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THE GENOTYPIC EFFECT ON PHYSICAL PROPERTIES OF THREE EARLY MATURATED APPLE CULTIVARS

I. OZTURK[1], S. ERCISLI[2], M. KARA[1], Y. ERTURK[3] and F. KALKAN[1]
[1]*Department of Agricultural Machinery, Faculty of Agriculture, Ataturk University 25240 Erzurum, Turkey*
[2]*Department of Horticulture, Faculty of Agriculture, Ataturk University, 25240 Erzurum, Turkey*
[3]*Department of Horticulture, Ispir Hamza Polat Vocational School, 25900 Ispir-Erzurum, Turkey*

Abstract

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Several physical properties of three early maturated apple cultivars (Vista Bella, Summerred and Jerseymac), grown in same orchard in Northeast part of Turkey, have been investigated. The results showed that there were important statistical differences among cultivars in most of the parameters determined. Among the cultivars, cv Jerseymac (154 g) had the highest average fruit mass and followed by cv. Vista Bella (133 g) and cv. Summerred (115 g). Fruit density as kg/cm^3 ranged from 929 (Jerseymac) to 946 (Summerred). The highest dynamic coefficient of friction was observed on fiberglass for all cultivars. The color intensity (chroma) was the highest in cv. Vista Bella (33.06%) while the lowest in cv. Summerred (29.39%). The projected area, surface area and sphericity of cultivars were between 36.10-39.74 cm^2; 121.69-140.10 cm^2 and 88.26-95.82%. These results showed that the physical properties of early maturated apples are strongly affected by genotypes

Key words: Apples, *Malus domestica*, Physical properties, genotypic effect

Introduction

Historically, the apple has been the principal fruit in Turkey and the country is one of the most important apple producers in the world (Anon., 2007). The production is not merely confined to the temperate agricultural zones but extends to higher subtropical plains along the Mediterranean and Aegean Sea Coastlines in the country.

More recently summer or early maturated apple cultivation using standard cultivars has been gained more importance among growers in Turkey and the area planted with summer apple cultivars has been increasing steadily. Several fruit research institutes and universities in Turkey introduced a lot of summer apple cultivars and they established experiments to obtain most adapted summer apple cultivars in their region (Karslioglu, 1991; Burak and Buyukyilmaz, 1999; Yasasin et al., 2006). Among cultivars Jerseymac, Breaburn,

[1]*Corresponding author: E-mail: iozturk@atauni.edu.tr*

Vista Bella and Summerred have been suggested to growers in Turkey (Kaska, 1997). In fact, most of the public and private nurseries produce plant material mainly from these early maturated apples after autumn cultivars.

Early maturated apple cultivars are known to be more vulnerable for transportation than late maturated apple cultivars and this situation may result an important crop loss for these cultivars after harvest in Turkey. This situation adversely affects the growers and consumers, as well as the national economy within the period from the harvest to the marketing of product. This also reveals the need for conducting the studies to develop relevant equipments and machineries taking in account physical properties of apple fruits to overcome these problems. One of the most important physical characteristics of apples are fruit firmness and knowledge of fruit firmness is required to know the minimum pressure required for skin puncture and hence design of suspension system of transport vehicle. On the other hand, proper design of machines and processes to harvest, handle and store of apples and to convert it into food and feed requires an understanding of their physical properties (Mohsenin, 1986).

Previously a lot of researchers tried various digital and mechanical methods to measure physical properties of different fruit species such as pomegranate (Celik and Ercisli, 2009), date fruit (Keramat Jahromi et al., 2008), kiwifruit (Celik et al., 2007), pear (Ozturk et al., 2009), oranges (Topuz et al., 2005), plums (Calisir et al., 2005) and apricots (Haciseferogullari et al., 2006). In addition there were several studies conducted on apple cultivars in different part of both Turkey and the other countries related to physical properties of the fruits (Kaynas, 1987; Ozyigit, 1991; Yasasin et al., 2006; Acican et al., 2007). However, to our knowledge, no comparative study concerning detailed physical and mechanical properties of summer apple cultivars has been performed in the literature.

