Determination of Some Biotechnical Characteristics of Ornamental Plum *(Prunus cerasifera* var. *atropurpurea)* Fruit

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Abstract

Ornamental plum (*Prunus cerasifera* var. *atropurpurea* (Rosaceae)) is a species of ornamental tree. The fruits turn red when ripening and are edible. Ornamental plum fruit has bioactive substance potential. In this study, some biotechnical characteristics of the ornamental plum fruits such as size dimensions, sphericity, surface area, geometric mean diameter, colour properties, frictional properties and mechanical behaviors were determined in this study. The puncture and compression tests were carried out for the behavior of fruits against mechanical forces. Three different loading speeds (30, 60, and 90 mm min^{-1}) were used in mechanical tests. The sizes such as length, width, and thickness values of ornamental plum were determined as 2.785 cm, 2.638 cm, 2.568 cm and fruit weight of 10.34 g, respectively. The sphericity, surface area, and geometric mean diameter, values of fruits were determined as 95.28% and 22.13 cm^2, and 6.53 mm, respectively. Among the volumetric properties of ornamental plum, the porosity value was determined as 57.16%. *L**, *a**, *b** colour characteristics were determined as 35.59, 6.83 and 8.82, respectively. The coefficient of static friction values of the ornamental plum on different friction surfaces were higher on the rubber surface than the other surfaces. The highest compression force value was measured as 82.14 N in the Y- axis at a loading speed of 90 mm min^{-1}. The results of the bio-technical characteristics must be taken into account for the quality of ornamental plum fruit during processing, sorting, cleaning, storage, packaging, and presentation to the consumer after harvesting.

Keywords: Plum, Surface area, Friction, Chroma, Puncture, Compression

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INTRODUCTION

Ornamental plum (*Prunus cerasifera* var. *Atropurpurea*) (Pruno) is a tree from the Prunus Pissardii Rosaceae family (peach, cherry, plum, almond). It has an average height of 6-7 meters, with a solid and deep root system. Pruno is is known as the 'purple-leaf plum'. Its leaves have year-round purple or red (Zhang et al., 2013). Its origin is Turkey, the Balkans and Iran. It grows in the Black Sea, Marmara and Central Anatolia in Turkey. They are generally sensitive to frost (-20°C). It grows in sunny places and in temperate climates. Although it grows in all kinds of soils, it prefers moist, fertile, less clay soils. It can be used as an ornamental plant in parks and gardens, as an ornamental plant, and in fruit gardens, and there are also different cultural forms (Anonymous 2022a, 2022b).

The edible fruits are about 1 inch diameter and dark purple during maturity. The ripe fruit can be used for jams, jellies and juices (Anonymous 2022c).

Knowing of the biotechnical (physical, colur, mechanical) characteristics such as size and shape, sphericity, surface area, geometric mean diameter, porosity fruit and bulk densities, mechanical behaviors under dynamic or static forces during the compression and puncture tests, friction coefficients, colour characteristics of agricultural materials will increase the value of the product for the preservation of the commercial and economic quality of agricultural products (Şahin et al., 2020).

The puncture and compression force of agricultural products are the basic parameters that show the behavior of the products under the post-harvest load. They constitute the basic parameter for the design of machine and equipments to be developed in the storage, transportation and packaging stages (Coşkun et al., 2005, Işık and Ünal, 2007, Kabas et al., 2007, Alnıak, 2012).

Many studies have been carried out to determine the physical and mechanical properties of biological materials such as fruits, vegetables, grains and seeds. It is revealed in the literature review that there is a limited number of studies on the biotechnical properties of plum fruits.

Altuntas et al. (2020) determined the effects of different harvest times and MeJA (Methyl Jasmonate) sprayed at 1120 mg L^{-1} and 2240 mg L^{-1} concentrations on pre-harvest plum (*Prunus domestica*) fruits on the mechanical, physical and chemical characteristics of fruits. Alnıak (2012) studied the determination of some mechanical and physical characteristics of plum (*Prunus cerasifera* Ehrh.) fruits in different harvest times.

