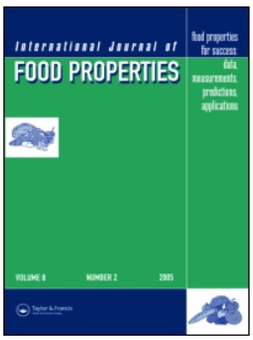

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Black plum peel jam: physicochemical properties, sensory attributes, and antioxidant capacity

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ABSTRACT

The aim of this study was to investigate the chemical composition, sensory attributes, texture properties (Back extrusion test), antioxidant activity, and phenolic compounds of black plum peel jam as a function of black plum puree (40, 50, and 60%) and pectin (0, 0.1, 0.2, 0.3, and 0.4%). Instrumental texture evaluation showed that increasing the pectin level increased texture parameters (firmness, cohesiveness, consistency, and index of viscosity), nonlinearly. Sensory evaluations showed that total acceptance decreased by black plum peel puree. It seems that brighter samples received more acceptance for panelists. Black plum peel jam including 40% puree and without pectin was determined as the best formulation among the samples. Antioxidant capacity and total phenolic compounds of black plum peel jam picked up with increasing the puree concentration. PLS analysis showed that the results of sensory and instrumental properties were in agreement with each other.

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Black plum peel; Jam; Antioxidant activity; Texture

Introduction

Plum (*Prunus subg. Prunus*) is one of the important fruits of moderate regions. This fruit originated in the area bordering the Caspian Sea. It is a single-core fruit of the apricot and peach family, with a varied flavor (from sour to sweet) and yellow, green, red, and purple colors that are present in more than thousands of varieties of fruit in color, size, and shape.[1,2] Plum is a rich source of carbohydrates and sugars, amino acids, vitamins (vitamins A, B2, C, and PP), minerals (iron, calcium, phosphorus, magnesium, manganese, fluorine, sulfur, and potassium), dietary fibers (specially pectin), and phenolic compounds .[3–6] Studies have shown that this fruit has antioxidant, anticancer, antihyperglycemic, antihyperlipidemic, antihypertensive, antiosteoporosis, and laxative activities.[7,8] Also because of sorbitol, pectin, and its phenolic compounds like anthocyanins, flavonols and carotenoids, it can be useful for human diet.[9–12] Dietary fiber of plum, especially soluble fiber appears to have health-beneficial properties, like lowering LDL cholesterol, improving glucose tolerance, and promoting Bifidobacteria in gut.[13,14]

Plum fruit is processed into foods contain, jam, marmalade, prune juice, and beverage. However, drying is the oldest and most common way of plum processing.[12] According to the FAO, the amount of plums produced in Iran in 2018 was 313,103 tons.[15] In general, every five kilograms of black plum contain one kilogram of peel. Therefore, more than 62,000 tons of plum peel was produced in Iran. During the plum drying process, a considerable amount of plum peel remains. They can pollute the environment and impose environmental cleanup costs, while it contains all the nutritional properties of plums and can be used to produce new food products.[2]

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Jam is a product derived from cooking fruits with sugar, water, acid and gelling agents such as pectin.[16] In some cases, fruit byproducts are used for jam production.[17–20] Literature review shows that there have been lots of research into the quality of jams.[19,21–31][20, 32–38] However, to our knowledge, there is no study available concerning about the physicochemical and sensory properties of black plum peel jam. The purpose of this study was to use the black plum peel for jam production and to study the chemical properties (acidity, pH, brix and moisture content), sensory attributes (flavor, color, consistency, firmness, adhesiveness, and total acceptance), texture characteristics (firmness, cohesiveness, consistency, and index of viscosity), antioxidant capacity, and total phenolic compounds of black plum peel jam in different levels of pectin and black plum peel. In the end, antioxidant capacity and phenolic compounds of black plum peel jam were compared with six jams (raspberry, strawberry, sour cherry, plum, carrot, and rose petals) in the markets. Black plum peel jam is a novel food that uses the by-product of plum processing and helps to reduce environmental pollution and improve the agricultural economy.

Materials and methods

Raw materials

Raw materials were frozen black plum peel, water, pectin, sugar, and citric acid. Plum peel was obtained from plum processing factories, Neyshabur, Iran, pectin (Green Ribbon, Citrus, 57–62% degree esterification, NATUREX, Switzerland), citric acid (Jovein, Sabzevar, Iran), and sugar from Neyshabour supermarkets, Khorasan Razavi, Iran.

Sample preparation

Black plum peels were sorted to remove impurities. After that, they were washed, crushed, and frozen. For jam production, the crushed peel mixed with water at a ratio of four times and passed through the filter to obtain a uniform material that named black plum puree. Brix and pH of black plum puree were 24 and 3.79, respectively. Black plum peel fragments (10%) with a length of 2 mm and a width of 1 mm was added to the plum puree and was heated with sugar to 60° Brix. Then, pectin and citric acid were added and the heating process was continued to 65–70° Brix and pH = 2.8–3.5. After that, jam samples were filled in glassware and placed at room temperature (25°C ±2) for 24 hours to perform the gelation process. Figure 1 shows images of black plum, dried plum, and black plum peel jam. The components of the black plum peel jam were plum puree (40, 50, and 60%) and pectin (0, 0.1, 0.2, 0.3, and 0.4%).

Chemical composition

Chemical compositions of the black plum peel jam samples were pH, Brix, acidity, and moisture content. The acidity was measured according to AOAC official method 942.15.[39] Soluble solid (Brix) was measured using a refractometer (RHBO_80, Link, Fuzhou, China). The pH was controlled by a pH meter (Sartorius PB_11, Göttingen, Germany), moisture content was measured by an oven (Fan-Azma-Gostar, Iran at 70°C). Chemical measurements were performed at three replications.

