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Effect of fall height and impact surface material on the bruise surface of persimmon (*Fuyo* var)

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Abstract

Persimmon fruit is susceptible to injury, this fruit is under different loads from harvest to delivery to the customer. Bruise occurs due to injury during the various stages of handling, transport and packaging. In this study, some effective factors on level of bruise persimmon such as fall height and type of impact surface were studied. Also some physical and storage properties of this product before and after impact testing at room temperature were investigated. The effect of these factors on bruise persimmons were analyzed by using factorial experiment in a completely randomized design with three levels of fall height of 15, 30, 45 cm, three levels of hitting such as wood, plastic, steel with same thickness of 6 mm and a total of 27 treatments with three replications. Analysis of variance showed that the effect of fall height and impact surface material on the bruise level was significant at the 5% level ($p<5\%$). After 6 days storage of persimmons at room temperature the length from 74.44 to71.16 mm, width from72.82 to 69.14 mm, thickness from 48.87 to 45.09 mm, weight from 175.98 to 165.23 g, the arithmetic mean diameter from 65.38 to 61.80 mm, the geometric mean diameter from 64.20 to 60.51 mm, coefficient of sphericity from 0.86 to .085, surface area from 129.47 to 115.27 cm^2, volume from 139.35 to 116.72 cm^3 and density from 1.26 to 1.41 (g /cm^3) changed.

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Introduction

With scientific name of *Diospyros Kaki*, persimmon fruit is from *Ebenaceae* family. Origin of persimmon tree is China country and later it was taken to Japan and to America in 1970s. This fruit grows in north and south jungles of Iran and it is also cultivated in Tehran and another cities. China has maximum production amount of persimmon in the world, so that it produced persimmon over 1.655×10^9 kg in 2007. According to statistics, produced amount of persimmon in Iran is about 1.006×10^9 kg and annual cultivation of persimmon tree is 244429.6 ha (Safiyari *et al*, 2012).

A significant percentage of fruits are wasted for different reasons such as mechanical damages. From harvest phase to reaching the customer, fruits may pass the processes such as picking, handling, packing, sorting, storing and transmitting and fruits can be exposed in different dynamic and static loads and damaged in each of these phases (Tabatabaekoloor *et al.* 2011). Bruise often is occurred during relocating, transmitting and packing via impact. Mechanical impacts are indentified as main factors of wasting after harvesting products. During phases after harvesting, dynamic loads are more effective in making bruise, because dynamic loads have greater effect than static loads in terms of amount and frequency. Amount and existence of bruise also plays role key in assorting and rating health products (Kafashan *et al.* 2008). Amount and existence of bruise also plays role key in assorting and rating health products (Studman *et al.*,1997).

Some related researches with current study are: Tabatabaekoloor *et al.* (2011), they studied some effective factors on level of surface and volume of bruise in apple fruit (*Golden Delicious var.*) including fall height, impact surface material and linear speed of apple on conveyor. The their results showed that the effect of fall height and impact surface material is significant on bruised surface in 1% level, while bruise volume only is affected impact surface material. Idah *et al.* (2007) considered the damage due to impact on fresh tomato via determining the effect of fall height, surface material and ripeness effect and fruit size on wastes. They concluded that the maximum damage is due to the impact resulting from falling fruit on metal surface and the released energy due to impact is affected fruit mass and fall height.

Mohammadi Ailar *et al.* (2010) studied some mechanical properties of tomato under impact loading test, the effect of factors of fall height, variety and time of post harvest on rupture amount and making mechanical damages in health fruits within three days of storage. They concluded there was a significant relationship between the effect of fall height and time of post harvest on damage percentage and mechanical damages of impacted place in health fruits. Hazbavi *et al.* (2008) measured mechanical and physical properties of persimmon. These measurements are needed for designing harvesting equipment, processing, transmitting, packing and sorting. Afshari *et al.* (2008) tested volume and type of damage in three variety potato under impact loading with pendulum instrument. Altuntas *et al.* (2010) measured chemical and physical properties of *Fuyu var.* persimmon. Hasanpour Kahnamuyi *et al.* (2013) investigated some of hydrodynamic, chemical and physical properties of two varieties of persimmon (*Diospyros* and *Diospyros Virginiana*) that these fruits were ripping.

Determining physical properties of agricultural products is a base for designing and building machines of harvesting, packing and processing of agricultural crops. Studying behavior in effect of falling from a height and strikeing with different surfaces has special importance because of reducing mechanical damages to crops during harvest and after harvest phases. Because of this, this article was studied physical properties and the bruise resulting from fall of persimmon fruit on different surfaces.

Material and methods

Preparation of samples

Fuyo var. of persimmon is provided from gardens located in Ali Abad city in Golestan province. 81

health ripping persimmons were selected. Moisture content was determined using the standard oven drying procedure ASAE Standard S.352 (ASAE, 1979). At first, mass of samples were measured via digital scale with accuracy of 0.01 g then placed in a constant temperature oven for drying at a temperature of about 80 ± 2 °C for a minimum drying period of 24 hours Initial moisture was 74.9% .

