	26.60	1.31
29	Steroid	Ethyl iso-allocholate	32.49	0.21
30	Alkene	17-pentatriacontene	35.87	0.20
31	Steroid	Stigmasterol	37.78	0.13
32	Steroid	β-sitosterol	38.53	0.36

Table 5. Chemical compounds detected in the methanolic extract of the HNAPS

Peak Number	Compound class	Chemical Compound	Retention time (min)	Relative peak area (%)
1	Anhydride	Acetic anhydride	3.15	0.05
2	Ester	Carbonocyanidic acid, ethylester	3.24	0.19
3	Furan	2-furanmethanol	3.37	1.79
4	Aldehyde	Furfural	3.48	4.40
5	Ketone	4-cyclopentene-1,3-dione	3.89	0.58
6	Ketone	Acetyl furan	4.12	0.25
7	Epoxide	6-oxa-bicyclo [3.1.0] hexan-3-one	4.27	0.38
8	Monosaccharide	DL-arabinose	4.42	0.23
9	Pyridine derivatives	4-pyridinoloxide	4.56	0.31
10	Aldehyde	2-furaldehyde, 5-methyl-	4.66	0.54
11	Ketone	2,4-dihydroxy-2,5-dimethyl-3(2h)-furan-3-one	4.83	0.96
12	Ketone	2-(3-hydroxy-propyl)-cyclohexane 1,3 dione	5.10	0.15
13	Carboxylic acid	Levulinic acid	5.72	1.58
14	Ester	2-furancarboxylic acid, 2,2-dimethyl propyl ester	6.11	1.79
15	Ketone	Pyranone	6.78	10.90
16	Ketone	5-hydroxymaltol	7.79	0.46
17	Monosaccharide	6-acetyl-β-d-mannose	8.20	3.97
18	Furan	5-hydroxymethylfurfural	8.61	61.61
19	Trisaccharide	Melezitose	9.58	6.92
20	Disaccharide	Maltose	10.35	0.10
21	Phenol	2-4-di-tertbutylphenol	11.96	0.28
22	Steroid	Estra-1,3,5(10)-trien-17β-ol	18.65	0.09
23	Ester	Cyclopropanetetradecanoic acid 2-octyl- methyl ester	21.57	0.70
24	Amide	Oleic acid amide	26.75	0.48
25	Steroid	Ethyl iso-allocholate	32.48	0.24
26	Alkene	17-pentatriacontene	35.87	0.18
27	Tocol	α-tocopherol	36.28	0.12
28	Steroid	β-sitosterol	38.53	0.52

3.3. Antioxidant properties

Table 6 shows the total phenolic contents of PP, PS, and HNAPS. The HNAPS had the highest total phenolic content (146.57±2.13 mg GAE/g), while PP had the lowest (132.00±1.39 mg GAE/g). The higher total phenolic content of pulp and pestil samples compared to fresh fruit (130.92±1.72) can be explained by the proportional increase of dried matter,

which becomes more concentrated after boiling and drying processes.

DPPH free radical-scavenging activities of the PP, PS and HNAPS samples are also shown in Table 6. The IC_{50} (extract concentration that scavenged 50 % of free radicals) values of the DPPH radical-scavenging activities were 27.56±0.56, 21.69±0.65 and 16.79±0.35 for PP, PS and HNAPS, respectively. As it can be seen in Table 6, the ABTS radical scavenging activities of the samples varied between 9.61±0.21 and 15.28±0.15 µg/ml, while the ABTS radical scavenging activity of the standard antioxidants BHA, BHT, Trolox and α-tocopherol were found to be higher as follows; 8.37±0.83 µg/ ml, 7.94±0.73 µg/ ml, 8.05±0.75 µg/ ml and 7.92±0.68 µg/ ml, respectively. In addition, a positive correlation was determined between DPPH and ABTS radical scavenging activities at p <0.01 level (r = 0.958).

Table 6. DPPH, ABTS and total phenolic values of pulp and pestil samples

Samples	DPPH (IC_{50}, µg/ml)	ABTS (IC_{50}, µg/ml)	Total phenolic content (mg GAE/g)
PP	27.56±0.56^{f}	15.28±0.15^{d}	132.00±1.39^{a}
PS	21.69±0.65^{d}	11.11±0.32^{c}	140.35±1.12^{b}
HNAPS	16.79±0.35^{c}	9.61±0.21^{b}	146.57±2.13^{c}
BHA	10.44±0.35^{b}	8.37±0.83^{a}	-
BHT	23.15±0.57^{e}	7.94±0.73^{a}	-
Troloks	8.93±0.35^{a}	8.05±0.75^{a}	-
α-Tokoferol	10.85±0.29^{b}	7.92±0.68^{a}	-

*Values are given as mean ± standard deviation (n = 3). Statistical analysis for each column was made within itself and the different letters in the same column are significantly different at p <0.05 level.