Instrumental textural properties

Texture properties of the jam samples were obtained from a backward extrusion test using a TA.XT Plus Texture Analyzer (Stable Micro Systems, England, UK). Backward extrusion quipped with a disc (45 mm diameter) was used for evaluating the textural attributes of black plum peel jam. Tests were carried out in a standard size container with 50 mm diameter and 70 mm height. During the test, the disc was displaced to a depth of 50% at 60 mm/min test speed. At this point (most likely to be the maximum force), the probe returned to its original position. The textural parameters of jam expressed

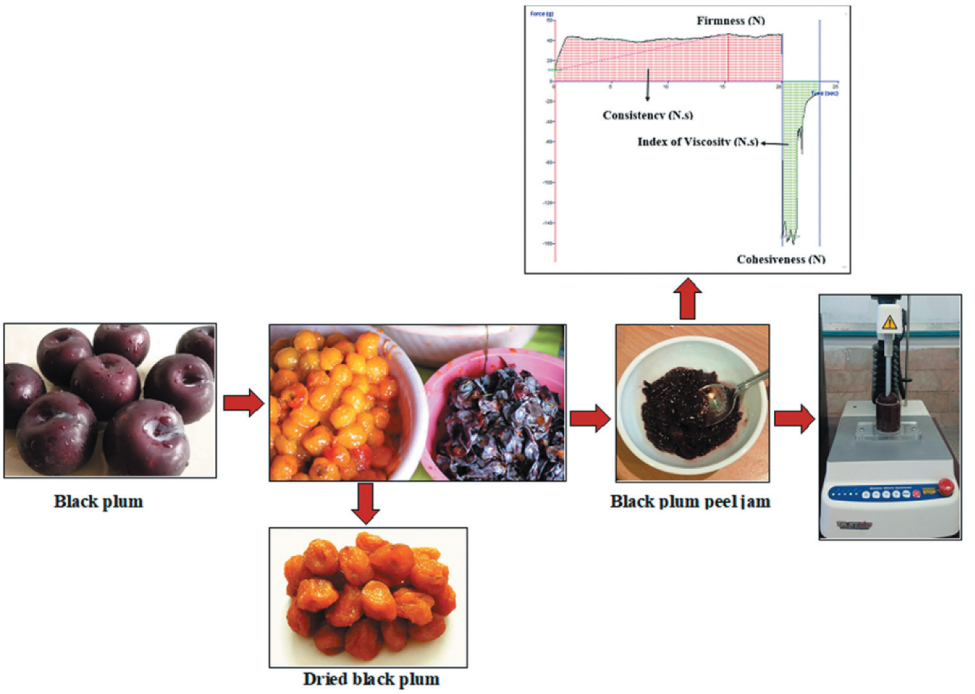

Figure 1. Black plum and plum peel, black plum peel jam and an example of Back extrusion curve.

as firmness (N), (The maximum force of graph), cohesiveness (N) (The maximum negative force), index of viscosity (The negative area of graph) (N.s), and consistency [N.s] (The positive area of curve). Back extrusion test was performed in three replications. Figure 1 shows back extrusion test and a typical curve of black plum peel jam.

Sensory properties of black plum peel jam

Sensory properties of jam were performed by 14 panelists (7 men and 7 women, 20–40 years old) from students and staff of Neyshabur University of Medical Sciences, Iran). Initially, the sensory characteristics of plum peel jam was explained to the panelists. As regards, the panelists were familiar with plum jam, so, they knew the sensory properties of the black plum peel jam, very well. Triangle test was used to identify sensory differences between the samples. Sensory attributes were evaluated by panelists according to Bourne.[2002,40] Evaluations were done at room temperature and under white fluorescent light. The nine-point hedonic scale[41] (1 = Dislike extremely, 9 = like extremely) was used to assess the sensory attributes of black plum peel jam. Seven black plum peel jam factors including flavor, color, consistency, firmness, adhesiveness, spreadability, and total acceptance were evaluated.

Antioxidant activity (AO) and total phenolic compounds (TPC)

Antioxidant compounds extracted by the method of Ref.[42] Five gram of each sample was weighed and extracted with 20 ml methanol/water solvent mixture under stirring for one hour. The extract was filtered by Whatman filter paper. The obtained extract was used to determine total phenolic compounds and antioxidant activity. Total phenolic compounds were determined using the Folin–Ciocalteu method reported by Ref.[43] The absorbance was measured at 765 nm using UV/Vis (Jenway 7315 model, U.K.) spectrophotometer. The results were expressed based on different concentrations (10–100 ppm) of gallic acid using calibration curve.

Antioxidant activity was determined using 2,2-DiPhenyl-1-PicrylHydrazyl (DPPH) method.[44] Six different concentrations of each jam extract were used. The absorbance of the samples was measured at 517 nm at UV/Vis spectrophotometer. Antioxidant activity and phenolic compounds were measured at three replications. It should be noted that antioxidant activity and phenolic compounds of various kind of jams in the markets including raspberry, strawberry, sour cherry, plum, rose petals, and carrot were also measured and compared with black plum peel jam.

Statistical analysis

Data were analyzed using the general linear model procedure with Minitab statistical software (Version 16, USA, 2010). Means were separated by Tukey analysis at a least significant difference of $P \leq 0.05$ value. Partial Least Square (PLS) was applied to explore relationships between sensory attributes, textural properties and antioxidant activity of black plum peel jam. GraphPad Prism (Version 8.0.1, USA) also utilized to plot the curves.

Results and discussion

Chemical properties

The results of chemical properties of black plum peel jams are presented in Table 1. The Brix and pH of the samples were controlled within a specified range, so, no statistical analysis was performed on them. The results showed that the Brix and pH of the samples were in the range of 70–75% and 2.80–4.00, respectively.

Increasing the concentration of black plum peel puree rose acidity that can be due to the low pH of the black plum peel (pH = 3.79). The acidity declined with increasing pectin content Table 1. Increasing the concentration of pectin caused to form a tighter gel network and kept the acid inside. Therefore, the amount of acid in the aqueous medium decreased and acidity was reduced. The acidity of jams varied from 0.38–0.58%.

