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THE PHYSICAL AND CHEMICAL PROPERTIES OF KIWIFRUIT HARVESTED AT FOUR STAGES

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Abstract

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Comprehensive information on properties of agricultural crops facilitates the design of modern machinery and processing equipment with modified quality specifications. Hence, mechanics of agricultural materials due to its special importance has quite developed despite being young. In this research some physical properties of the kiwifruit (Hayward and Bruno cultivars), soluble solid content and pH were investigated for two fruit cultivar during four harvest stages. The objective of this study was to investigate the effect of harvest time and cultivar on some physical properties of kiwifruit varieties, typically cultivated in Iran. Physical properties of kiwifruit were determined at a moisture content of 80% to 86% (wet basis). The considered parameters were geometric mean diameter, Arithmetic mean diameter sphericity, true density and aspect ratio. Results showed that geometric mean diameter and sphericity were significantly affected by fruit cultivar. However, there was no significant effect on true density. Soluble solid content and pH values increased in both cultivars with increasing harvest time.

Key words: kiwifruit; harvest stage; physical properties, variety

Abbreviations: M - moisture content (% d. b.); L - length of the seed (mm); W - width of the seed (mm); T - thickness of the seed (mm); D_a - Arithmetic mean diameter (mm); φ - sphericity; m - mass of the fruit (g); V - volume of fruit (mm^3); ρ_t - true density (g/cm^3); D_g - geometric mean diameter (mm)

Introduction

Commercial kiwifruit cultivars are part of the genus *Actinidia*, which has species that express diverse skin characteristics (Ferguson, 1990). Commercial cultivars of kiwifruit are large-fruited selections of *Actinidia deliciosa* (A. Chevalier, C.F. Liang et al., A. R. Ferguson). The genus *Actinidia* is solely of Asian origin; plants are found ranging from northeast India through China to tropical Java and into the cold climates of Manchuria, Japan, and eastern Siberia. Kiwifruit has high levels of vitamin C and citric acid. Vitamin C content is at least twice that of the orange. Starch is high at harvest, but it is converted to soluble sugars during storage and ripening (Carlos et al., 1999). *A. arguta* has diploid, tetraploid, hexaploid, and octoploid cytotypes, and characteristically has small smooth green-skinned fruit that grow singly or in multiples. The fruit has been reported to contain a high vitamin C content, good flavour, and to be more cold resistant during growth than commercial kiwifruit. Therefore, the species is of commercial interest in several countries (e.g., Kabaluk et al., 1997). The estimated world production is about 1313827 tonnes of kiwifruit from an area of 82547 ha land (FAO, 2008). The estimated Iran production is about 30000 tonnes of kiwifruit over an area of 23000 ha (FAO, 2008). Physical proper-

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ties of crops are essential parameters in utilization, development of processing methods, and design of equipment (Bagherpour et al., 2010; Ogunsina et al., 2008).

Many researches on physical properties are reported for different types of fruits, such as apricot (Hacisefergullari et al., 2007), tomato (Baltazar et al., 2007), peaches nectarines, plums (Valero et al., 2007). Physical properties of food materials also affect on handling/conveying characteristics and estimating cooling and heating leads (Mohsenin, 1978). Physical attributes such as size, shape, density are major consideration in designing of hopper, drying and aeration systems, as these properties affect on the resistance to airflow of the stored mass. (Bern and Charity, 1975). Therefore, the objective of this study was to investigate the influence of harvest time and cultivar on some physical and chemical properties of the kiwifruit typically cultivated in Iran. The parameters measured at different harvest time and cultivar were size, volume, geometric mean diameter, arithmetic mean diameter, sphericity, true density, aspect ratio, SSC, pH, M.C.