A study examining the mechanical, physical, and colour characteristics of the ornamental plum fruit with biotechnological properties could not be reached. Therefore, in this study, biotechnological properties such as physical, colour, coefficient of static friction and mechanical behaviors under compression and puncture tests of ornamental plum fruits were investigated.

MATERIALS and METHODS

In this study, ornamental plum fruits used were obtained from the garden of the Faculty of Agriculture at Tokat Gaziosmanpaşa University during the semi-maturity period in June 2022. Experiments were carried out in the Department of Biosystem Engineering, Biological Materials Laboratory, Faculty of Agriculture at Tokat Gaziosmanpaşa University. For the initial moisture content, the samples were dried by oven at 70±1°C for 24 hours and taking the wet basis (Suthar and Das, 1996). Fruits' moisture content were determined as 85.53% on a wet basis and the fruit samples was given in Figure 1.

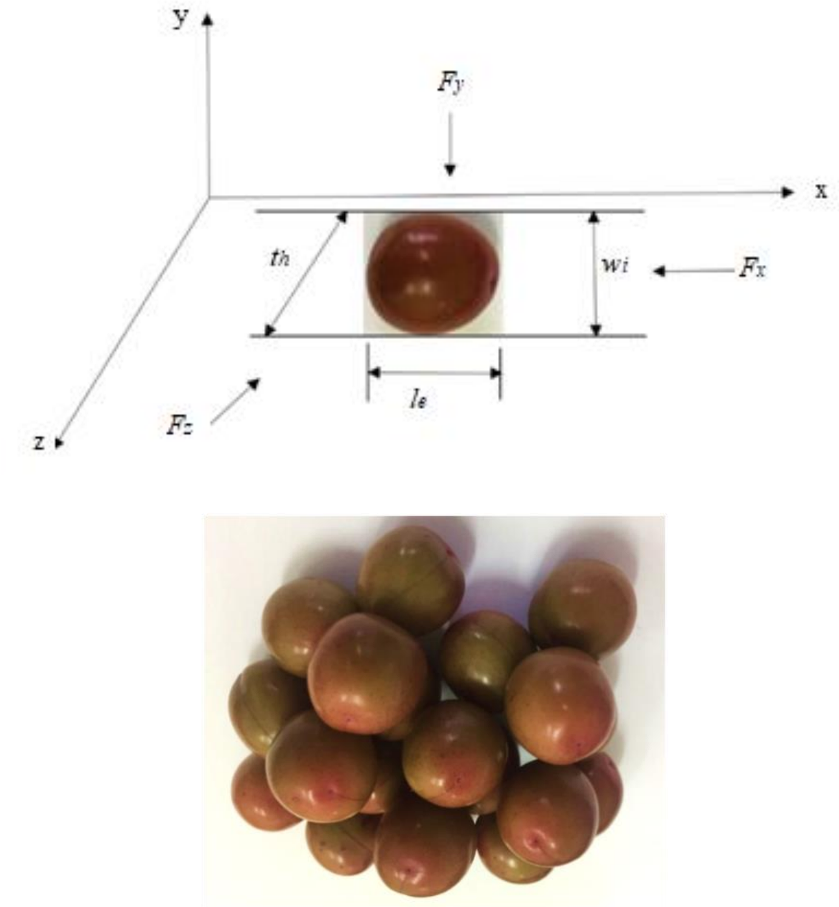

Figure 1. Representation of the axial dimensions (F_x, F_y, F_z) forces of a sample ornamental plum fruit and the ornamental plum fruit samples.

The geometric and volumetric properties of the fruits, the size dimensions were measured with a digital caliper (Precision: 0.01 mm). Fruit masses were determined with KERN brand EW620-3NM model (Precision: 0.001 g). The following equations were used to calculate the geometric mean diameter (D_{ge}) (cm), sphericity (S_{ph}) (%), surface area (Sar) (cm^2) and volume (V_{fr}) (cm^3) of fruits (Mohsenin, 1980).

$$D_{ge}= (l_e.w_i.t_h)^{1/3} \quad (1)$$

$$S_{ar}= \pi (D_{ge})^2 \quad (2)$$

$$S_{ph}=(D_{ge}/l_e)100 \quad (3)$$

$$V_{fr}=\pi /6 \, (l_e.w_i.t_h) \quad (4)$$

Where; l_e: Length (cm), w_i: Width (cm), t_h: Thickness (cm), D_{ge}: Geometric mean diameter (cm), S_{ar}: Surface area (cm^2), S_{sh}: Sphericity (%).