The results indicated that significant decrease ($P < .05$) in moisture content when the black plum peel level was increased that is due to tighter texture in samples with higher black plum peel Table 1. The moisture content of samples varied from 28.25 to 34.45%.[24] reported Brix = 68, pH = 3.42 and acidity = 0.34 for black plum (Vitex doniana) jam. The result of their study was a little different from the results obtained in this study, which is due to the difference in variety (Vitex doniana) and composition of black plum that they used. In other study[25] reported pH = 3.39–4.05, acidity = 0.84–-2.32, dry matter = 49.01–63.7% and soluble dry matter = 42.57–68.13% for sugar free traditional plum jam.

Table 1. The effect of pectin and puree concentrations on chemical properties, antioxidant activity and phenolic compounds of black plum peel jam.

Variable	Concentration (%)	Brix (%)	pH	Acidity (%)	Moisture content (%)	AO (%)	TPC (mg GAE/100 g FW)
Pectin	0	74.3 ± 0.2	3.16 ± 0.08	^{a}0.52 ± 0.02	28.43 ± 2.00	^{a}30.00 ± 2.01	432 ± 12
	0.1	70.0 ± 0.5	3.16 ± 0.09	^{b}0.48 ± 0.02	31.85 ± 1.00	^{b}27.30 ± 3.56	400 ± 17
	0.2	70.0 ± 0.5	3.22 ± 0.10	^{ab}0.47 ± 0.01	30.74 ± 1.02	^{b}27.71 ± 3.42	392 ± 11
	0.3	70.0 ± 0.5	3.20 ± 0.04	^{ab}0.45 ± 0.02	30.74 ± 1.45	^{b}27.71 ± 3.78	378 ± 8
	0.4	71.0 ± 0.6	3.19 ± 0.04	^{b}0.40 ± 0.01	31.83 ± 2.04	^{c}25.87 ± 3.12	372 ± 10
Black plum peel	40	71.0 ± 0.6	3.23 ± 0.07	^{b}0.45 ± 0.03	^{a}31.06 ± 1.26	^{c}20.94 ± 3.04	^{c}304 ± 10
	50	71.4 ± 0.5	3.17 ± 0.07	^{a}0.50 ± 0.04	^{b}29.48 ± 2.03	^{b}28.13 ± 4.02	^{b}402 ± 14
	60	70.8 ± 0.6	3.16 ± 0.12	^{a}0.49 ± 0.55	^{b}29.33 ± 1.14	^{a}34.08 ± 5.02	^{a}487 ± 16

Instrumental textural properties

Texture is an important parameter for sensory acceptance and depends on the composition of raw materials. Texture analysis can be considered as an imitation of the mastication operation and may be used to predict the behavior of a semisolid food in mouth.[40] The graph of a typical back extrusion test for black plum peel jam is shown in Figure 1.

Firmness, or the resistance of the food to deformation under an applied force, is one of the most researched texture attributes for a wide variety of foods. It can be determined either by human senses using touch or sight or instrumentally.[40] Significant increase ($P < .05$) in the firmness of samples was observed with increase in pectin concentration Figure 2. As the pectin concentration increases and the pH reduces, the number of H^+ in the methyl groups of pectin structure increased, leading to a decreased interchain repulsion. So, the binding of pectin with sugar increases and the denser and tighter gel network is formed and firmness increases. This result was similar to the findings of[25] for sugar-free traditional plum jam.

Cohesiveness is the negative force for the first bite representing the force required to pull the plunger away from the food.[40] The results showed that cohesiveness increased non-linearly with increasing the level of pectin ($P < .05$) Figure 2. It seems that increasing the level of pectin and interaction with crude fiber and carbohydrates in black plum peel causes to increase the amount of bonding between components in the formulation and the cohesiveness increased.

Results of ANOVA showed that pectin concentration had significant effect ($P < .05$) on consistency of samples. Generally, the more the pectin concentration, the higher the consistency Figure 2. It may be due to increase in firmness of samples with increasing the pectin concentration. Index of viscosity defined as the degree of resistance to flow. The results of texture measurement showed that increasing the pectin concentration increased the index of viscosity, nonlinearly Figure 2.

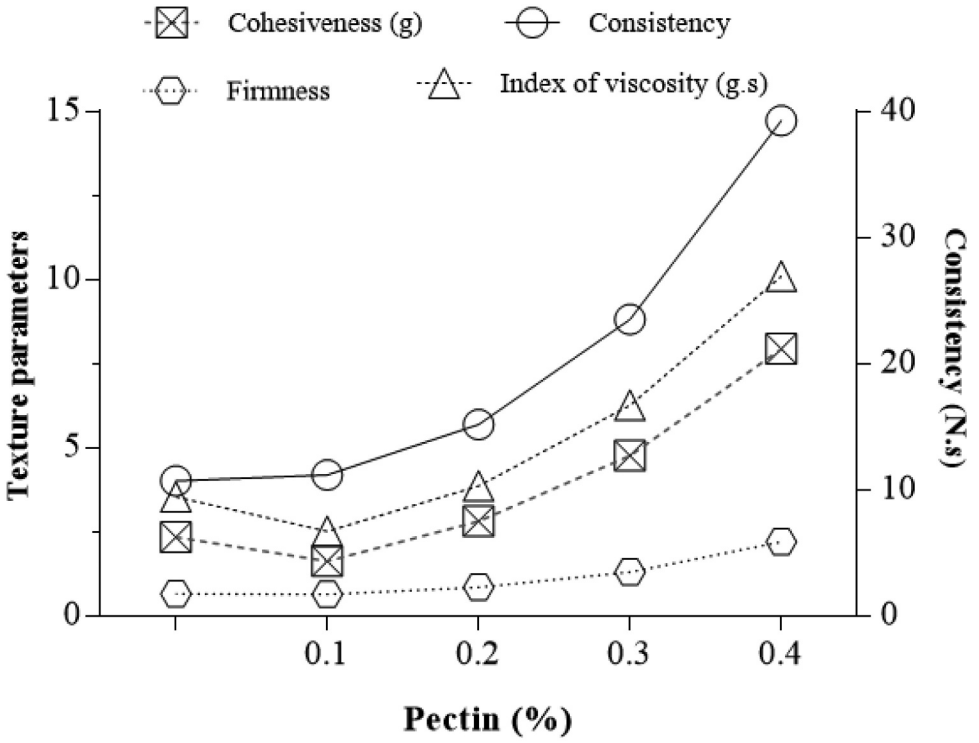

Figure 2. The effect of pectin concentration on textural properties of black plum peel jam.