Tools and Needed Devices

Caliper with accuracy of 0.01 mm was used to calculate length, width and thickness, mass was measured via a digital scale with accuracy of 0.01 g and a model similar Figure 1 was used to survey the effect of the parameters such as height and impact surface material on bruise of persimmon. According to depicted model, heights of 15, 30 and 45 cm are marked on a column and then three different levels of wood, plastic and steel were paired with same thickness and persimmon fruit was released from above heights on different surfaces.

Test Method

First, some of physical properties were calculated according to following relations, such as length (L), Width (W), thickness (T), mass (M), arithmetic mean diameter (d_α), geometric mean diameter (d_g), equivalent diameter (d_{eq}), volume (V), density (ρ), sphericity ratio (Φ) and surface (S) (Mohsenin,1986).

$$d_a = \frac{L+W+T}{3} \quad 1$$

$$d_g = (LWT)^{1/3} \quad 2$$

$$d_{eq} = 2r = 2[\frac{3V}{4\pi}]^{1/3} \quad 3$$

$$V = \frac{\pi LWT}{6} \quad 4$$

$$\rho = \frac{M}{V} \quad 5$$

$$\Phi = \frac{(LWT)^{1/3}}{L} \quad 6$$

$$S = \pi {d_g}^2 \quad 7$$

Then for studying the effect of bruise surface based on above model, persimmon was released from three heights of 15, 30 and 40 cm on the surfaces from tissue of wood, plastic and steel with same thickness of 6 mm. Table 1 provide the properties of each from material based on Lewis *et al.* (2007b).

Then the samples were kept at room temperature for 72 hours to appear damaged sections of samples. Since in this study, bruise surfaces were oval, small and large diameter were measured after appearing damaged points. Some researchers calculated bruise surface at the point of impact using oval bruise thickness method (Mohsenin, 1986; Lewis *et al.*, 2007a). Bruise surface was calculated using oval bruise thickness based on Eq. 8.

$$S = \pi ab \quad 8$$

Where, a is half of large diameter of oval and b is half of small diameter of oval.

3 and 6 days after impact test, physical properties of product were calculated with previous method. SPSS software was used to analyze data and excel software was used to draw diagrams.

Results and discussion

Changes in Level of Bruise

Table 2 provides the results of variance analysis related to fall height and surface of impact along with their reciprocal effects on bruise surface of persimmon.

It can be seen that there is a significant relationship between height and type of impact surface on bruise in 5% level. There is a significant difference between bruise surface in different levels of fall height (15, 30 and 45 cm). As it can be observed with reducing height, bruise surface will decrease. Bruise surface equals to 456.42 mm² in height of 45 cm and it equals to 159.63 mm² in height of 15 cm. these results are similar to obtained result by Tabatabaekoloor *et al.* (2011). they reported the reduction of fall height from 30 to 10 cm can be decreased bruise surface 28% for apple (*Golden Delicious var.*). Figure 2 shows changes of bruise surface with changes of height.

Table 1. Properties of used material in impact surface.

Material	Thickness (mm)	Poison ratio	Elastic module (Gpa)
Steel	6	0.3	200
Wood	6	0.341	8.89
Plastic	6	0.5	0.1

Table 2. Variance analysis related to main factors and their mutual effects on bruise surface in persimmon *Fuyo* var.

Source of variation	df	F_ value	Mean square	sum of squares	Sig
Surface treatment	2	3.945*	199251.511	398503.021	0.038
Height of fall	2	3.953*	199645.544	399291.088	0.038
Height * Surface	4	1.137ns	57426.504	229706.016	0.371
Error	18		50507.135	909128.427	
Total	27			4621808.115	

* Significant in statistic level of 5 % (P<5%). ns isn't significant.

Table 3. Average of physical properties of persimmon fruit in storage time after impact test.

Cases	The first day (before impact testing)	3 days after impact testing	6 days after impact testing
Mass(g)	175.98	170.34	165.23
Length(mm)	74.44	72.58	71.16
Width (mm)	72.82	71.07	69.14
Thickness (mm)	48.87	47.38	45.09
Arithmetic mean diameter (mm)	65.38	38.67	61.80
Geometric mean diameter (mm)	64.20	62.49	60.51
Equal diameter (mm)	64.20	62.49	60.51
Sphericity index	0.8629	0.8616	0.8507
Area of Practice (cm^2)	129.74	122.91	115.27
Volume (cm^3)	139.35	128.46	116.72
Density (g/cm^3)	1.26	1.32	1.41

It also was seen that bruise surface will decrease from 456.87 mm² to 168.34 mm² with change of impact surface from steel to plastic. These results are similar to obtained results by Lewise *et al.* (2007). Using tissue of cartoon and wood instead of steel in impact surface can decrease bruise level 26% and 7%, respectively. Persimmon fruit is very sensitive to impact and its sensitivity will increase to ripe it. So having a proper system of harvest, transportation and packing is vital. As influential factors in bruise surface, fall height and impact surface tissue should be determined with high accuracy. Figure 3 shows changes of bruise surface with changes of impact surface.