4. Results

4.1. Physicochemical properties

When the total dry matter amounts of the pestil samples are examined (Table 2), it is thought that the higher dry matter content of the HNAPS is due to the hazelnut. The difference between the dry matter amounts of pulp and pestil samples was caused by the fact that a more concentrated product was obtained due to the removal of water during drying. Atıcı (2013) reported that the dry matter content of the plum pestil that he dried and stored by different methods was 84.70-92.60%. Ekşi and Artık (1984) found that the dry matter amount as 80.5% in pestil. Dry matter amount was found between 85.61-86.88% in starch added apricot pestil by Suna et al. (2014). Kaya and Maskan (2003) found the dry matter amount as 88.8% in starch added grape pestil. Cagindi and Otles (2005) reported that the dry matter amount between 81.7 and 88.20% in grape, mulberry and apricot pestils. The reason for the high amount of ash of the HNAPS sample is due to the hazelnut addition. Ekşi and Artık (1984) reported the ash content of plum pestil as 1.60% and Cagindi and Otles (2005) reported as 0.2-3.6% in grape, mulberry and apricot pestils. Ash content of our pestil samples is considerably higher than the values determined by other researchers.

In line with our findings, Atıcı (2013) determined the pH value between 3.19-3.40 in the plum pestil that he dried and stored with different methods. The protein content of PS (1.25±0.10%) was determined to be considerably lower than

that of HNAPS (4.39±0.14) (Table 2). The protein amount reported by researchers as 2.00% in plum pestil (Eksi and Artık, 1984) and between 3.0-4.6% in grape, mulberry and apricot pestils (Cagindi and Otles, 2005). Differences in protein amounts are due to the differences in fruits.

It was observed that there was a decrease in L*, b* and a* values. In addition, the color values of our pestils were lower than the color values found by PP. Atıcı (2013), who reported the L* values as 28.55-34.21, a* values as (+25.95)-(+29.22) and b* values as (+12.41)-(+14.22) in plum pestil, which was dried by using different methods. All of these color values are much higher than the values of our fruit pestil samples.

In the present study, some physicochemical properties was different from those reported previous studies. The cultivar, ecologic conditions, ripening stage, storage of plum fruit; processing conditions of the pulp and pestil and analyses method could be causing these differences.

4.2. Chemical compounds profile

In this study generally pestil samples contained epoxide, alchene-alcohol, carboxylic acid, ketone, hydrazide, ether-alcohol, diether- nitrile, carbohydrate, aldehyde, diazopirol-ketone, ester, furan, ether, phenol, alcohol, saccharide, amide, steroid (Table 1). PS and HNAPS contained β-sitosterol at 0.36% and 0.52%, respectively. This compound, derived from plants, is one of the most abundant phytosterols. B-sitosterol is found in natural products and foods such as vegetables, vegetable oils, fruits, berries and nuts. It has nutritional properties such as antioxidant, anticancer, angiogenic, antidiabetic, antinociceptive, antimicrobial, anti-inflammatory and immunomodulatory properties and can lower cholesterol, reduce serum lipid levels and ameliorate the oxidative damage (Cheng et al., 2020). B-sitosterol is also added to cosmetic products such as moisturizers, sunscreens, anti-aging products and liquid soaps (Santos et al., 2020). Ketones were also abundantly (6 compounds) isolated in the plum pestil. However, the levels were relatively low at approximately 12.58% of the total content of the chemical compounds (Table 4).

Rahaman et al. (2019) detected dimethyl ether, 3-Furaldehyde, 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-, Melezitose, 5-Hydroxymethylfurfural, D-Streptamine, O-6-amino-6-deoxy-alpha-D-glucopyranosyl-(1–4)-O-(3-deoxy-4-C-methyl 3(methylamino) beta-L-arabinopyranosyl, Pterin-6-carboxylic acid, 1-Nitro-2-acetamido-1 and 2-dideoxy-d-mannitol in ultrasound-assisted osmotic dehydrated dried plum and control samples. Studies in the literature have determined the aroma profile of plum fruit (Chai et al., 2012; Louw and Theron, 2012; Nunes e al., 2008), plum puree (González-Cebrino et al., 2016) and dried plum (Rahaman et al., 2019).