Materials and Methods

Kiwifruit used in the present study were collected from a farm, north of Iran (Chubar Talesh) at four harvest stages from October to January 2010. Fruits of two kiwifruit cultivars raised in humid condition namely Hyward and Brono at four harvest times (0-20-40-60 days) were used for this study. All fruits were cultivated in an identical environment condition. Subsequently, these fruits were transported to the laboratory. The fruit's surface was cleaned manually and tested within 24. All the experiments were conducted at room temperature (23 ± 2^0C). Physical parameters were studied for 50 fruits from each cultivar at each harvest time. In all four-harvest times, moisture content was obtained. The moisture content (MC) of the fruits was determined by the oven method (Mc Glone et al., 2002) and was found to vary between 81.45% and 83.32% wb.

The three linear dimensions of the kiwifruit, namely length (L), width (W) and thickness (T) were measured (Figure 1). The geometric and arithmetic mean diameter (D_g and D_a respectively) of the kiwifruit was calculated by using the following equation (Mohsenin, 1978):

$$D_g = (LWT)^{\frac{1}{3}} \qquad (1)$$

$$D_a = \frac{L + W + T}{3} \qquad (2)$$

The sphericity φ was determined using the following relationship (Mohsenin, 1978):

$$D_a = \frac{(LWT)^{\frac{1}{3}}}{L} \qquad (3)$$

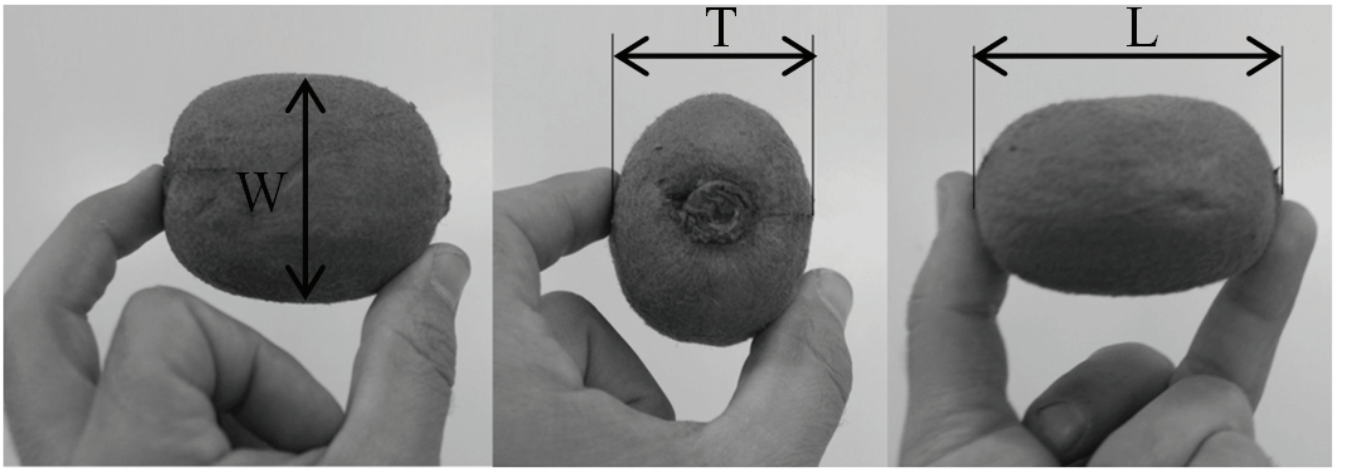

Fig. 1. Representation of the three perpendicular dimensions of kiwifruit: longitudinal axis through the hilum (length); transverse axis containing the intermediate dimension (width) at right angles to the longitudinal axis; transverse axis containing the minimum dimension (thickness)

Kiwifruit mass (m) was measured by means of an electronic balance (0.01 g accuracy). The volume (V) of each kiwifruit was determined using a method described by (Mohsenin, 1978).

Liquid displacement method was used for true density (ρ_t). Due to the short duration of experiments, moisture adsorption was found to be negligible and therefore fruits were not coated for moisture adsorption prevention (Mohsenin, 1978).

An ATAGO refractometer (Master- a) and a CRISO pH meter was used to measure SSC and pH values of sample respectively. Using factorial experiment with completely randomized design, the effect of independent factors including four harvest time stages and cultivars, in physical and chemical properties using PASW STATISTICS 18 package were studied for fresh kiwifruits.