The effect of black plum peel level on firmness, cohesiveness, consistency and index of viscosity was not dramatic ($P > .05$). The firmness, cohesiveness, consistency and index of viscosity of black plum peel jam samples ranged 0.65–2.21 N, 1.63–7.94 N, 10.72–39.29 N.s, and 2.52–39.29 N.s, respectively.

Sensory evaluation

Sensory properties of foods is affected by many factors contain kind of food, the environment and individual as a consumer. For semisolid foods, in addition to price, consumer acceptability is determined by food sensory attributes including flavor, texture, appearance, and packaging. Acceptability is a subjective measure based on hedonics (pleasure) and it can be influenced by the sensory properties of the food, expectations of consumer, culture, physiological status like hunger, thirst, illness, and many other factors .[45–47]

Color is the first feature that motivates and attracts buyers to buy food. Environment doesn't play important role in conveying information about color and awareness of color is deeply engrained in our genes.[48] Results of ANOVA showed that black plum peel puree concentration had significant effect ($P < .05$) on color acceptance of samples. Generally, the more the puree concentration, the less the color acceptance jams Figure 3. From the panelists' point of view, brighter examples seem to be more acceptable. The samples containing 0.2% pectin, 40% plum peel, and 0.3% pectin, 60% plum puree had the highest and lowest color score, respectively.

Firmness is the force to compress semisolid foods partially.[40] Similar to instrumental measurement, panelists' perception of firmness increased significantly ($P < .05$) with increase in pectin level. Effect of black plum peel puree on firmness was not significantly important ($P > .05$). The results showed that the samples

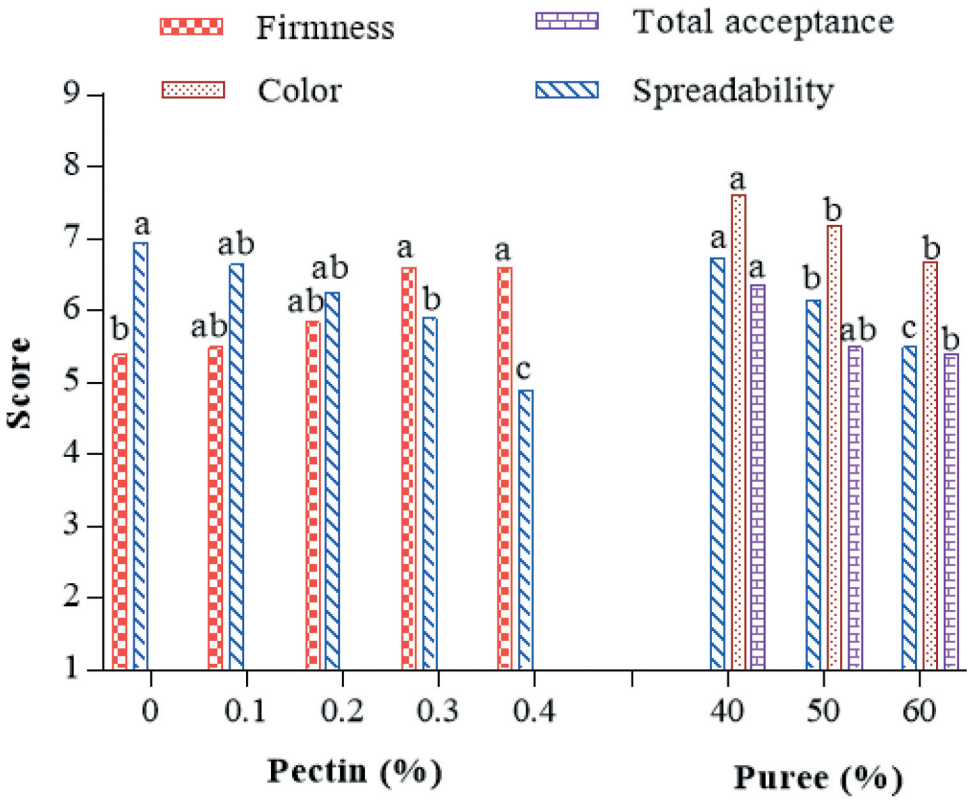

Figure 3. The effect of black plum peel puree and pectin concentrations on sensory properties of black plum peel jam.

containing 0.4% pectin, 50% plum peel and 0.1% pectin, and 40% plum puree had the highest and least firmness score, respectively.

Spreadability is the ease of moving of food product in term of viscosity and it's evaluated using circular and gentle motion.[40] The general acceptance of jam by consumers depends on how it is deformed and spread on the bread.[49] Increasing the black plum peel puree and pectin level significantly reduced the spreadability of samples ($P < 0/05$) Figure 3. It seems that increasing pectin level and interaction between pectin with carbohydrates and crude fiber of black plum peel caused to form the stiffer and stronger gel network and spreadability was decreased. The samples without pectin, 40% black plum peel, and 0.4% pectin, 60% black plum puree had the highest and lowest spreadabilty score, respectively.

