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Investigating the effect of sensory properties of black plum peel marmalade on consumers acceptance by Discriminant Analysis

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ABSTRACT

One of the goals of producing and developing new products is to provide desirable features to the target community, followed by promoting marketability and gaining more market share in similar products basket. In this study, in order to investigate the effect of sensory characteristics of black plum marmalade on its acceptance, sample data with 180 observations and discriminant analysis method were used. The sensory properties that were evaluated in this product included color, flavor, firmness, adhesiveness and spreadability. Discriminant analysis classified 89% of observations correctly in the acceptance and non-acceptance classes. Accordingly, the characteristics of color, consistency, flavor, hardness and spreadability had a positive and significant effect on the acceptance of the product by the respondents and adhesiveness had a negative and significant effect on the acceptance of the product. Also, based on these results, the largest contribution in discriminating the acceptance and non-acceptance of this product is related to the spreadability, flavor and hardness, respectively. Therefore, in order to attract customers and market effectiveness, it is suggested to pay special attention to these characteristics in the production of black plum marmalade.

1. Introduction

Plum (prune) is a fruit from *Rosacea* family and *Prunus* genus and the origin of that is from the border of the Caspian Sea. Plums are consumed fresh or processed (Stacewicz-Sapuntzakis et al., 2001). Prune fruits have different color (yellow, red, and purple or black), flavor (from sour to sweet), shape (spherical or oval), size (6–10 cm), and ripening date (Łucka, 1994; SOMOGAI, 2005). According to the FAO, Iran is one of the largest producer of prunes in the world by 313,103 tons in 2018 (FAO, 2020). It's reported that more than 50,000 tons of plum peel was produced in Iran (Jihad Agriculture, 2020). Nutritionally, prune is a useful fruit and a rich source of carbohydrates, amino acids, vitamins, minerals, dietary fibers, and phenolic compounds (Donovan et al., 1998; Jones and Bullis, 1929; Kimura et al., 2008; SIDDIQ, 2006). It is a fruit with antioxidant, anticancer, antihyperglycemic, anti-hyperlipidemic, antihypertensive, anti-osteoporosis, and laxative activities (Jabeen and Aslam, 2011).

During the plum drying process, a considerable amount of plum peel remains. Moisture content, bulk of this material and its spoilage can pollute the environment. Although, it contains valuable compounds and it can be used to produce high value products (Mohammadi-Moghaddam et al., 2020a). Black plum peel marmalade is a semisolid food and it's made of black plum peel, water, sugar, citric acid, and pectin. This food can be used for breakfast or in cookies, cakes and chocolates as confectionary products. There are a number of published researches about the usage of chemometric methods for classification of fruit products (Powers and Keith, 1968; Jahanbakhshi and Kheiralipour, 2020; Lashgari and Mohammadigol, 2016; Hidalgo et al., 2018; Zimmer and Schneider, 2019; Abad-García et al., 2012; Mitic et al., 2014; Zielinski et al., 2014; Gliszczyńska-Świgło et al., 2018; Mohammadi-Moghaddam et al., 2020b; Moghaddam et al., 2016; Estaji et al., 2020). Our studies showed that, no published literature was found on the usage of Discriminant Analysis (DA) for classification of semisolid foods like jam and marmalade. So, the objectives of this study were to (1) usage of Discriminant Analysis to divide the black plum peel marmalade into acceptable and unacceptable categories (2) study the effect of pectin and black plum peel concentrations on the acceptance of samples (3) Identify the effect of each sensory parameter on the acceptance of marmalade.

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2. Materials and methods

2.1. Marmalade preparation

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

The black plum peels were washed, squeezed, frosted, and accumulated in a freezer (−18 °C) until production. The defrosted plum peels were mixed with water and homogenized (Sunwood food processor, Italy). Therefore, the mixture was filtered in order to get the puree. To produce marmalade, sugar syrup was firstly prepared (70°Brix). Then, it was mixed with puree and cooked. In the end, pectin, remained sugar and citric acid were added and the heating process was continued to 65-70° Brix and pH = 2.8 to 3.5. The marmalade samples were cooled and filled in glass dishes and cumulated at room temperature (25 °C ± 2) for at least 24 h. The ingredients of marmalade were plum puree (40, 50 and 60%), and pectin (0.3, 0.4, 0.5, and 0.6%). Table 1 shows different formulations of black plum peel marmalade.