Results and Discussion

The moisture content of the kiwifruit in each harvest time was obtained. Table 1 shows the results of analysis of variance for some physical properties of fresh kiwifruits in four different harvest times. As indicated, some physical parameters were significantly ($p<0.05$) effected by them. Statistical analysis showed that the cultivar had a significant effect ($p\leq0.05$) on sphericity, arithmetic mean diameter, geometric mean diameter and aspect ratio. In addition, harvest stages had significant effect on aspect ratio and sphericity. Interaction of harvest stages and cultivar had significant effect on sphericity, geometric mean diameter, arithmetic mean diameter and aspect ratio at $p\leq0.05$ and finally none of the independent variables had significant on true density.

Results showed that sphericity, arithmetic mean diameter, geometric mean diameter and aspect ratio of Hayward cultivar was higher than Bruno cultivar (Table 2). This indicates that there is a difference in shape and size of fruits in two cultivars. It is an important factor in designing of sorting machines.

As indicated in Table 3 mean of physical properties in different harvest stages showed that there was significant effect ($p\leq0.05$) on sphericity and aspect ratio. Whereas harvesting of kiwifruits in Iran dependents on the different climate condition is started in mid October and continues to mid January. On the average the maximum value for sphericity and aspect ratio were obtained

Table 2
Mean values of the physical properties of two kiwifruit cultivars (Duncan, P≤0.05)

Cultivar	Sphericity	Arithmetic mean diameter	Geometric mean diameter	Aspect ratio
Hayward	0.84	59.58	59.01	81.01
Bruno	0.68	54.75	52.53	58.45

Table 3
Mean values of the physical properties of kiwifruit at four-harvest stage (Duncan, P≤0.05)

Harvest time	Sphericity	Aspect ratio
0	0.771^{a}	71.848^{a}
20	0.768^{ab}	71.75^{a}
40	0.751^{d}	67.625^{b}
60	0.755^{bc}	67.709^{b}

* Means in columns with same letters are not significantly different at $p\leq0.05$

Table 1
Results of analysis of variance (ANOVA) of the physical properties of kiwifruit

Variables	DF	Mean of square Sphericity	AMD	GMD	Aspect ratio	True density
Variety	1	1.04**	935.56**	1680.52**	20355.26**	0.0001^{ns}
Harvest time	3	0.004^{*}	19.37^{ns}	17.03^{ns}	227.78**	0.0001^{ns}
Varity× Harvest Time	3	0.004^{*}	63.77*	57.69*	207.4*	0.0009^{ns}
Error	152	0.001	12.38	11.38	35.81	0.0001
CV		0.042	0.062	0.06	0.086	0.01

^{ns} , * ,** , not significant, significant at $p\leq0.05$ and significant at $p\leq0.01$ respectively

at the second and third harvest stages, which is the best harvest time in Iran.

As Figure 2 indicates there is a difference on shpericity between two cultivars. This can be because of the shape and size of two cultivars. Maximum sphericity for Hayward and Bruno were found to be 0.93 and 0.81 and minimum values were 0.75 and 0.62, respectively. A similar result was obtained by Razavi and Bahram-Parvar (2007). The high sphericity of kiwifruit is indication of the tendency of the shape towards a sphere.

According to the Figure 3 there is a significant effect on arithmetic mean diameter between two cultivars and this difference is because of the size of the two cultivars.

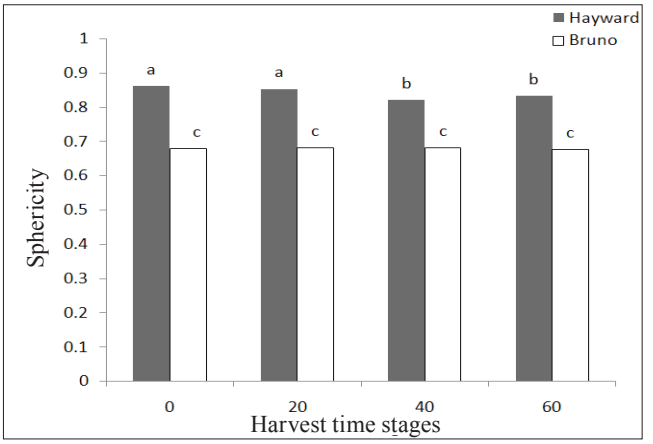

Fig. 2. Comparison of average sphericity for the interaction of cultivars and harvest time (Duncan, P≤0.05)