The pulp had a lower HMF content compared to the pestil samples (Table 3, 4 and 5). HMF can form during the thermal processing, namely the concentration and drying processes, of the pestil production. HMF formation is considered as a quality index for dried products and its amount is determined after the drying process (Kayacan et al., 2020). HMF is formed during thermal processing in the initial

stages of the Maillard reaction, which is a reaction between indirgen sugars such as glucose and fructose and proteins and it is used as an indicator of quality deterioration (Kanar and Mazı, 2019).

Furthermore, the HNAPS had a higher HMF content (61.61%) compared to the pure plum pestil (Table 4 and 5). This may be due to the addition of roasted hazelnuts in hazelnut added pestil processing. It was determined that the addition of hazelnut affected the distribution and amount of chemical compound in the pestil samples. HNAPS contained HMF more than others samples. Tontul and Topuz (2017) determined that pomegranate pestil contained 142.80-626.11 mg/kg of HMF and that the traditional pestil had the highest HMF content.

4.3. Antioxidant properties

Phenolics compounds exhibit anti-carcinogenic, anti-inflammatory and anti-mutagenic effects, mainly resulting from their antioxidant properties (Kaliora et al., 2014). Therefore, the phenolic compounds can be considered as a positive quality parameter in fruits, vegetables and their products. The high temperature exposure during the preparation of pulp, which is one of the traditional pulp production stages, has a destructive effect on polyphenols. However, the total phenolic content of the samples increased significantly ($p< 0.05$) with processing the fruit into pestil. The higher total phenolic content of pulp and pestil samples compared to fresh fruit can be explained by the proportional increase of dried matter, which becomes more concentrated after boiling and drying processes. When the studies on pestils produced from different fruits in the literature were scanned, it was seen that the reported total phenolic contents were in the range of 27.42-32.24 mg GAE/100g in mulberry pestils (Yildiz, 2013), 35.50-38.24 mg GAE/100 g in sugar beet pestils (Yildiz and Boyraci, 2020), 110.03- 121.24 mg GAE/100g in apricot pestils, respectively (Suna et al., 2014). In another study conducted on mulberry, cornelian cherry and plum pestils, the highest total phenolic content was found in plum pestil as 28.36 µg GAE/mg (Sengul et al., 2010). The results obtained in the current study are higher than these values. Differences may be related to fruit variety, kind of product, production conditions, extraction procedure or storage conditions.

As seen in Table 6, results revealed that HNAPS had significantly ($p<0.05$) higher antioxidant activity compared to other samples. DPPH assays also indicated that increases in concentration affected DPPH radical scavenging activity of the PP, PS and HNAPS. Also, the high antioxidant capacity of the hazelnut may have been effective in the high antioxidant activity of the HNAPS compared to other fruit pulp samples.

Similar to DPPH radical scavenging activity, ABTS radical scavenging activity results showed that IC50 values decreased with increasing concentration. In other words, antioxidant activity increased significantly ($p<0.05$) in the production steps of pulp produced from fruit and pestil produced from pulp.

When we compare our study with other literature, Sengul et al., (2010) found that the antioxidant activity of mulberry, cornelian cherry and plum pestils between

40.05% and 90.95%. Suna et al., (2014) determined the antioxidant activity between 19.15% and 59.81% by DPPH method in apricot pestil produced using three different drying techniques. Yıldız (2013) found that pestil with hazelnuts 82.6 mM TE g-1, pestil with walnuts 88.4 mM TE g–1 in the study of antioxidant activity in mulberry pestil with FRAP method. These differences in antioxidant values are thought to be caused by the difference in fruit variety and drying methods.

5. Conclusion

This study provided basic information about the chemical compound profiles of plum pulp, pure plum pestil and hazelnut added plum pestil of P. salicina. The analysis results of the GC-MS showed that furans, ketones, carbohydrates and aldehydes were the most abundant compounds detected in both the plum pulp and pestil samples. When the samples were evaluated in terms of antioxidant properties, it was seen that HNAPS had the highest values. This high value was thought to may be due to the added hazelnuts. In addition, despite the high temperature applied during the pestil production, it was observed that the total phenolic content and antioxidant activity was increased due to the increase in concentration. It was determined that the hazelnut added to the pestil improves the taste. With high antioxidant properties, the current product can qualify as a healthy snack. Furthermore, new products can be developed by adding different nuts to the pestil in other researches.