Therefore, the present research aimed to investigate the physical properties of summer apple fruits and then establishing convenient reference tables by using physical data for summer apple mechanization and processing.

Materials and Methods

The apple cultivars used in present study were Vista Bella, Summerred and Jerseymac. The cultivars were found in same experimental orchard in Ispir-Erzurum region and grafted on MM106 rootstocks. The fruits were hand picked in late July and first week of August at commercial maturity stage (Rajkumari and Mitali, 2009). Harvested fruits immediately transferred to the laboratory in cooled polythene bags to reduce water loss during transport. The analyses were carried out at a room temperature of 22°C. All tests were carried out at the Biological Material Laboratory in Agricultural Machinery Department and Fruit Science Laboratory in Horticulture Department of Ataturk University, Erzurum, Turkey.

Linear dimensions of fruits as length (L) and width (W) were measured by using a digital calliper gauge with a sensitivity of 0.01 mm. Geometric mean diameter (D_g) and sphericity (ϕ) were calculated by Mohsenin (1986), The surface area (S) of the fruit was calculated from the relationship given by McCabe et al. (1986). Projected area of the apples was determined from pictures

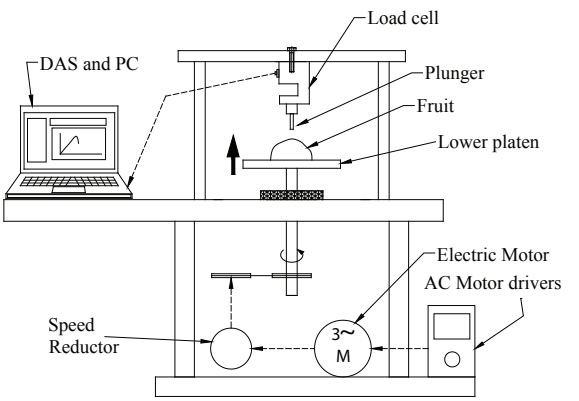

Fig. 1. Measurement setup for rupture properties

Table 1
Some color properties of apple cultivars

Color properties	Vista Bella	Summerred	Jerseymac	Signif. Lev.
L	34.95±1.59[b]	50.80±3.36[a]	51.72±3.18[a]	**
a	30.48±3.15	28.56±2.75	29.03±8.54	ns
b	12.72±1.80[a]	6.68±1.47[b]	13.11±1.67[a]	**
Hue, deg.	22.68±2.78[a]	13.36±3.91[b]	25.31±6.16[a]	**
Chroma	33.06±3.26	29.39±2.46	32.03±7.95	ns

*, ** Significant levels at 5% and 1%. ns: Not significants. a-b letters indicate the statistical difference within same rows

taken by a digital camera (Casio Exilim EX-Z60, 6.0 Mpixels), and then comparing the reference area to a sample area, by using the Image Tool for Windows (version 3.00) program. Fruit mass was measured by using a digital balance with a sensitivity of 0.001 g. Fruit density was determined by Mohsenin (1986). To determine the friction force a direct shear test device was used (Omobuwajo et al., 2000). The rupture properties of the apple fruits were determined by a quasi-static loading device (Figure 1) (Kara et al., 1999). The energy absorbed during the loading up to rupture was calculated from the area under the load-deformation curve (Altuntas and Yildiz, 2007). Apparent modulus of elasticity was calculated by using the equation given by Anonymous (2005) for the method of spherical indenter in contact with curved surface of fruit. Skin color of fruits was measured on the cheek area of 50 fruit with a Minolta Chroma Meter CR-400 (Minolta-Konica, Japan) (Kok et al., 2010).

Descriptive statistics was carried out on the three apple cultivars, and the difference between the mean values was investigated by using the Duncan tests. Mean values were reported with the standard deviation.