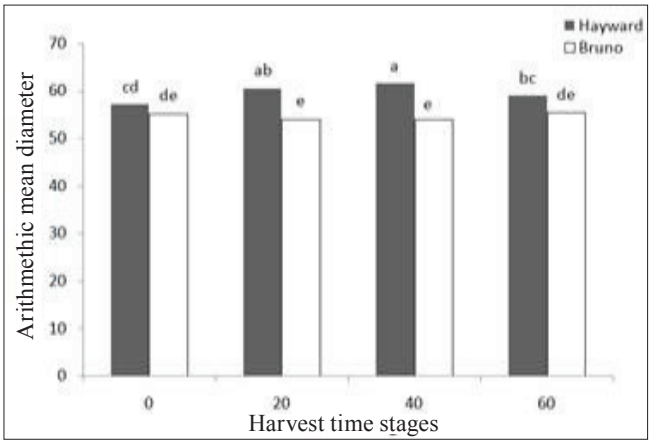

Fig. 3. Comparison of average arithmetic mean diameter for the interaction of cultivars and harvest time (Duncan, P≤0.05)

Hayward kiwi fruits were and more homogenous than Bruno kiwifruits. In addition, the maximum value of arithmetic mean diameter of Hayward and Bruno were found to 65.96 & 68.96 mm, respectively and minimum values were found to 51.63 and 48.08mm, respectively. Arithmetic mean diameter increased with increasing the size of fruit. According to table (1-3) there was not significant effect on true density between two cultivars and the true density value for Hayward and Bruno were 1.045 and 1.05 g/cm^2, respectively. These values were similar to those reported by Harris and McDonald (1975).

According to Figure 4 there was significant effect on geometric mean diameter between two cultivars this can be related to the differences in the size of two cultivars as indicated Hayward kiwi fruits were bigger than Bruno kiwifruits. Maximum value of geometric mean diameter for Hayward an Bruno kiwifruits were 64.16 and 63.23 mm and minimum values were 54.97 and 45.98 mm, respectively. Geometric mean increased with increasing the size of fruit.

Taken along with the high aspect ratio of 90.84%, it may be deduced that Hayward variety of kiwifruit will rather roll than slide on their flat surfaces. However, the aspect ratio value is being close to the sphericity value may also mean that the kiwifruit will undergo a combination of rolling and sliding action on their flat surface (Figure 5).

The soluble solid content (SSC), moisture content(MC) and ph of the kiwifruit in each harvest

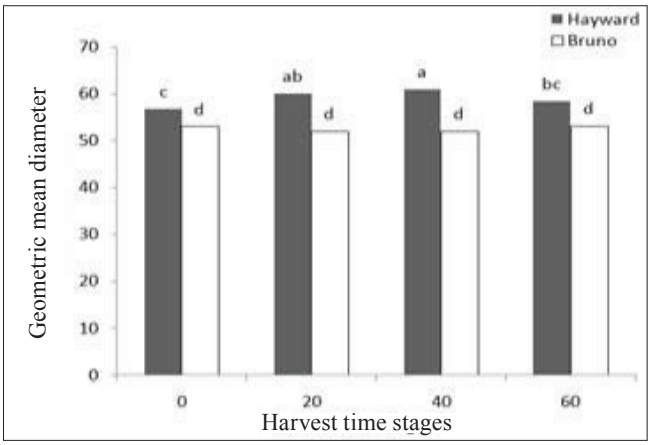

Fig. 4. Comparison of average geometric mean diameter for the interaction of cultivars and harvest time (Duncan, P≤0.05)

time was obtained. Table 5 shows the results of analysis of variance for these attributes of fresh kiwifruits at four different harvest times. As indicated the effect of cultivar on MC is not significant. While the effect of harvest time, cultivar and their interaction on pH and soluble solid content is significant.