The liquid displacement as method was used to determine the fruit density ($\rho_{fr,}$ kg m^{-3}) of the samples, pure water was used as the fluid (Saçılık et al., 2003). Hectoliter method was applied for bulk denstiy ($\rho_{bl,}$ (kg m^{-3}). Porosity (P_{or}) was calculated according to fruit density and bulk density values (Mohsenin, 1980).

In order to determine the colour (L^*, a^*, b^*) properties of fruits on the fruit peel surface, a colorimeter (Minolta, CR-400 (Tokyo, Japan) was used (McGuire, 1992). Hue angle ($h°$) and Chroma were calculated according to Equations 5 and 6. The chroma value (C_h) indicates the vivid or pastel tone of the fruit, values close to 0 are defined as pastel tones, and values close to 100 are defined as vivid tones (Günaydın, 2020).

$$h° = tan^{-1}[b^*/a^*] \quad (5)$$

$$C_h = \sqrt{a*2 + b*2} \quad (6)$$

As the mechanical properties of fruits, a friction measurement device was used to measure the coefficient of the static friction on different friction surfaces (rubber, galvanized metal, PVC, plywood, and laminate). The coefficient of the friction was calculated from the equation $\mu = tan\alpha$ depending on the angle of inclination (α) in the device where the movement of the fruit sample from the surface that can be tilted with a lever is allowed (Yılmaz and Altuntas, 2020).

As Biological Materials testing device (Sundoo HP-500) was used fort he mechanical tests. Test device has drawbar pressure dynamometer, measuring stand, a motorized motion unit and a computer connection. In the compression and puncture tests, both the force and deformation ranges of the fruits were determined, and the force and time curves can also be taken graphically. The deformation was determined in millimeters from the measuring stand attached to the test device. Three different loading rates (30, 60, and 90 mm min^{-1}) were used for drilling tests. In the study, the energy absorbed (E_{ab}), hardness (H_r) and power required for drilling (P_w) were determined with the help of the following equations (Mohsenin, 1980).

$$E_{ab} = (F_r . D_{ef}) / 2 \quad (7)$$

$$H_r = F_r / D_{ef} \quad (8)$$

$$P_w = \left[\frac{E_{ab} H_r}{60000 D_{ef}}\right] \quad (9)$$

Where; E_{ab}: Absorbed energy (N mm), F_r: Puncture force (N), D_{ef}: Deformation (mm), H_r: Hardness (N mm^{-1}), and P_w: Puncture power (W).

For the statistical analysis, SPSS 17 (Statistical Package for Social Sciences) program was used. The analysis of variance was performed for mechanical test results and the multiple comparison (Duncan) test was also applied to determine the differences related to the parameters examined for mechanical test results.

RESULTS and DISCUSSION

Physical Properties

Within the scope of biotechnological characteristics of ornamental plum samples, size-dimensional properties, sphericity, surface area, geometric mean diameter, fruit volume and mass, porosity, fruit and bulk densities were determined. The geometric and volumetric properties of fruits are given in Table 1.

Table 1. Some geometric and volumetric characteristics of ornamental plum fruits.

Physical properties	Parameter	Mean (*)	Maximum	Minimum	Variation coefficient	Standard error
Geometric	l_e (cm)	2.785±0.081	2.990	2.625	2.910	0.0256
	w_i (cm)	2.638±0.083	2.836	2.427	3.160	0.0264
	t_h (cm)	2.568±0.082	2.749	2.300	3.190	0.0260
	D_{ge} (cm)	2.653±0.074	2.827	2.464	2.780	0.0233
	S_{ph} (%)	95.28±1.057	98.47	91.04	1.650	0.0497
	S_{ar} (cm^2)	22.130±1.233	25.100	19.079	5.570	3.9024
Mass and Volumetric	M_s (g)	10.34±0.870	12.580	8.600	8.380	0.0270
	V_{fr} (cm^3)	9.898±0.830	11.943	7.912	8.390	0.2630
	ρ_{bl} (kg m^{-3})	423.60±88.17	476.15	174.49	20.810	27.900
	ρ_{fr} (kg m^{-3})	989.79±21.74	1016.39	943.95	2.200	6.880
	P_{or} (%)	57.16±9.01	82.510	52.490	15.750	2.850