References

Atıcı G (2013): Determination the effects of hot air drying and microwave drying operations on the quality parameters and drying behavior of plum leather. Msc Thesis, Graduate School of Natural and Applied Sciences, Department of Food Engineering, Çukurova University, Adana, Turkey. 95 p.

Ayanoğlu H, Bayazit S, Inan G, Bakır M, Akpınar AE, Kazan K, Ergül A (2007): AFLP analysis of genetic diversity in Turkish green plum accessions (Prunus cerasifera L.) adapted to the Mediterranean region. Scientia horticulturae, 14(4): 263-267.

Batu A, Kaya C, Çatak J, Şahin C (2007): "Pestil üretim tekniği." GTED, 1: 71-81.

Birwal P, Saurabh SP (2017): Plums: a Brief Introduction. Journal of Food, Nutrition and Population Health, 1(1).

Cagindi O, Otles S (2005): Comparison of some properties on the different types of pestil: a traditional product in Turkey. International Journal of Food Science and Technology, 40: 897-901.

Cemeroğlu BS (2013): Gıda Analizleri. Bizim Grup Basımevi. Ankara, Turkey, 480 p.

Chai Q, Wu B, Liu W, Wang L, Yang C, Wang Y, Fang J, Liu Y, Li S (2012): Volatiles of plums evaluated by HS-SPME with GC–MS at the germplasm level. Food Chemistry, 130(2): 432-440.

Cheng Y, Chen Y, Li J, Qu H, Zhao Y, Wen C, Zhou Y (2020): Dietary β-sitosterol regulates serum lipid level and improves immune function, antioxidant status, and intestinal morphology in

broilers. Poultry Science, 99(3): 1400-1408.

Chowdhury MMI, Bala BK, Haque MA (2011): Mathematical modeling of thinlayer drying of jackfruit leather. Journal of Food Processing and Preservation, 35: 797-805.

Ekşi A, Artık N (1984): Pestil işleme tekniği ve kimyasal bileşimi. Gıda, 263-266. (in Turkish)

Gliszczyńska-Świgło A (2006): Antioxidant activity of water soluble vitamins in the TEAC (trolox equivalent antioxidant capacity) and the FRAP (ferric reducing antioxidant power) assays. Food Chem., 96(1): 131–136.

González-Cebrino F, García-Parra J, Ramírez R (2016): Aroma profile of a red plum purée processed by high hydrostatic pressure and analysed by SPME–GC/MS. Innovative Food Science & Emerging Technologies, 33: 108-114.

Gökçe, E. (2015). The Effects of Different Drying Parameters on the Persimmon Pestil Quality. Gaziantep, Turkey, University of Gaziantep Graduate School of Natural and Applied Sciences, M.Sc. Thesis.

Gulcin I, Oktay M, Kufrevioglu OI, Aslan A (2002): Determination of antioxidant activity of lichen Cetraria islandica (L) ach. J. Ethnopharmacol., 79: 325-329.

Kaliora AC, Kogiannou DA, Kefalas P, Papassideri IS, Kalogeropoulos N (2014): Phenolic profiles and antioxidant and anticarcinogenic activities of Greek herbal infusions; balancing delight and chemoprevention? Food Chemistry, 142: 233-241.

Kalkışım Ö, Özdemir M (2012): "Pestil ve Köme Teknolojisi." http://kutuphane.gumushane.edu.tr/media/uploads/kutuphane/files/pestil_kome. pdf. 1. Baskı, Gümüşhane, Turkey.

Kanar Y, Mazı BG (2019): HMF formation, diastase activity and proline content changes in bee pollen dried by different drying methods. LWT, 113: 108273.

Kara OO, Küçüköner E (2019): A traditional fruit snack: fruit leather. Academic Food Journal, 17(2).

Kaya S, Maskan A (2003): Water vapor permeability of pestil (a fruit leather) made from boiled grape juice with starch. Journal of Food Engineering, 57(3): 295-299.

Kayacan S, Karasu S, Akman PK, Goktas H, Doymaz I, Sagdic O (2020): Effect of different drying methods on total bioactive compounds, phenolic profile, in vitro bioaccessibility of phenolic and HMF formation of persimmon. LWT, 118: 108830.

Kurt A, Çakmakçı S, Çağlar A (1999): "Süt ve mamülleri muayene ve analiz metodları rehberi." Atatürk Üniv. Ziraat Fak. Yay. No:18, Erzurum, Turkey.