2.2. Sensory evaluation

Sensory properties of black plum peel marmalade was evaluated by 15 trained panelists (7 men and 8 women, 20 – 40 years old) from students and personnel of Neyshabur University of Medical Sciences, Iran). As mentioned, Neyshabur city is the largest producer of plums in Iran and the people who live in this city have complete information about the various characteristics of plums and its products. In Neyshabur University of Medical Sciences, various researches have been conducted about the production of new products from plums. In our university, there is a sensory evaluation team to evaluate the sensory properties of plum products. Initially, standards were used to select the panel leader and panelists (ISO 13300-2:, 2006; ISO 5492:, 2008). In order to train panelists, the panel leader trained them in 4 groups of 5 people at the same time, and in the next stages, these groups were integrated. The Triangle method was used for the initial evaluation of the panelists. This means that each panelists evaluated 3 samples of marmalade, that two of them were the same. The panelists must be able to identify different sample. Next, the panel leader studied the perceptions of panelists and eliminated those who have had poor results (five panelists). To train the panelists, four purposeful 30-minute sessions were held and sensory and textual properties, related standards, evaluation methods and product presentation were explained. Each time the evaluation was completed, the team leader and the panelists evaluated the quality of the products during a roundtable discussion. Evaluations were done at room temperature (25 ± 5 °C) and under white fluorescent light. The nine-point hedonic score (Standardization, 2003) (1 = Dislike extremely, 9 = like extremely) was used to specify the sensory properties of black plum peel marmalade. Four panelists performed the sensory evaluation in the same time. Throughout panel sessions, panelists were instructed to rinse their mouths with water before testing each sample. For sensory evaluation, seven parameters containing color, consistency, flavor, firmness, adhesiveness, spreadability (This parameter was determined by rubbing the sample with a spoon on the toast bread.) and total acceptance of black plum peel marmalade were measurement. Table 1 shows the sensory scores of black plum peel marmalade samples. The information obtained in this section was used for Discriminant Analysis and based on this statistical method, marmalade samples were classified into two categories: unacceptable (score 1 to 6) and acceptable (score 7 to 9). Considering that the number of samples was 12 which were examined by 15 panelists, totally, 180 data were analyzed by Discriminant Analysis method (IBM SPSS Statistics version 19).

2.3. Discriminant Analysis

Discriminant Analysis is an advanced statistical method that simultaneously examines different variables and determines that a parameter is from which group. This method makes a linear combination of independent variables to examine a parameter is dependent on one of two groups (Lekshmi et al., 1998).

If there are two groups, a linear function can be defined as λ′ X consisting of k explanatory variable - $X = X_1, X_2, \cdots, X_K$)- which best discriminates between the two groups. Therefore, different λ must be chosen in such a way that the variance of λ′ X between groups is greater than its variance within groups (λ and X are vectors with dimensions k). Discriminant Analysis makes it possible to identify variables that are different significantly in the mean of the two groups. These variables are then used to predict which observation will be into which group. Equations (1) – (4) show the definition of Discriminant Analysis (DA) method.

$$\bar{x}_1 = \frac{1}{n_1}\sum_{i}^{n_1} x_{1i} \tag{1}$$

$$\bar{x}_2 = \frac{1}{n_2}\sum_{i}^{n_2} x_{2i} \tag{2}$$

$$\bar{x} = \frac{1}{n_1 + n_2}(n_1 x_1 + n_2 x_2) \tag{3}$$

Table 1
Different formulations and sensory scores of black plum peel marmalade.