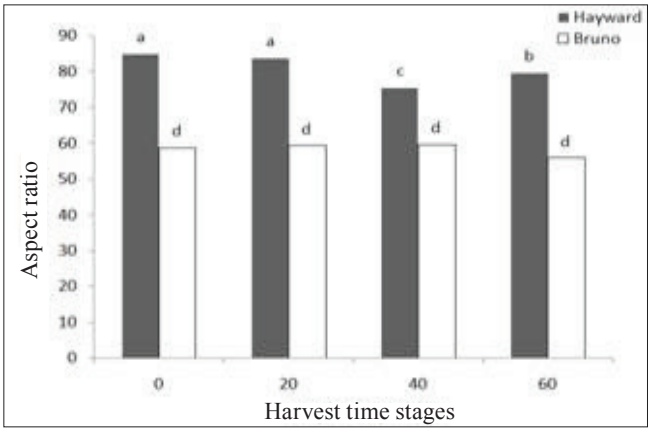

Fig. 5. Comparison of average aspect ratio for the interaction of cultivars and harvest time (Duncan, P≤0.05)

Table 4
Results of analysis of variance (ANOVA) of the chemical properties of kiwifruit

Variables	DF	M.S	SSC[a]	PH
		MC		
Varity	1	0.39[ns]	11.82**	0.242**
Harvest Time	3	4.495*	233.65**	2.002**
Varity× Harvest Time	3	4.128*	3.077*	0.21*
error	72	0.771	0.455	0.009
CV		1.07	5.8	3.1

[a].Brix
[ns] , * ,** , not significant, significant at p≤0.05 and significant at p≤0.01 respectively

Table 5
Mean values of the chemical properties of two kiwifruit cultivars (Duncan, P≤0.05)

Variety	MC	SSC	PH
Hayward	82.36	11.26	2.99
Bruno	82.5	12.03	3.1

Based on Table 5 on average soluble solid content and pH value in Hayward cultivar is more than Bruno cultivar in other words Bruno cultivar is sweeter than Hayward cultivar and contain high amount of soluble solid contents and this is one of the priorities of Bruno cultivar.

As Table 6 shows, there is a significant effect (p≤0.05) on moisture content at four different harvest times but According to Table 7 there is not a big difference. This small difference can result from changes in fruit texture and reduction of its firmness. Other researchers has investigated the effect of storage on moisture content and did not obtained significant effect (p≤0.05) (Harris and McDonald, 1975). Hayward cultivar at the second harvest time had the most moisture content and Bruno cultivar at the third harvest time had the least moisture

Table 6
Mean values of the chemical properties of kiwifruit at four harvest stage (Duncan, P≤0.05)

Harvest time	MC	SSC	PH
1	81.85[c]	7.78[d]	2.69[d]
2	82.85[a]	10.38[c]	2.94[c]
3	82.24[bc]	12.58[b]	3.1[b]
4	82.79[ab]	15.84[a]	3.44[a]

Table 7
Mean values of the physical properties of two cultivars of kiwifruit at four harvest stage (Duncan, P≤0.05)

Variety	Harvest Time	MC	SSC	PH
Hayward	1	81.45 [a]	7.25[a]	2.64[a]
	2	83.33 [b]	9.75[c]	2.87[c]
	3	82.35 [ab]	12.45[e]	3.08[de]
	4	82.31 [ab]	15.59[f]	3.35[f]
Bruno	1	82.25 [c]	8.31[b]	2.74[b]
	2	82.36 [b]	11[d]	3[d]
	3	82.12 [b]	12.71[e]	3.11[e]
	4	83.27 [c]	16.09[f]	3.54[g]
S.D		1.02	3.08	0.3

* Means in columns with same letters are not significantly different at p≤0.05

content. But soluble solid content and pH value considerably increased with increasing harvest time and this is fruits natural maturity procedure , with starting growth period internal fruit reactions occurs and this trend continues up to complete ripeness and maturity point of fruit.