Results and Discussion

Table 1 shows the some color properties of early maturated apple cultivars. L (brightness; 100: white, 0: black), a (+: red; −: green) and b (+: yellow; −: blue). Hue and chroma describe color intensity. The L, b and hue values of statistically affected by cultivars at 0.01 significant level (Table 1). Among apple cultivars, Jerseymac had the highest L (51.72%), b (13.11) and hue (25.31%) values than the other cultivars. However the cultivar Vista Bella with red skin color, not surprisingly, had higher a value (30.48%) (Table 1). Skin color change from green to red (for red colored cultivars) is a good indicator for harvest maturity in apples (Reid, 1992). Color in apple skin is a blend of various amounts of chlorophyll, carotenoids, and anthocyanins/flavonols. A variety of red colors are produced by cyanidin glycosides copigmented with flavonols and other compounds. Light is a key regulatory factor in apple skin reddening? Since non-red apples, such as Granny Smith and Golden Delicious, accumulate quercetin glycosides and catechin/epicatechin, the color production in red apples is likely to involve the induction of enzymes between leucocyanidin and cyanidin glycosides (Karacali, 1990; Lancaster, 1992). Previously L, a and b values of Starking Delicious apple cultivar grown in Mediterranean area in Turkey were 46.60%, 23.06% and 17.45%, respectively (Eren et al., 2002).

Tables 2 and 3 are showing the some physical and mechanical properties of 3 early maturated apple cultivars. As can bee seen in Tables 2 and 3, all searched parameters were significantly affected

Table 2
Some physical properties of apple cultivars

Physical properties		Vista Bella	Summerred	Jerseymac	Signif. Lev.
Fruit length, mm		71.84±3.99^{b}	64.77±2.91^{c}	75.30±4.94^{a}	**
Fruit width, mm		59.54±3.52^{b}	60.84±5.38^{ab}	62.59±6.18^{a}	*
Geo. mean diameter,mm		63.37±3.37^{b}	62.09±4.42^{b}	66.55±5.64^{a}	**
Surface area, cm^2		126.49±13.43^{b}	121.69±16.18^{b}	140.10±23.98^{a}	**
Projected area, cm^2		36.10±4.41^{b}	34.28±3.51^{b}	39.74±5.63^{a}	**
Sphericity, %		88.26±2.99^{b}	95.82±4.80^{a}	88.31±3.18^{b}	**
Shape factor		0.97±0.01^{b}	0.99±0.01^{a}	0.97±0.01^{b}	**
Compactness		12.94±0.14^{a}	12.77±0.07^{b}	12.96±0.17^{b}	**
Fruit mass, g		133.35±20.39^{b}	114.89±13.43^{c}	153.95±42.11^{a}	**
Fruit density, kg/m^3		930.65±17.43	945.93±10.05	928.53±18.09	ns
Dynamic coefficient of friction	Steel	0.45±0.03^{a}	0.29±0.03^{b}	0.32±0.01^{b}	**
	Plywood	0.33±0.01^{a}	0.26±0.01^{c}	0.30±0.01^{b}	**
	Fiberglass	0.54±0.06^{a}	0.35±0.01^{b}	0.50±0.01^{a}	**

*, ** Significant levels at 5% and 1%. ns: Not significants. a-b letters indicate the statistical difference within same rows

by cultivars, except fruit density.

Mean fruit mass, width and length was 133.35 g, 59.54 mm and 71.84 mm for cv. Vista Bella, 114.89 g, 60.84 mm and 64.77 mm for cv. Summerred and 153.95 g, 62.59 mm and 75.30 mm for cv. Jerseymac, respectively (Table 2). To determine fruit mass of apple cultivars may be useful in the separation and transportation of the fruit by hydrodynamic means (Haciseferoglu et al., 2006). The importance of determining dimensions in apple cultivars is useful for aperture size of machines, particularly in separation. These dimensions may also be useful in estimating the size of machine components. For example, it may be useful in the spacing of slicing discs and number of slices expected from an average fruit. As well known, fruit shape is determined by fruit dimensions and fruit shape is a useful indicator for description of