Number	Puree (%)	Sugar (%)	Pectin (%)	Color	Consistency	Flavor	Firmness	Adhesiveness	Spreadability	Total acceptance
1	40	60	0.3	8.00 ± 0.56*	6.36 ± 1.12	6.64 ± 0.65	5.46 ± 0.67	6.82 ± 0.66	7.82 ± 0.67	7.09 ± 0.52
2	50	50	0.3	7.65 ± 0.52	6.423 ± 1.03	7.35 ± 0.60	6.69 ± 0.61	7.08 ± 0.61	7.92 ± 0.61	7.62 ± 0.48
3	60	40	0.3	7.00 ± 0.52	6.42 ± 1.03	6.27 ± 0.60	6.81 ± 0.61	7.08 ± 0.61	7.15 ± 0.61	7.00 ± 0.48
4	40	60	0.4	6.62 ± 0.52	5.92 ± 1.03	5.54 ± 0.60	6.85 ± 0.61	7.08 ± 0.61	6.77 ± 0.61	6.23 ± 0.48
5	50	50	0.4	7.85 ± 0.52	7.462 ± 1.03	6.92 ± 0.60	6.77 ± 0.61	7.08 ± 0.61	7.23 ± 0.61	7.92 ± 0.48
6	60	40	0.4	6.07 ± 0.48	5.13 ± 0.96	5.27 ± 0.56	5.27 ± 0.57	5.60 ± 0.57	4.87 ± 0.57	5.27 ± 0.44
7	40	60	0.5	7.54 ± 0.54	6.875 ± 1.07	7.17 ± 0.62	7.08 ± 0.64	6.92 ± 0.64	7.33 ± 0.64	7.50 ± 0.50
8	50	50	0.5	6.29 ± 0.54	6.08 ± 1.07	6.42 ± 0.62	5.58 ± 0.64	5.67 ± 0.64	6.50 ± 0.64	6.67 ± 050
9	60	40	0.5	4.85 ± 0.52	4.15 ± 1.03	4.46 ± 0.60	5.23 ± 0.61	4.69 ± 0.61	4.38 ± 0.61	4.62 ± 0.48
10	40	60	0.6	7.75 ± 0.54	6.92 ± 1.07	7.17 ± 0.63	7.25 ± 0.64	7.33 ± 0.64	7.29 ± 0.64	7.08 ± 0.50
11	50	50	0.6	6.86 ± 0.50	8.57 ± 0.99	6.07 ± 0.58	6.79 ± 0.59	5.79 ± 0.59	6.14 ± 0.59	6.86 ± 0.46
12	60	40	0.6	6.79 ± 0.50	6.64 ± 0.99	6.21 ± 0.58	6.36 ± 0.59	5.79 ± 0.59	5.36 ± 0.59	6.50 ± 0.46

* Mean ± SE

$$S = \frac{1}{n_1 + n_2 - 2}\left[\sum_i \left(x_{1i} - \bar{x}_1\right)\left(x_{1i} - \bar{x}_1\right)^{\hat{A}} + \sum_i \left(x_{2i} - \bar{x}_2\right)\left(x_{2i} - \bar{x}_2\right)^{\hat{A}}\right] \quad (4)$$

where $\bar{x}_1$ and $\bar{x}_2$ are the mean of discriminatory variables in the first and second groups, respectively, and x and S are the mean of the variables and variance of observations in the two groups, respectively. The intergroup variance is also equal to $\overset{\hat{A}}{\lambda}(\bar{x}_1 - \bar{x}_2)^2$ and the intragroup variance is $\overset{\hat{A}}{\lambda}S\lambda$ (Maddala, 1983). λ should be selected so that the following statement (equation (5)) is maximized:

$$\Phi = \frac{\overset{\hat{A}}{\lambda}\left(\bar{x}_1 - \bar{x}_2\right)^2}{\overset{\hat{A}}{\lambda}S\lambda} \quad (5)$$

By deriving equation (5) from λ and equating it to zero, the value of λ is obtained equation (6):

$$\hat{\lambda} = S^{-1}\left(\bar{x}_1 - \bar{x}_2\right) \quad (6)$$

By calculating the coefficients of discriminatory variables, the average of the Discriminant function for the two groups can be obtained, which is equal to equations 7–8:

$$\bar{y}_1 = \widehat{\overset{\hat{A}}{\lambda}}\overset{\hat{A}}{\bar{x}}_1 = (\bar{x}_1 - \bar{x}_2)^{\hat{A}} S^{-1}\bar{x}_1 \quad (7)$$

$$\bar{y}_2 = \widehat{\overset{\hat{A}}{\lambda}}\overset{\hat{A}}{\bar{x}}_2 = (\bar{x}_1 - \bar{x}_2)^{\hat{A}} S^{-1}\bar{x}_2 \quad (8)$$