l_e: Length, w_i: Width, t_h: Thickness, S_{ph}: Sphericity, S_{ar}: Surface area, D_{ge}: Geometric mean diameter, M_s: Fruit mass, V_{fr} Fruit volume, P_{or}: Porosity (%) ρ_{fr}: Fruit density, ρ_{bl}: Bulk density, (*): ± values indicate standard deviation.

The width, length and thickness of the ornamental plum fruits were determined as 2.638 cm, 2.785 cm and 2.568 cm, respectively. The sphericity, geometric mean diameter and surface area of fruits were determined as 95.28%, 2.653 cm and 22.130 cm^2, respectively. The fruit mass was 10.34 g, and the porosity value was 57.16%. Alnıak and Çetin (2021) reported that length values fruits ranged from 2.292 to 3.001 cm, width values ranged from 2.084 cm to 2.888 cm, thickness changed from 2.028 cm to 2.754 cm, and fruit mass between 5.49 g and 20.03 g for Papaz plum varieties in three harvest (15 April, 1 May and 15 May) periods respectively. Esehaghbeygi et al. (2013) reported that the physical properties of varied from 2.805 to 3.652 cm, from 2.678 to 3.546 cm and from 2.585 to 3.401 cm for the length, width and thickness for Ghandi, Gatretala and Black plum cultivars. Calisir et al. (2005) reported that the mass, diameter, length, sphericity and geometric mean diameter values of plum (wild) fruits were as 15.330 g, 3.016 cm, 2.814 cm, 1.04, and 2.947 cm, respectively. In the studies different plum varieties were studied and it was seen that the geometric properties were similar and close to the values found in the ornamental plum fruit.

Colour characteristics

The values of the colour characteristics of the ornamental plum are given in Table 2.

Table 2. Colour characteristics of ornamental plum fruit.

Colour characteristics	Mean (*)	Maximum	Minimum	Variation coefficient	Standard error
L^*	32.59±0.93	33.98	31.07	2.85	0.29
a^*	6.83±0.59	7.84	6.21	8.71	0.19
b^*	8.82±0.70	9.81	7.82	7.96	0.22
C_h	11.17±0.63	11.89	9.99	5.63	0.20
h°	52.22±3.44	56.55	44.93	6.58	1.09

(*): ± values indicate standard deviaiton.

*a** and *b** and *L** colour characteristics of the ornamental plum fruits were determined as 6.83, 8.82 and 32.59, respectively. Ertekin et al. (2006) examined some nutritional, pomological and physical properties of Stanley and Frenze 90 plum (*Prunus domestica* L.) cultivars. The mean values for the *a** value were 2.40 and 9.51, respectively, and the mean values for the *b** value were -7.11 and -0.66, respectively. *L** (brightness) value showed similar results with literature, but there was a difference in the *a** and *b** values.

Frictional properties

Coefficient of static friction values of ornamental plum fruits aere given in Table 3. The coefficient of the static friction for ornamental plum fruits was found with the highest value of 0.363 on the rubber surface and the lowest on the galvanized sheet surface with the value of 0.207 (Table 3). Calisir et al. (2005) observed the coefficients of static friction of wild plums at 20% moisture content on rubber, galvanized metal and plywood surfaces and determined that the highest value was on the rubber surface. According to the literature, the friction coefficient values were found similar.

Table 3. Static friction coefficients of ornamental plum fruits.