Louw ED, Theron KI (2012): Volatile dynamics during maturation, ripening and cold storage of three Japanese plum cultivars (Prunus salicina Lindl.). Postharvest Biology and Technology, 70: 13-24.

Luo MR (2006): Applying colour science in colour design. Optics & Laser Technology, 38: 392-398.

Nas S, Gökalp HY (1993): "Kuşburnu ve pestil teknolojisi ve gıda değeri."Journal of the Faculty of Agriculture, 24(2): 142-150.

Nunes, C., Coimbra, M. A., Saraiva, J. & Rocha, S. M. (2008). Study of the volatile components of a candied plum and estimation of their contribution to the aroma. Food Chemistry, 111(4): 897-905.

Özçağıran R, Ünal A, Özeker E, İsfendiyaroğlu M (2011): "Ilıman İklim Meyve Türleri: Sert Çekirdekli Meyveler." Cilt-I. Ege Üniversitesi Ziraat Fakültesi Yayınları, İzmir, Turkey. (in Turkish)

Özgüven AI, Küden A. Yılmaz C (2000): "Güneydoğu Anadolu Bölgesinde Erik Yetiştiriciliği." TUBİTAK, Adana, Turkey. 22 p. (in Turkish)

Raab C, Oehler N (2000): Making Dried Fruit Leather. Fact Sheet 232, Oregon State University Extension Service.

Rahaman A, Zeng XA, Kumari A, Rafiq M, Siddeeg A, Manzoor MF, Baloch Z, Ahmed Z (2019): Influence of ultrasound-assisted osmotic dehydration on texture, bioactive compounds and metabolites analysis of plum. Ultrasonics sonochemistry, 58: 104643.

Santos KA, Klein EJ, Fiorese ML, Palú F, Da Silva C, Da Silva EA (2020): Extraction of Morus alba leaves using supercritical CO2 and ultrasound-assisted solvent: evaluation of β-sitosterol content. The Journal of Supercritical Fluids, 159: 104752.

Sengul, M., Yildiz, H., Gungor, N. & Okcu, Z. (2010). Total phenolic content, antioxidant activity, some physical and chemical properties of pestil. Asian Journal of Chemistry, 22(1), 448-454.

Slinkard, K., & Singleton, V. L. (1977). Total phenol analysis: automation and comparison with manual methods. American journal of enology and viticulture, 28(1): 49-55.

Suna S, Tamer CE, İnceday B, Sinir GÖ, Çopur ÖU (2014): Impact of drying methods on physicochemical and sensory properties of apricot pestil. Indian Journal of Traditional Knowledge, 13(1): 47-55.

Srinivasan C, Padilla IMG, Scorza R (2005): Prunus ssp., almond, apricot, cherry, nectarine, peach and plum R.E. Litz (Ed.), Biotechnology of fruit and nut crops, CABI Publishing, Wallingford, UK, 512-542.

Tontul I, Topuz A (2017): Effects of different drying methods on the physicochemical properties of pomegranate leather (pestil). LWT, 80: 294-303.

Tunalıoğlu R, Keskin G (2004): "Erik." Tarımsal Ekonomi Araştırma Enstitüsü, 7(9): 1303-8349.

Usenik V, Kastelec D, Veberic R, Stampar F (2008): Quality changes during ripening of plums (Prunus domestica L.). Food Chemistry, 111(4): 830-836.

Walkowiak-Tomczak D (2008): Characteristics of plums as a raw material with valuable nutritive and dietary properties-a review. Polish Journal of Food and Nutrition Sciences, 58(4).

Yang Z, Zhai W (2010): Identification and antioxidant activity of anthocyanins extracted from the seed and cob of purple corn (Zea mays L.). Innov. Food Sci. Emerg. Technol., 11(1): 169-176.

Yildiz O, Aliyazıcıoğlu R, Şahin H, Aydın Ö, Kolaylı S (2011): "Ak dut (Morus alba) pekmezi, pestili ve kömesinin üretim metotları" Gümüşhane University Journal of Science and Technology Institute, 1 (1): 47-56. (in Turkish)

Yildiz O (2013): Physicochemical and sensory properties of mulberry products: Gümüşhane pestil and köme. Turkish Journal of Agriculture and Forestry, 37: 762-771.

Yildiz O, Boyraci GM (2020): Production and Some Quality Parameters of Sugar Beet Sweets (Pestil and Köme). Sugar Tech (Sept-Oct 2020) 22(5): 842–852.