To attribute a new observation to the Discriminant vector x_0, the value of the Discriminant function (y_0) is calculated using the discrimination coefficients obtained equation (9):

$$\bar{y}_0 = \widehat{\overset{\hat{A}}{\lambda}}\overset{\hat{A}}{\bar{x}}_0 = (\bar{x}_1 - \bar{x}_2)^{\hat{A}} S^{-1}\bar{x}_0 \quad (9)$$

If y is closer to y_1, the new observation will belong to the first group, and if it is closer to y_2, it will belong to the second group. In fact, y_0 is closer to y_1 when, assuming $\bar{y}_1 > \bar{y}_2$ the equation (10) is established:

$$y_0 > \frac{1}{2}\left(\bar{y}_1 + \bar{y}_2\right) or \left|y_0 - \bar{y}_1\right| > \left|y_0 - \bar{y}_2\right| \quad (10)$$

Inequality 10 is used when the number of observations in two groups is equal. Otherwise the equation (11) is used:

$$y_0 = \frac{1}{n_1 + n_2}(n_1 y_1 + n_2 y_{2)} \quad (11)$$

where n_1 and n_2 are the number of observations in the first and second groups, respectively.

To perform the classification using Discriminant Analysis, a new observation must be attributed to one of the two groups using a criterion. Cutt-off value is one of the criteria used for this case. To calculate this criterion, at first, using the estimated coefficients of the Discriminant function, the value of the Discriminant score is obtained for all observations. Then, if the number of observations in the two groups is not equal, the equation (12) is used to calculate the mean value (Sharma, 1996).

$$Meanvalue = \frac{n_0\overline{Z}_0 + n_1\overline{Z}_1}{n_0 + n_1} \quad (12)$$

where $\overline{Z}_0$ and $\overline{Z}_1$ are the average of the Discriminant score for the two groups, respectively, and n_0 and n_1 are the number of group members, respectively. If the value of the Discriminant score for the new observation is greater than or equal to the median value, the new observation belongs to the first group and otherwise to the second group.

To analyze this method, it is necessary to examine the differences between groups by univariate statistical test. The *U* or *Wilks Lambda* statistic is used to make a decision the equality of means. This statistic expresses the significance of a variable when compared individually between two groups and is equal to the ratio of the sum of the squares within the group to the sum of the total squares for each variable (Grimm and Yarnold, 1995). When the means are equal in the two groups, the Wilkes-Lambda statistic equals one. In other words, larger values of the statistics did not indicate a significant difference between the means between the groups, while smaller values showed that the means of the groups were different (Huberty and Olejnik, 2006). In the pattern of differentiation of standardized and non-standardized coefficients, in fact, the coefficients of the variables when expressed in terms of initial values; and standardized coefficients are used when the variables are standardized with a mean of zero and a standard deviation of one criterion. Since the values of the coefficients of the Discriminant function do not provide any indicators to express the relative importance of the variables with differences in the two groups, to achieve this goal, the correlation between the Discriminant function and the values of the variables is used. The structure matrix is presented. In other words, the values of the structure matrix or correlation coefficients reflect the amount of variance explained by each of the independent variables regarding the Discriminant function.

3. Results and discussion

Sensory properties of foods is very important and it can be effected by many factors such as type of foods, the environmental conditions and consumers that use the foods. The acceptability of foods is very important because it is an enjoyment for people from eating food and pleasure of food is perceive from the cradle to the grave (Bourne, 2002). For semisolid foods, acceptability is determined by food sensory attributes including color, flavor, texture, appearance and packaging. Acceptability of foods can be influenced by the sensory properties of the food, outlook of consumer, culture, physiological status like hunger, thirst, illness and other features (Murray and Baxter, 2003; Joyner, 2019; Costell et al., 2010). Table 2 shows the results of the group means equality test for each variable. As can be seen, the sensory parameters of black plum peel marmalade are significantly different from each other ($p < 0.01$). In order to achieve the degree of participation of each variable in the Discriminant function, the coefficients of this function were examined. Table 3 shows the results of standardized and non-

Table 2
The results of Wilk's Lambda test for the mean of independent variables in the two groups.