	Coefficient of static friction				
Friction surfaces	**Mean (*)**	**Maximum**	**Minimum**	**Variation coefficient**	**Standard error**
PVC	0.209±0.022	0.249	0.176	10.735	0.0071
Galvanized metal	0.207±0.029	0.249	0.176	13.794	0.0090
Laminate	0.213±0.023	0.249	0.176	10.703	0.0072
Plywood	0.266±0.021	0.306	0.249	7.756	0.0065
Rubber	0.363±0.049	0.424	0.287	13.638	0.0157

PVC: Polivinil Klorür, (*): ± values indicate standard deviation.

Puncture and compression tests

The results of the puncture test and compression test results for the mechanical behaviors of ornamental plum fruits are given in Tables 4 and 5. As a result of the puncture test of ornamental plum fruits, the changes in force, deformation, absorbed energy, hardness and power values required along loading speeds and loading axes.

The highest puncture force was obtained as 8.02 N in the Y- axis and at 90 mm min^{-1} loading speed (Table 4). The highest hardness was found with 0.424 N mm^{-1} in the X- axis at 30 mm min^{-1} loading speed. The significant statistically differences were observed in the puncture force, deformation, absorbed energy, hardness and puncture power of ornamental plum fruits at 90 mm min^{-1} loading speed.

Table 4. The mechanical behaviors related to the puncture tests of ornamental plum fruit according to different loading axes and loading speeds.

Loading speeds (mm min^{-1})	Loading axes	Puncture force (N)	Deformation (mm)	Puncture energy (N mm)	Hardness (N mm^{-1})	Puncture power (W)
30	X-	6.13±1.26^{ns}	16.55±4.32^{ns}	48.76±10.25^{ns}	0.424±0.20^{ns}	0.0015±0.0003b**
	Y-	5.20±1.10^{ns}	17.08±1.86^{ns}	44.89±11.12^{ns}	0.304±0.06^{ns}	0.0026±0.0006a**
	Z-	5.00±0.86^{ns}	17.52±2.19^{ns}	42.83±4.60^{ns}	0.299±0.09^{ns}	0.0013±0.0002b**
	F value	3.04	0.26	1.10	2.98	33.68
60	X-	6.89±1.00a*	21.10±4.00^{ns}	71.66±11.34^{ns}	0.344±0.11^{ns}	0.0034±0.0005a*
	Y-	7.15±0.66a*	20.65±2.19^{ns}	74.11±12.14^{ns}	0.348±0.03^{ns}	0.0036±0.0003a*
	Z-	6.01±0.82b*	21.44±1.91^{ns}	63.99±7.38^{ns}	0.285±0.06^{ns}	0.0030±0.0004b*
	F value	5.03	0.20	2.53	2.27	5.03
90	X-	6.98±0.92b**	25.11±2.29a**	87.40±12.52a**	0.281±0.05b**	0.0052±0.0007b**
	Y-	8.02±0.85a**	22.77±1.16b**	91.26±10.16a**	0.353±0.04a**	0.0060±0.0006a**
	Z-	6.49±0.63b**	21.55±1.81b**	70.08±10.34b**	0.303±0.03b**	0.0049±0.0005b**
	F value	6.14	4.42	7.14	2.53	6.14

***:p<0.01, *: 0.01<p<0.05 ns: non significant, ± values indicate standard deviation.*

The changes in compression force, deformation, absorbed energy, hardness and compression power of ornamental plum fruits according to different loading speeds and loading axes as a result of the compression tests are given in Table 5.

Table 5. The mechanical behaviors related to the compression tests of ornamental plum fruit according to different loading axes and loading speeds.