The sensory acceptability of foods are extremely important because people obtain great enjoyment from eating their food and, furthermore, the enjoyment of food is a sensory pleasure that is appreciated from the cradle to the grave.[40] Results of ANOVA showed that increasing the concentration of black plum peel puree decreased the acceptability of samples Figure 3. This can be due to the darkening of the color, a decrease in transparency and tightening of its texture with an increase in black plum peel puree concentration. The sample with no pectin and 40% black plum peel had the highest total acceptance and the sample without pectin and 50% black plum puree had the lowest total acceptance. Sensory evaluation indicated that black plum peel jam was acceptable to consumers.[25] used to plum for sugar free traditional jam production. The results of their study showed that plum sugar free jam had good taste, moderate sweetness and sourness, very dark color and very hard consistency. According to panelists plum jam was acceptable.[24] reported that black plum jam had good color, high flavor and spreadability and acceptable with panelists.

Antioxidant activity and phenolic compounds

Significant increase ($P < .05$) in the antioxidant activity and total phenolic compounds of samples was observed with increase in black plum peel puree concentration Table 1. Most of phenolic compounds especially anthocyanins and neochlorogenic acid are concentrated in the plum peel, moreover, antioxidant activity, and phenolic compounds have strong correlation with each other .[50–54] The results of this study showed that total phenolic compounds of jam samples are excellent and higher than plum fruit.[55] reported the average TPC in 13 plum cultivars as 370 mg GAE/100 g FW, while, TPC of black plum peel jams varied from 242 to 670 mg GAE 100/g FW. It's reported that plum fruit with dark purple color contained over 200% higher TPC than others.[53] So it's logical to increase TPC and AO by increasing black plum peel puree concentration. The results showed that AO decreased with increasing the pectin concentration ($P < .05$) Table 1. It maybe, increasing the pectin level increased the amount of bonding water and components in the formulation and AO and TPC were trapped in the gel network. Increasing pectin concentration had no significant effect on phenolic compounds ($P > .05$). Antioxidant activity of black plum peel jam ranged 15.43–45.54%. The TPC of black plum peel jam was higher than bilberry jam[30] and gabiroba jam[29] and lower than strawberry and cherry[28] and seabuckthorn[27] jams.

Table 2 shows the antioxidant activity and phenolic compounds of raspberry, strawberry, cherry, plum, rose petals and carrot jams in the markets and in comparison with the best black plum peel jam formulation (without pectin and 40% black plum peel). It can be seen, rose petals, and raspberry jam had the highest AO and TPC, respectively. Antioxidant capacity and total phenolic compounds of black plum peel jam was higher than carrot jam and close to the plum jam.

Correlation between sensory and instrumental variables

Texture evaluation is very important in developing and optimizing the processing of new foods. Both sensory evaluation and instrumental measurements are used in food texture researches. The sensory attributes of semisolid foods are texture dependent. Correlation are generally used to assess the relationship between the instrumental measurement and sensory perception in order to predict

Table 2. Antioxidant activity and phenolic compounds of different jams in the markets in comparison with the best formulation of black plum peel jam.

Jam	AO (%)	TPC (mg GAE/100 g FW)
Black plum peel (Best formulation)	26.56 ± 2.00	338.75 ± 10.65
Raspberry	52.24 ± 4.25	1384.94 ± 10.25
Strawberry	40.87 ± 3.18	1068.09 ± 11.20
Sour cherry	48.40 ± 4.23	1122.02 ± 9.89
Plum	18.59 ± 2.35	342.25 ± 3.56
Carrot	2.56 ± 0.20	182.70 ± 4.25
Rose petal	79.64 ± 4.35	1043.37 ± 10.25

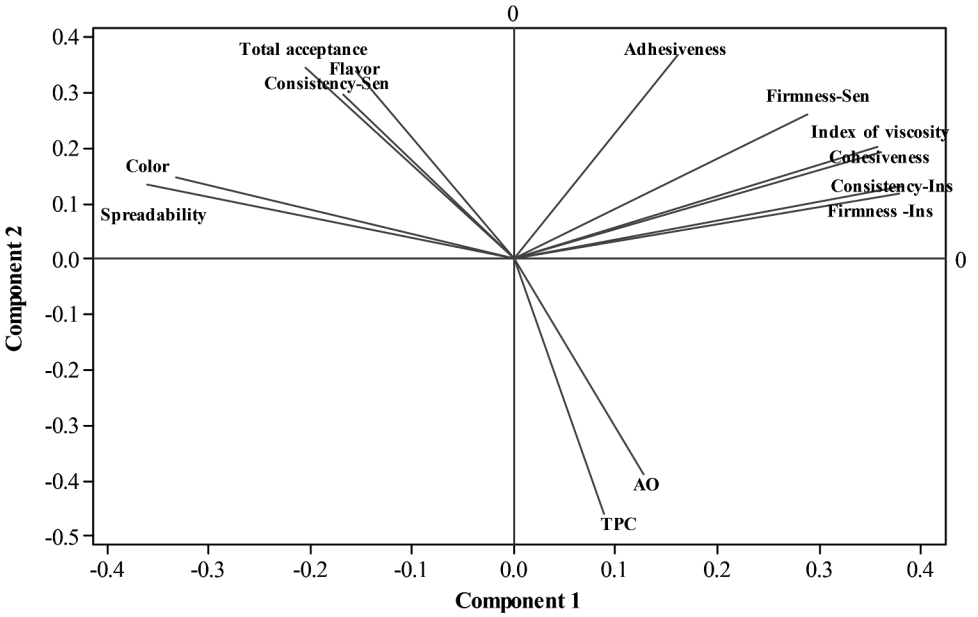

Figure 4. Correlation between sensory and instrumental properties of black plum peel jam.

consumer responses or to evaluate quality control tools or parameters.[56] Obtaining a high correlation between textural and sensory properties has been the goal of scientists include food scientists, physicists, psychologists and dentists.[40,46]