Variables	Wilk's Lambda	F
Color	0.689	69.093***
Consistency	0.847	27.670***
Flavor	0.571	114.969***
Firmness	0.613	96.462***
Adhesiveness	0.617	95.026***
Spreadability	0.481	165.038***
***Significance at 0.01		

Table 3
Estimation of standardized and non-standardized coefficients of Discriminant Analysis model.

Variables	Standardized coefficient	Non-standardized coefficient
Color	0.137	0.082
Consistency	0.200	0.058
Flavor	0.369	0.216
Firmness	0.336	0.190
Adhesiveness	−0.197	−0.110
Spreadability	0.639	0.381
Constant		−5.275

Table 4
Correlation between common groups between Discriminant variables and Discriminant function.

Variables	Structure matrix values
Color	0.817
Consistency	0.682
Flavor	0.624
Firmness	0.620
Adhesiveness	0.528
Spreadability	0.334
Canonical correlation coefficient	0.786

standardized Discriminant function coefficients. Standardized coefficients show that the adhesiveness of the samples has a negative effect and the color, flavor, consistency, firmness and spreadability have positive effects on the total acceptance of the samples. Non-standardized coefficients are the values of the coefficients of the detection equation or distinguishing between acceptable and unacceptable samples, and the magnitude of these coefficients indicates the change in the degree of discrimination due to the change of a unit of independent variables. Based on this, it can be expected that the spreadability increases the Discriminant score by 0.381 units (Table 3). In other words, by assuming other conditions to be constant, having a good spreadability can increase the quality of the product and its acceptance probability. Based on this result, it seems that, the ability to move and place the marmalade on the bread is of great importance from the point of view of the panelists.

According to the results of Table 4, with falling one unit of color, consistency, flavor and firmness, the Discriminant score increases by 0.082, 0.058, 0.216 and 0.190 units, respectively, and with increasing adhesiveness, the Discriminant score reduces by 0.110 units. These results are consistent with our consequences in ANOVA test. According to ANOVA test, increasing the black plum peel puree reduced the flavor, color, spreadability, adhesiveness, and total acceptance scores. The increase of pectin led to a decrease in spreadability and color scores. According to the panelists, the sample with 50% black plum peel puree and 0.4% pectin had the highest acceptability (Estaji et al., 2020). Based on these two statistical methods, it can be said that the lower the amount of pectin and black plum peel puree concentrations, the higher the quality and acceptance of marmalade samples.

The values of the coefficients of the Discriminant function do not provide any indicators to express the relative importance of the variables with differences in the two groups. To achieve this goal, the structure matrix is used. Table 4 shows the values of structure matrix. According to Table 4, by comparing the structure matrix, it can be said that color, consistency, flavor and firmness have the largest structural coefficient and they have the greatest contribution in discriminating between marmalade samples. While adhesiveness and spreadability have the lowest structural coefficient and therefore has the lowest contribution in discriminating between products. As can be seen in Table 4, the canonical coefficient is equal to 0.786. This value indicates that there is a good correlation between the independent variables and the Discriminant score. The greater the degree of this correlation, the greater the ability of the model to discriminate between individuals in groups.

In addition to the values that show the degree of participation of each variable in the Discriminant pattern, the significance of the whole Discriminant function can also be examined in terms of the overall fit of the information. Significant test results based on Chi-square criteria are given in Table 5. As can be seen, it is 144,330, which is significant at the level of 0.01%, which means that the average of all Discriminant variables in the two groups are completely different at the same time, and the two groups can be distinguished using these variables.

Table 5
The results of significant test of Discriminant Analysis model.

Test of function (s)	Wilk's Lambda	Chi-square	df	Sig.
1	0.382	144.330	6	0.000

Table 6
Classification of marmalade samples into accepted and non-accepted samples.