According to Table 7 soluble solid content and pH in both cultivars increased with increasing harvest time and soluble solid content of Bruno cultivar were found to be more than Hayward cultivar at all four different harvest times. The maximum value of soluble solid content for Hayward and Bruno cultivars were 16 and 16.75 Brix and the minimum values were 6 and 7.5, respectively. Other researchers reported similar results for storage time of the kiwifruit ((Manolopolo and Papadopolo,1998 and Mirzaye Magdam and et al , 2006). As Figure 6 and Figure 7 indicate in both cultivars soluble solid content and pH increases nearly with a fixed rate. The maximum value of pH for Hayward and Bruno cultivars were 3.6 and 3.63 and the minimum values were 2.5 and 2.69, respectively.

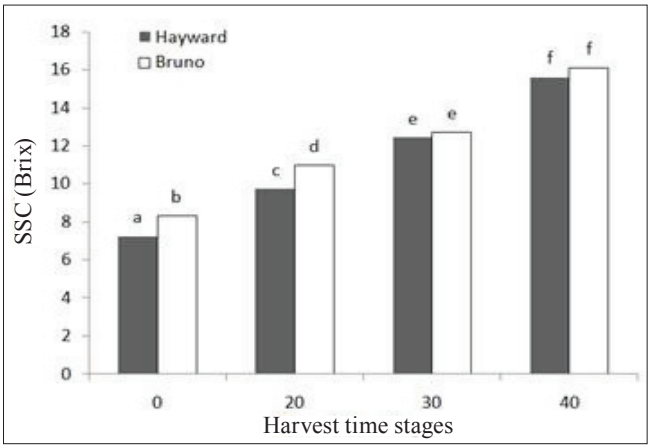

Fig. 6. Comparison of average SSC for the interaction of cultivars and harvest time (Duncan, P≤0.05)

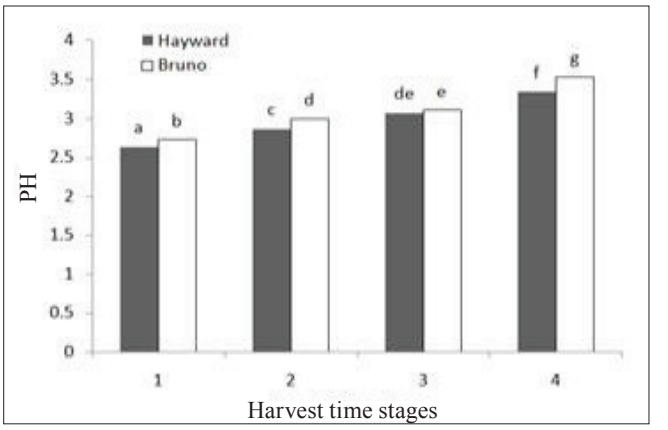

Fig. 7. Comparison of average pH for the interaction of cultivars and harvest time (Duncan, P≤0.05)

Conclusions

The Geometric mean diameter, Arithmetic mean diameter, Sphericity, True density, Aspect ratio, SSC, pH and M.C. of the kiwifruit varied within the ranges of 50.2-64.14, 50.79-64.69, 0.75-0.93, 1.03-1.07, 63.86-99.95, 6.0-16.0, 2.5-3.60 and 80.18-85.15 for Hayward cultivar and 45.98-63.22, 48.08-65.96, 0.62-0.81, 1.02-1.09, 50.44-83.51, 7.5-16.75, 2.69-3.8 and 80.28-84.9 for Bruno cultivar respectively.

Sphericity of Hayward was higher than Bruno. This means that Hayward is more spherical than Bruno and therefore, Hayward cultivar can more easily roll on the surfaces. It can be used in sorting machines.

Kiwifruits are heavier than water and this characteristic can be used to design separation or cleaning process for fruits.

Result showed that Bruno cultivar was sweeter than Hayward. Therefore, Bruno's application in the food industry will be higher than Hayward.

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