Figure 4a shows the results from PLS2 regression analysis, which describe the relationship between instrumental and sensory properties. It can be seen, color-spreadability, sensory consistency-total acceptance, instrumental firmness-instrumental consistency, and cohesiveness-index of viscosity are highly correlated, because angles between them are small. It seems that all parameters have the same importance, becase the length of the lines is almost the same. The first and second PLS represented 63% and 61% of the variations fore pectin and puree, respectively. Sensory properties contain color, total acceptance, flavor, consistency, and spreadabiliy were positively correlated together and negatively correlated with sensory firmness and adhesiveness, texture parameters, AO and TPC. That is to say, the lower the textural values, AO, TPC, adhesiveness, and sensory firmness, the higher acceptance scores and total acceptability. In other words, the panelists preferred softer and brighter samples with lower texture parameters, AO and TPC. This finding is similar to the results of Ref.[25] According to their results good correlation was found between the textural properties and sensory attributes of sugar-free plum jam

Conclusion

Black plum peel is the by-product of black plum drying, which has nutritional properties such as vitamins, minerals, carbohydrates, and crude fibers. It is a wealthy source of antioxidant activity and phenolic compounds and it can be used to produce novel foods. In this study, chemical, sensory and textural properties, antioxidant capacity, and phenolic compounds of black plum peel jam in different levels of black plum puree and pectin was studied. Sensory evaluations showed that the sample containing 40% black plum peel puree and without pectin had the highest acceptance. Increasing black plum puree decreased the total acceptance of the samples. Texture measurement showed that increasing the pectin concentration increased all texture parameters nonlinearly. Black plum peel jam is a novel food that uses the by-product of plum processing and helps to reduce environmental pollution and improve the agricultural economy.

Acknowledgments

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References

[1] Bolin, H.;. Effect of Processing on Nutrient Composition and Texture of Prunes. *J. Food Qual.* 1977, *1*(2), 125–133. DOI: 10.1111/j.1745-4557.1977.tb00935.x.
[2] Renard, C. M.; Ginies, C. Comparison of the Cell Wall Composition for Flesh and Skin from Five Different Plums. *Food Chem.* 2009, *114*(3), 1042–1049. DOI: 10.1016/j.foodchem.2008.10.073.
[3] Donovan, J. L.; Meyer, A. S.; Waterhouse, A. L. Phenolic Composition and Antioxidant Activity of Prunes and Prune Juice (Prunus Domestica). *J. Agric. Food Chem.* 1998, *46*(4), 1247–1252. DOI: 10.1021/jf970831x.
[4] Jhones JS, Bullis DE (1929). The chemical composition and food value of Oregon dried prunes. Agric. Exp. Station Bull., 249, 1–10.
[5] Kimura, Y.; Ito, H.; Kawaji, M.; Ikami, T.; Hatano, T. Characterization and Antioxidative Properties of Oligomeric Proanthocyanidin from Prunes, Dried Fruit of Prunus Domestica L. *Biosci., Biotechnol., Biochem.* 2008, *72*(6), 1615–1618. DOI: 10.1271/bbb.70823.
[6] Siddiq, M.;. Plums and Prunes. In *Handbook of Fruits and Fruit Processing*, editor : Hui, Y. H. , Blackwell Publishing , Oxford, pp 553.
[7] Jabeen, Q.; Aslam, N. The Pharmacological Activities of Prunes: The Dried Plums. *J. Med. Plants Res.* 2011, *5*(9), 1508–1511.
[8] Bennett, L. E.; Singh, D. P.; Clingeleffer, P. R. Micronutrient Mineral and Folate Content of Australian and Imported Dried Fruit Products. *Crit. Rev. Food Sci. Nutr.* 2010, *51*(1), 38–49. DOI: 10.1080/10408390903044552.
[9] Balasundram, N.; Sundram, K.; Samman, S. Phenolic Compounds in Plants and Agri-industrial By-products: Antioxidant Activity, Occurrence, and Potential Uses. *Food Chem.* 2006, *99*(1), 191–203. DOI: 10.1016/j.foodchem.2005.07.042.
[10] Chun, O. K.; Kim, D.-O.; Moon, H. Y.; Kang, H. G.; Lee, C. Y. Contribution of Individual Polyphenolics to Total Antioxidant Capacity of Plums. *J. Agric. Food Chem.* 2003, *51*(25), 7240–7245. DOI: 10.1021/jf0343579.
[11] Stacewicz-Sapuntzakis, M.; Bowen, P. E.; Hussain, E. A.; Damayanti-Wood, B. I.; Farnsworth, N. R. Chemical Composition and Potential Health Effects of Prunes: A Functional Food? *Crit. Rev. Food Sci. Nutr.* 2001, *41*(4), 251–286. DOI: 10.1080/20014091091814.
[12] Walkowiak-Tomczak, D.;. Characteristics of Plums as a Raw Material with Valuable Nutritive and Dietary Properties-a Review. *Pol. J. Food Nutr. Sci.* 2008, *58*(4), 401–405.
[13] Das, L.; Bhaumik, E.; Raychaudhuri, U.; Chakraborty, R. Role of Nutraceuticals in Human Health. *J. Food Sci. Technol.* 2012, *49*(2), 173–183. DOI: 10.1007/s13197-011-0269-4.
[14] Ahmed, F.; Sairam, S.; Urooj, A. In Vitro Hypoglycemic Effects of Selected Dietary Fiber Sources. *J. Food Sci. Technol.* 2011, *48*(3), 285–289. DOI: 10.1007/s13197-010-0153-7.
[15] FAO. Food and Agriculture Organization of the United Nations. 2020.
[16] Bhatia, S. C.;. *Canning and Preservation of Fruit and Vegetables*; Small Industry Research Institute (SIRI): Delhi, India, 1977.
[17] Mazaheri Tehrani, M.; Razavi, S. M. A., . Using of Orange Pomace for Marmalade Processing. *Zeiton J.* 1997, *141*, 61–62.