Loading speeds (mm min^{-1})	Loading axes	Compression force (N)	Deformation (mm)	Compression energy (N mm)	Hardness (N mm^{-1})	Compression power (W)
30	X-	40.22±7.83c**	4.09±1.01a**	82.09±24.39b**	10.28±3.14c**	0.0101±0.0020c**
	Y-	59.86±3.26b**	3.61±0.16ab**	107.73±4.43a**	16.67±1.55b**	0.015±0.00068b**
	Z-	68.25±2.85a**	3.07±0.18b**	104.96±9.59a**	22.31±1.04a**	0.0171±0.0007a**
	F value	77.55	7.29	8.41	81.55	77.53
60	X-	72.02±7.51^{ns}	3.67±0.38b**	131.62±16.43b**	19.91±3.61a**	0.0360±0.0038^{ns}
	Y-	73.60±1.16^{ns}	4.33±0.14a**	159.25±5.38a**	17.04±0.62b**	0.0368±0.0006^{ns}
	Z-	69.68±1.56^{ns}	3.52±0.07b**	122.65±5.02b**	19.81±0.21a**	0.0348±0.0008^{ns}
	F value	1.94	32.71	33.67	5.93	1.94
90	X-	81.45±10.26^{ns}	3.94±0.38a**	161.21±28.54a**	20.78±2.44^{ns}	0.0611±0.0077^{ns}
	Y-	82.14±1.18^{ns}	4.17±0.28a**	171.39±12.65a**	19.83±1.11^{ns}	0.0616±0.0009^{ns}
	Z-	77.18±1.63^{ns}	3.58±0.12b**	138.15±2.79b**	21.61±1.17^{ns}	0.0579±0.0012^{ns}
	F value	1.98	11.24	8.85	2.78	1.98

***:p<0.01, *: 0.01<p<0.05 ns: non significant, ± values indicate standard deviation.*

The highest compression force of the ornamental plum fruits was found with 82.14 N on the width (Y-) axis) of 90 mm min^{-1} loading speed (Table 5). The highest hardness value was found as 22.31 N mm^{-1} in the Z- axis at 30 mm min^{-1} loading speed. The significant statistically differences were observed in the compression force, deformation, absorbed energy, hardness and compression power values of the ornamental plum fruits in three loading axes at 30 mm min^{-1} loading speed.

Altuntas et al. (2013) reported the compression force, absorbed energy, and compression power of the President plum variety are effective for different harvest times and compression axes for 1.120 mg L^{-1} and 2.240 mg L^{-1} MeJA applications at a constant 1.06 mm s^{-1} loading speed. They also reported the specific deformation and absorbed energy values observed for plum fruits compressed along the X- and Z-axes were lower than Y-axis.

CONCLUSION

In this study, the geometric, volumetric, colour, coefficients of static friction on different surfaces and mechanical resistance properties within the scope of the bio-technical characteristics of the ornamental plum fruit were investigated. The length, width and thickness values were determined as 2.785 cm, 2.638 cm, 2.568 cm and fruit mass was 10.34 g, respectively. The porosity, fruit density, and bulk density were determined as 57.16%, 989.79 kg m^{-3}, 423.60 kg m^{-3}, respectively. In terms of colour characteristics, the highest *a**, *b**, and *L*, values were determined as 7.84, 9.81 and 33.98, respectively. For the coefficient of static friction values of ornamental plum on different friction surfaces, the highest value was found on the rubber surface. In the mechanical test results, the highest puncture force value was 8.02 N on the width (Y-) axis along the 90 mm min^{-1} compression speed, and the highest hardness value was 0.38 N mm^{-1} in the length (X-) axis at 60 mm min^{-1} loading speed. The highest force value was found to be 82.14 N in the width (Y-) axis of 90 mm min^{-1} and the highest hardness value was found with 22.31 N mm^{-1} in the thickness (Z-) axis at 30 mm min^{-1} loading speed according the compression test. Depending on the increase in ornamental plum production areas, the results of the biotechnological properties of the equipment of the systems and facilities to be used for the sorting, classification and packaging of fruits in fresh and industrial applications can be used as engineering data. It is thought that these data may contribute to the increase of the commercial value of ornamental plums, as well as the quality of the harvest and post-harvest product.

REFERENCES

Alnıak S. 2012. *Erik meyvesinin (Prunus cerasifera* Ehrh.) *farklı hasat dönemlerindeki bazı fiziksel ve mekanik özelliklerinin belirlenmesi*. Yüksek Lisans Tezi, Adnan Menderes Üniversitesi, Fen Bilimleri Enstitüsü, Aydın.

Alnıak S. & Çetin M. 2021. Erik Meyvesinin Farklı Hasat Dönemlerindeki Bazı Fiziksel ve Mekanik Özelliklerinin Belirlenmesi, *Anadolu Tarım Bilimleri Dergisi*, 36(1), 73-79.