	Main observations	Number of observations	Predictive results
		Acceptance	Rejection
Acceptance	94	88	6
Rejection	61	11	50
		Percentage of correctly classified observations of the total observations	89

The results of Table 6 show that the estimated Discriminant Analysis model from 94 observations of the first group (acceptance group), 88 observations (93.62%) correctly placed in the accepted group. However, 6 observations (6.38%) were incorrectly placed in the second group (non-acceptance group). Also, out of 61 observations of the second group (non-acceptance samples), 50 cases (81.97%) were correctly classified in this group and 11 (18.03%) observations were incorrectly placed in the acceptance group. In this analysis, the accuracy of prediction is 89%. In other words, it can be said that the Discriminant Analysis model estimated with the above-mentioned characteristics is able to predict the group of marmalade samples based on the different amount of plum peel puree and their pectin.

4. Conclusion

The results of Discriminant Analysis showed that spreadability and adhesiveness have important effect on the total acceptance of marmalade samples. Increasing the spreadability enhanced the Discriminant Analysis score while increasing the adhesiveness reduced the Discriminant Analysis score. Although increasing the color, consistency, flavor, and firmness also increased the Discriminant Analysis score, the increase in spreadability had the greatest effect on the score. According to the results of structure matrix, spreadability, flavor, firmness, adhesiveness and color had the largest structural coefficient and the greatest contribution in differentiating between marmalade samples, while consistency had the lowest in differentiating between products. The Discriminant Analysis model was able to predict the samples based on the amount of pectin and black plum peel puree (the prediction percentage of the samples was 89%). Therefore, using the results obtained from the above Discriminant Analysis model and placing variables in the framework of this model, it is possible to determine to a large extent in which group the produced sample will be placed so that an appropriate and acceptable formula can be determined before the production of the product. By recognizing the characteristics preferred by consumers, a formulation can be prepared and presented that has the highest acceptance among consumers, and in this way, with the lowest cost, the highest consumer satisfaction and income for the producer is achieved.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Abad-García, B., Berrueta, L. A., Garmón-Lobato, S., Urkaregi, A., Gallo, B., & Vicente, F. (2012). Chemometric characterization of fruit juices from Spanish cultivars according to their phenolic compound contents: I. citrus fruits. *Journal of Agricultural and Food Chemistry, 60*, 3635–3644.

BOURNE, M. 2002. Food texture and viscosity: concept and measurement, Elsevier.

Costell, E., Tárrega, A., & Bayarri, S. (2010). Food acceptance: The role of consumer perception and attitudes. *Chemosensory Perception, 3*, 42–50.

Donovan, J. L., Meyer, A. S., & Waterhouse, A. L. (1998). Phenolic composition and antioxidant activity of prunes and prune juice (Prunus domestica). *Journal of Agricultural and Food Chemistry, 46*, 1247–1252.

Estaji, M., Mohammadi-Moghaddam, T., Gholizade-Eshan, L., Firoozzare, A., & Hooshmand-Dalir, M.-A.-R. (2020). Physicochemical characteristics, sensory attributes, and antioxidant activity of marmalade prepared from black plum peel. *International Journal of Food Properties, 23*, 1979–1992.

FAO 2020. Food and agriculture organization of the United Nations.

Gliszczyńska-Świgło, A., Klimczak, I., & Rybicka, I. (2018). Chemometric analysis of minerals in gluten-free products. *Journal of the Science of Food and Agriculture, 98*, 3041–3048.

Grimm, L. G., & Yarnold, P. R. (1995). *Reading and understanding multivariate statistics*. American psychological association.

Hidalgo, M. J., Pozzi, M. T., Furlong, O. J., Marchevsky, E. J., & Pellerano, R. G. (2018). Classification of organic olives based on chemometric analysis of elemental data. *Microchemical Journal, 142*, 30–35.

Huberty, C. J., & Olejnik, S. (2006). *Applied MANOVA and discriminant analysis*. John Wiley & Sons.

ISO 5492:2008 (E/F/R) Sensory analysis – vocabulary.

ISO 13300-2:2006 Sensory analysis — General guidance for the staff of a sensory evaluation laboratory- Part 2: Recruitment and training of panel leaders.

Jabeen, Q., & Aslam, N. (2011). The pharmacological activities of prunes: The dried plums. *Journal of Medicinal Plants Research, 5*, 1508–1511.

Jahanbakhshi, Ahmad, & Kheiralipour, Kamran (2020). Evaluation of image processing technique and discriminant analysis methods in postharvest processing of carrot fruit. *Food Science & Nutrition., 8*(7), 3346–3352.