[18] Belović, M.; Torbica, A.; Pajić-Lijaković, I.; Mastilović, J. Development of Low Calorie Jams with Increased Content of Natural Dietary Fibre Made from Tomato Pomace. *Food Chem.* 2017, *237*, 1226–1233. DOI: 10.1016/j.foodchem.2017.06.045.
[19] Moghaddam, T. M.; Razavi, S. M.; Malekzadegan, F.; Ardekani, A. S. Chemical Composition and Rheological Characterization of Pistachio Green Hull's Marmalade. *J. Texture Stud.* 2009, *40*, 390–405. DOI: 10.1111/j.1745-4603.2009.00188.x.
[20] Mohammadi Moghaddam, T.; Salehi, F.; Razavi, S. M. A. Sensory Acceptability Modeling of Pistachio Green Hull's Marmalade Using Fuzzy Approach. *J. Nuts (Int. J. Nuts relate. sci)* 2011, *2*(2), 1–8.
[21] Saenz, C.;. Processing Technologies: An Alternative for Cactus Pear (Opuntia Spp.) Fruits and Cladodes. *J. Arid Env.* 2000, *46*(3), 209–225. DOI: 10.1006/jare.2000.0676.
[22] Basu, S.; Shivhare, U. Rheological, Textural, Micro-structural and Sensory Properties of Mango Jam. *J. Food Eng.* 2010, *100*(2), 357–365. DOI: 10.1016/j.jfoodeng.2010.04.022.
[23] Basu, S.; Shivhare, U. Rheological, Textural, Microstructural, and Sensory Properties of Sorbitol-substituted Mango Jam. *Food Bioprocess. Technol.* 2013, *6*(6), 1401–1413. DOI: 10.1007/s11947-012-0795-8.
[24] Ajenifujah-Solebo, S.; Aina, J. Physico-chemical Properties and Sensory Evaluation of Jam Made from Black-plum Fruit (Vitex Doniana). *Afr. J. Food Agric. Nutr. Dev.* 2011, *11*(3). DOI: 10.4314/ajfand.v11i3.66629.
[25] Culetu, A.; Manolache, F.; Duta, D. Exploratory Study of Physicochemical, Textural and Sensory Characteristics of Sugar-Free Traditional Plum Jams. *J. Texture Stud.* 2014, *45*(2), 138–147. DOI: 10.1111/jtxs.12057.
[26] Howard, L. R.; Castrodale, C.; Brownmiller, C.; Mauromoustakos, A. Jam Processing and Storage Effects on Blueberry Polyphenolics and Antioxidant Capacity. *J. Agric. Food Chem.* 2010, *58*(7), 4022–4029. DOI: 10.1021/jf902850h.
[27] Selvamuthukumaran, M.; Khanum, F. Processing Seabuckthorn Fruit for Antioxidant Rich Jam Development and Shelf Stability Assessment. 2014.
[28] Rababah TM, Al-Mahasneh MA, Kilani I, Yang W, Alhamad MN, Ereifej K, Al-u'datt M. Effect of jam processing and storage on total phenolics, antioxidant activity, and anthocyanins of different fruits. *J. Sci Food Agric.* 2011 Apr;91(6):1096–1102.
[29] MdS, S.; JJd, L.; CLdO, P.; Candido, L. M. B. Chemical Characterization and Evaluation of the Antioxidant Potential of Gabiroba Jam (Campomanesia Xanthocarpa Berg). *Acta Scientiarum Agronomy* 2013, *35*(1), 73–82.
[30] Korus, A.; Jaworska, G.; Bernaś, E.; Juszczak, L. Characteristics of Physico-chemical Properties of Bilberry (Vaccinium Myrtillus L.) Jams with Added Herbs. *J. Food Sci. Technol.* 2015, *52*(5), 2815–2823. DOI: 10.1007/s13197-014-1315-9.
[31] Wojdyło, A.; Oszmiański, J.; Teleszko, M.; Sokół-Łętowska, A. Composition and Quantification of Major Polyphenolic Compounds, Antioxidant Activity and Colour Properties of Quince and Mixed Quince Jams. *Int. J. Food Sci. Nutr.* 2013, *64*(6), 749–756. DOI: 10.3109/09637486.2013.793297.
[32] Melgarejo, P.; Martínez, R.; Hernández, F.; Martínez, J.; Legua, P. Anthocyanin Content and Colour Development of Pomegranate Jam. *Food Bioprod. Process.* 2011, *89*(4), 477–481. DOI: 10.1016/j.fbp.2010.11.004.
[33] Touati, N.; Tarazona-Díaz, M. P.; Aguayo, E.; Louaileche, H. Effect of Storage Time and Temperature on the Physicochemical and Sensory Characteristics of Commercial Apricot Jam. *Food Chem.* 2014, *145*, 23–27. DOI: 10.1016/j.foodchem.2013.08.037.
[34] Kamiloglu, S.; Pasli, A. A.; Ozcelik, B.; Van Camp, J.; Capanoglu, E. Influence of Different Processing and Storage Conditions on in Vitro Bioaccessibility of Polyphenols in Black Carrot Jams and Marmalades. *Food Chem.* 2015, *186*, 74–82. DOI: 10.1016/j.foodchem.2014.12.046.
[35] Tomas, M.; Toydemir, G.; Boyacioglu, D.; Hall, R. D.; Beekwilder, J.; Capanoglu, E. Processing Black Mulberry into Jam: Effects on Antioxidant Potential and in Vitro Bioaccessibility. *J. Sci. Food Agric.* 2017, *97*(10), 3106–3113. DOI: 10.1002/jsfa.8152.
[36] Corrêa, R. C.; Haminiuk, C. W.; Sora, G. T.; Bergamasco, R.; Vieira, A. M. Antioxidant and Rheological Properties of Guava Jam with Added Concentrated Grape Juice. *J. Sci. Food Agric.* 2014, *94*(1), 146–152. DOI: 10.1002/jsfa.6233.
[37] Lotufo Haddad, A. M.; Margalef, M. I.; Armada, M.; Goldner, M. C. Physico-chemical and Sensory Properties of Marmalades Made from Mixtures of Fruits and Under-exploited Andean Tubers. *J. Sci. Food Agric.* 2017, *97*(12), 4124–4134. DOI: 10.1002/jsfa.8280.
[38] Lafarga, T.; Aguiló-Aguayo, I.; Bobo, G.; Chung, A. V.; Tiwari, B. K. Effect of Storage on Total Phenolics, Antioxidant Capacity, and Physicochemical Properties of Blueberry (Vaccinium Corymbosum L.) Jam. *J. Food Process. Preserv.* 2018, *42*(7), e13666. DOI: 10.1111/jfpp.13666.
[39] AOAC Titratable Acidity of Fruit Products *Off Methods Anal AOAC Int.* 1999, 82, 10–11
[40] Bourne, M.;. *Food Texture and Viscosity: Concept and Measurement*; Academic press, New York, 2002.
[41] ISO P. 4121. *Sensory analysis—Guidelines for the Use of Quantitative Response Scales Polski Komitet Normalizacyjny*; Warsaw, Poland, Polski Komitet Normalizacyjny, 2003.
[42] Moo-Huchin, V.M., Moo-Huchin, M.I., Estrada-León, R.J., Cuevas-Glory, L., Estrada-Mota, I.A., Ortiz-Vázquez, E., Betancur-Ancona, D. and Sauri-Duch, E., 2015. Antioxidant compounds, antioxidant activity and phenolic