Altuntas E., Somuncu C. & Ozturk B. 2013. Mechanical behaviour of plum fruits as affected by pre-harvest methyl jasmonate applications, *Agricultural Engineering International: CIGR Journal*, 15(2), 266-274.

Altuntaş E., Ozturk B. & Saracoglu O. 2020. Metil Jasmonat Uygulamaları ve Hasat Dönemlerinin Erik Meyvelerinin Fiziksel, Mekanik ve Kimyasal Özellikleri Üzerine Etkisi, *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi (UTYHBD)*, 6(1), 75-83.

Anonymous, 2022a. Büyüyen süs eriği (wiki-plant.net) (Access Date:24.07.2022).

Anonymous, 2022b. Süs eriği (aoc.gov.tr) (Access Date:24.07.2022).

Anonymous, c. 2022. Süs eriği ağacı meyvesi yenir mi? - Oterohealthcouncil.org (Access Date:24.07.2022).

Calisir S., Haciseferogullari H. Ozcan M. & Arslan D. 2005. Some nutritional and technological properties of wild plum (*Prunus* spp.) fruits in Turkey. *Journal of Food Engineering*, 66, 233-237.

Coşkun M.B., Yalçın İ. & Özarslan C. 2005. Physical properties of corn seed (*Zea mays saccharata* Sturt), *Journal of Food Engineering*, 74(4), 523-528.

Ertekin C., Gozlekci S., Kabas O., Sonmez S. & Akinci I. 2006. Some physical, pomological and nutritional properties of two plums (*Prunus domestica* L.) cultivars, *Journal of Food Engineering*, 75, 508-514.

Esehaghbeygi A., Pirnazari K., Kamali M.& Razavi J. 2013. Physical, and Mechanical Properties of Three Plum Varieties (*Prunus domestica* L.), Thai Journal of Agricultural Science, 46(2), 95-101.

Günaydın S. 2020. *Mikrodalga, konvektif ve gölgede kurutma yöntemleri kullanılarak kurutulmuş kuşburnu meyvesinin kurutma kinetiği, renk ve besin elementi içeriği açısından incelenmesi*. Yüksek Lisans Tezi. Bursa Uludağ Üniversitesi Fen Bilimleri Enstitüsü, s: 65, Bursa.

Isık E. & Ünal H. 2007. Moisture-dependent physical properties of white speckled red kidney bean grains, *Journal of Food Engineering, (Electronic Journal)*, 82(2), 209-216.

Kabas O., Yılmaz E., Ozmerzi A. & Akinci I. 2007. Some physical and nutritional properies of cowpea seed (Vigna sinensis L.). *Journal of Food Engineering*, 79(4), 1405-1409.

McGuire R.G. 1992. Reporting of objective colour measurements, *Hortscience*, 27(12), 1254-1255.

Mohsenin N.N. 1980. Physical properties of plants and animal materials. Gordon and Breach Science Publishers, NW, New York, pp. 742.

Saçılık K., Öztürk R. & Keskin R. 2003. Some physical properties of hemp seed, *Biosystems Engineering*, 86(2), 191-198.

Suthar S.H. & Das S.K. 1996. Some physical properties of Karingda [*Citrus lanatus* (thumb) mansf] grains. *Journal ofAgricultural Engineering Research*, 65(1), 15-22.

Şahin G., Altuntaş E., Polatcı H. 2020. Mersin (Myrtuscommunis L.) Mevyesinin Fiziksel, Mekanik, Renk ve Kimyasal Özellikleri, *KSÜ Tarım ve Doğa Dergisi*, 23(1), 59-68.

Yılmaz G. & Altuntas E. 2020. Some bio-technical properties of flax seeds, fennel seeds and harmal seed capsules, *Turkish Journal of Agricultural Engineering Research (TURKAGER)*, 1(2), 222-232.

Zhang Y.B., Zhao C.Z., Liang Y.H., Fu L.Z., Li F. & Cao X.J. 2013. A new variety breeding of hardy purple-leaf plum 'Beiguohong' *Northern Horticulture*, 1(12), 168-169.