Jihad Agriculture, K.R., 2020.

JONES, J. S. & BULLIS, D. 1929. The chemical composition and food value of Oregon dried prunes.

JOYNER, H. S. 2019. Rheology of Semisolid Foods, Springer.

Kimura, Y., Ito, H., Kawaji, M., Ikami, T., & Hatano, T. (2008). Characterization and antioxidative properties of oligomeric proanthocyanidin from prunes, dried fruit of Prunus domestica L. *Bioscience, Biotechnology, and Biochemistry, 72*, 1615–1618.

Lashgari, M., & Mohammadigol, R. (2016). Discrimination of Golab apple storage time using acoustic impulse response and LDA and QDA discriminant analysis techniques. *Iran Agricultural Research, 35*, 65–70.

Lekshmi, S., Rugmini, P., & Thomas, J. (1998). Characteristics of defaulters in agricultural credit use: A micro level analysis with reference to Kerala. *Indian Journal of Agricultural Economics, 53*, 640–647.

ŁUCKA M., Ś. P. T. 1994. in, Pomologia (Pomology) (ed. A. Rejman), 186–250.

BOURNE, M. 2002. Food texture and viscosity: concept and measurement, Elsevier.

Mitic, V., Jovanovic, V. S., Dimitrijevic, M., Cvetkovic, J., Simonovic, S., & Mandic, S. N. (2014). Chemometric analysis of antioxidant activity and anthocyanin content of selected wild and cultivated small fruit from Serbia. *Fruits, 69*, 413–422.

Moghaddam, T. M., Razavi, S. M., Taghizadeh, M., & Sazgarnia, A. (2016). Sensory and instrumental texture assessment of roasted pistachio nut/kernel by partial least square (PLS) regression analysis: Effect of roasting conditions. *Journal of Food Science and Technology, 53*, 370–380.

Mohammadi-Moghaddam, T., Firoozzare, A., Kariminejad, M., Sorahi, M., & Tavakoli, Z. (2020). Black plum peel as a useful by-product for the production of new foods: Chemical, textural, and sensory characteristics of Halva Masghati. *International Journal of Food Properties, 23*, 2005–2019.

Mohammadi-Moghaddam, T., Firoozzare, A., Parak, Z., & Mohammadnia, M. (2020). Physicochemical properties, sensory attributes, and antioxidant activity of black plum peel sharbat as affected by pectin and puree concentrations. *International Journal of Food Properties, 23*, 665–676.

MURRAY, J. & BAXTER, I. 2003. SENSORY EVALUATION| Food Acceptability and Sensory Evaluation.

Powers, J. J., & Keith, E. S. (1968). Stepwise discriminant analysis of gas chromatographic data as an aid in classifying the flavor quality of foods. *Journal of Food Science, 33*, 207–213.

SHARMA, S. 1996. Applied Multivariate Techniques, New York, John Willey & Sons. Inc OpenURL.

SIDDIQ, M. 2006. Plums and prunes. Handbook of fruits and fruit processing, 553.

SOMOGAI, L. 2005. Plums and prunes processing of fruits science and technology. CRC press, 21, 513-530.

Stacewicz-Sapuntzakis, M., Bowen, P. E., Hussain, E. A., Damayanti-Wood, B. I., & Farnsworth, N. R. (2001). Chemical composition and potential health effects of prunes: A functional food? *Critical reviews in food Science and Nutrition, 41*, 251–286.

Standardization, I.O.F. 2003. Sensory analysis-Guidelines for the use of quantitative response scales, ISO.

Zielinski, A. A., Haminiuk, C. W., Nunes, C. A., Schnitzler, E., van Ruth, S. M., & Granato, D. (2014). Chemical composition, sensory properties, provenance, and bioactivity of fruit juices as assessed by chemometrics: A critical review and guideline. *Comprehensive Reviews in Food Science and Food Safety, 13*, 300–316.

Zimmer, M., & Schneider, J. (2019). Near-infrared diffuse reflectance spectroscopy for discriminating fruit and vegetable products preserved in glass containers. *Croatian Journal of Food Science and Technology, 11*, 104–112.