content in peel from three tropical fruits from Yucatan, Mexico. *Food chemistry*, 166, pp.17-22. DOI: 10.1016/j.foodchem.2014.05.127.

[43] Spanos, G. A.; Wrolstad, R. E. Influence of Processing and Storage on the Phenolic Composition of Thompson Seedless Grape Juice. *J. Agric. Food Chem.* 1990, *38*(7), 1565–1571. DOI: 10.1021/jf00097a030.

[44] Brand-Williams, W.; Cuvelier, M.-E.; Berset, C. Use of a Free Radical Method to Evaluate Antioxidant Activity. *LWT Food Sci. Technol.* 1995, *28*(1), 25–30. DOI: 10.1016/S0023-6438(95)80008-5.

[45] Murray, J.; Baxter, I. SENSORY EVALUATION| Food Acceptability and SENSORY Evaluation. 2003.

[46] Joyner, H. S. (Ed.). (2019). *Rheology of Semisolid Foods. Springer International Publishing*. https://doi.org/10.1007/978-3-030-27134-3.

[47] Costell, E.; Tárrega, A.; Bayarri, S. Food Acceptance: The Role of Consumer Perception and Attitudes. *Chemosens. percept*. 2010, *3*(1), 42–50. DOI: 10.1007/s12078-009-9057-1.

[48] Stich, E.;. Food Color and Coloring Food: Quality, Differentiation and Regulatory Requirements in the European Union and the United States. In *Handbook on Natural Pigments in Food and Beverages*, Editors: Reinhold Carle, Ralf Schweiggert, Woodhead Publishing, Cambridge, 2016; pp 3–27.

[49] Sun, A.; Gunasekaran, S. Measuring Rheological Characteristics and Spreadability of Soft Foods Using a Modified Squeeze-flow Apparatus. *J. Texture Stud.* 2009, *40*(3), 275–287. DOI: 10.1111/j.1745-4603.2009.00181.x.

[50] Gil, M. I.; Tomás-Barberán, F. A.; Hess-Pierce, B.; Kader, A. A. Antioxidant Capacities, Phenolic Compounds, Carotenoids, and Vitamin C Contents of Nectarine, Peach, and Plum Cultivars from California. *J. Agric. Food Chem.* 2002, *50*(17), 4976–4982. DOI: 10.1021/jf020136b.

[51] Kim, D.-O.; Jeong, S. W.; Lee, C. Y. Antioxidant Capacity of Phenolic Phytochemicals from Various Cultivars of Plums. *Food Chem.* 2003, *81*(3), 321–326. DOI: 10.1016/S0308-8146(02)00423-5.

[52] Kim, D.-O.; Chun, O. K.; Kim, Y. J.; Moon, H.-Y.; Lee, C. Y. Quantification of Polyphenolics and Their Antioxidant Capacity in Fresh Plums. *J. Agric. Food Chem.* 2003, *51*(22), 6509–6515. DOI: 10.1021/jf0343074.

[53] Raynal, J.; Moutounet, M.; Souquet, J. M. Intervention of Phenolic Compounds in Plum Technology. 1. Changes during Drying. *J. Agric. Food Chem.* 1989, *37*(4), 1046–1050. DOI: 10.1021/jf00088a050.

[54] Tomás-Barberán, F. A.; Gil, M. I.; Cremin, P.; Waterhouse, A. L.; Hess-Pierce, B.; Kader, A. A. HPLC– DAD–ESIMS Analysis of Phenolic Compounds in Nectarines, Peaches, and Plums. *J. Agric. Food Chem.* 2001, *49*(10), 4748–4760. DOI: 10.1021/jf0104681.

[55] Chun, O. K.; Kim, D.-O. Consideration on Equivalent Chemicals in Total Phenolic Assay of Chlorogenic Acid-rich Plums. *Food Res. Int.* 2004, *37*(4), 337–342. DOI: 10.1016/j.foodres.2004.02.001.

[56] Szczesniak, A. S.;. Correlating Sensory with Instrumental Texture Measurements—an Overview of Recent Developments 1. *J. Texture Stud.* 1987, *18*(1), 1–15. DOI: 10.1111/j.1745-4603.1987.tb00566.x.