Table 3
Some mechanical properties of apple cultivars

Mechanical properties	Vista Bella	Summerred	Jerseymac	Signif. Lev.
Rupture force, N	32.31±5.01^{c}	53.50±6.79^{a}	48.27±9.86^{b}	**
Deformation at rupture, mm	2.71±0.49^{b}	3.61±0.52^{a}	3.52±0.40^{a}	**
Apparent Modulus of elasticity, MPa	4.74±1.02^{b}	6.59±1.65^{a}	6.04±1.74^{a}	**
Energy absorbed, Nmm	44.56±13.58^{b}	97.16±21.82^{a}	86.04±25.43^{a}	**
Hardness, N/mm	12.10±1.87^{c}	15.01±2.07^{a}	13.71±2.07^{b}	**

*, ** Significant levels at 5% and 1%. ns: Not significants. a-b letters indicate the statistical difference within same rows

cultivars in applications for plant variety rights (Beyer et al., 2002) and evaluation of consumer preference. Knowledge of shape and physical dimensions are important in screening solids to separate foreign materials and in sorting and sizing of apple fruits.

Previously a wide variation on fruit mass (157-240 g) has been observed on 18 apple cultivars grown in Western part of Turkey and average fruit mass were found lower in early maturated cultivars than late maturated ones (Yasasin et al., 2006).

The average values of the geometric mean diameter were calculated as 63.37 mm for cv. Vista Bella, 62.09 mm for cv. Summerred and 66.55 mm for cv. Jerseymac, respectively (Table 2). To obtain data on geometric mean diameter may be useful to use it designing the grading process. Previously an important difference on geometric mean diameter on apricot has been observed (Mirzaee et al., 2009). Sphericity of apple cultivars were 88.26, 95.82 and 88.31% for cv. Vista Bella, Summerred and Jerseymac (Table 2). Sphericity is an expression of a shape of a solid relative to that of a sphere of the same volume while the aspect ratio relates the width to the length of the fruit which is an indicative of its tendency toward being oblong in shape (Omobuwajo et al., 1999). Shape factor and compactness of cultivars were between 0.97-0.99 and 12.77-12.96, respectively (Table 2)..

Fruit density of apples cv. Vista Bella, Summerred and Jerseymac were 930.65, 945.93 and 928.53 kg/m^3, respectively (Table 2).

The surface and projected area of cultivars were 126.49 cm^2 and 36.10 cm^2 for cv. Vista Bella, 121.69 cm^2 and 34.28 cm^2 for cv. Summerred and 140.10 cm^2 and 39.74 cm^2 for cv. Jerseymac, respectively (Table 3). To determine of projected area of apples can be useful for accurate modeling of heat and mass transfer during cooling and drying.

The highest coefficient of dynamic friction was obtained on fiberglass as 0.54 for cv. Vista Bella, 0.50 for cv. Jerseymac and 0.35 for cv. Summerred and followed by steel (0.29-0.45) and plywood surface (0.26-0.33), respectively (Table 3). These physical results should be considered in the harvesting, handling and processing of early maturated apple cultivars.

The values of rupture force, deformation at rupture, apparent modulus of elasticity, energy absorbed and hardness of apple cultivars are given in Table 3. These values of rupture force, deformation at rupture, apparent modulus of elasticity, energy absorbed and hardness of apple cultivars were between 32.31 (Vista Bella)-53.50 N (Summerred), 2.71 (Vista Bella)-3.61 mm (Summerred) mm, 4.74 (Vista Bella)-6.59 Mpa (Summered), 44.56 (Vista Bella)-97.16 Nmm (Summerred) and 12.10 (Vista Bella)-15.01 N/mm (Summerred), respectively. Xing and De Baerdemaeker (2007) found the mean values of apparent modulus of elasticity of 'Braeburn' summer apples as 4.95 Mpa, confirming our results.

Conclusion

The physico-mechanical properties of the early maturated apple cultivars were described in order to better design a specific machine for harvesting and post harvesting operation. Therefore, the differences between the physical properties of apple cultivars should be considered in optimizing apple mechanization and processing.

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