Changes of Physical Properties

As can be observed in table 3, impact test and storage in room temperature, some factors decrease including mass, length, width, thickness, arithmetic mean diameter, geometric mean diameter, equivalent diameter, sphericity ratio, area and volume. These results are similar to obtained results by Safiyari *et al*, (2012). They reported that increase of the storage of persimmon fruit decreases significantly some factors including length, width, thickness, arithmetic mean diameter, geometric mean diameter, equivalent diameter, sphericity ratio, area and volume.

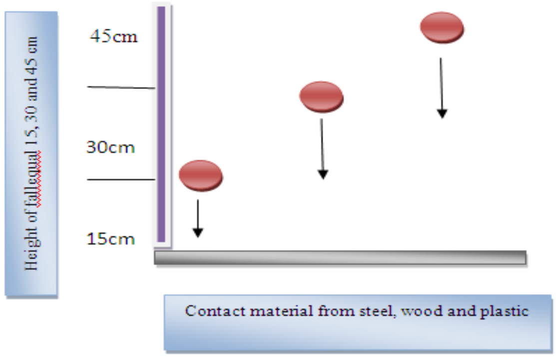

Fig. 1. Fall model of persimmon, horizontal surface representing impact surface from tissue of wood, plastic and steel and vertical surface representing fall height of 15, 30 and 45 cm.

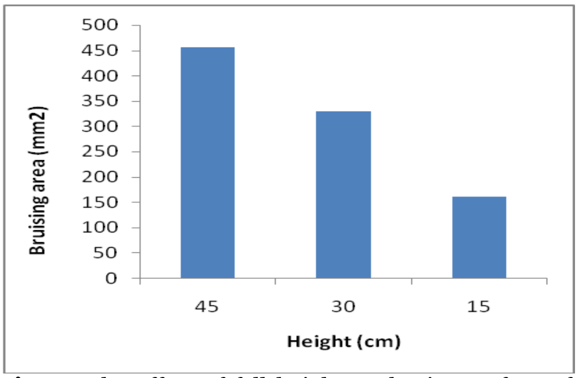

Fig. 2. The effect of fall height on bruise surface of persimmon.

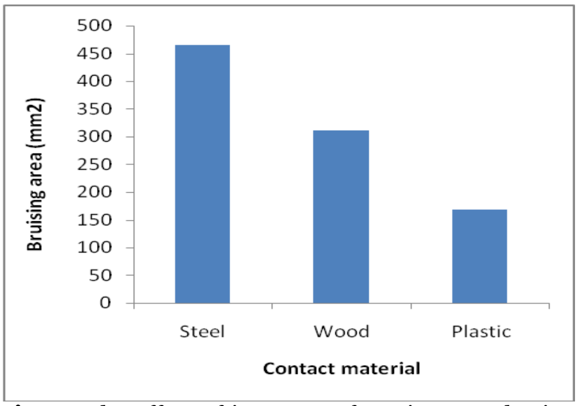

Fig. 3. The effect of impact surface tissue on bruise surface of persimmon.

As can be seen in Figures 4 and 5, surface and volume of persimmon fruit decrease linearly with increasing storage time.

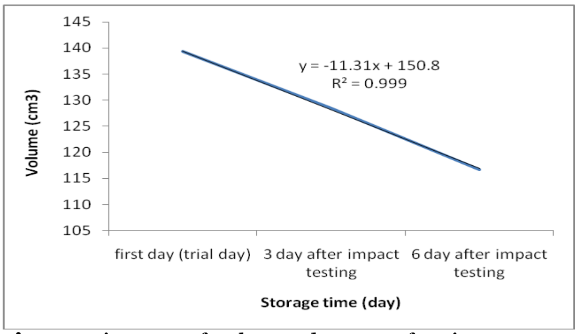

Fig. 4. Diagram of volume changes after impact test and storage in room temperature.

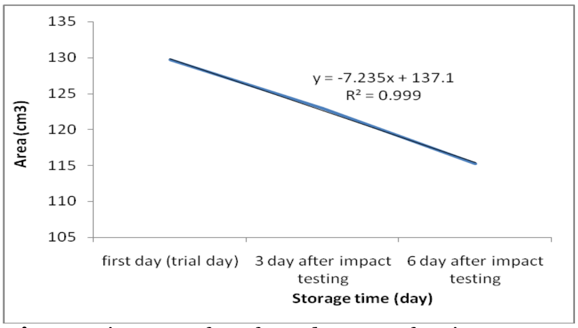

Fig. 5. Diagram of surface changes after impact test and storage in room temperature.

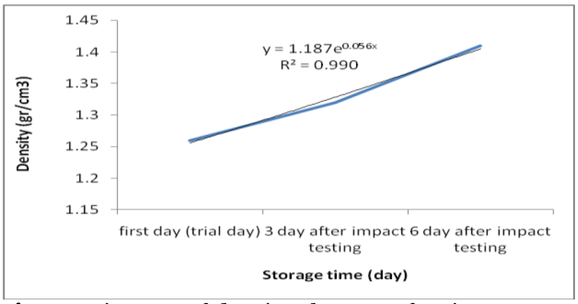

Fig. 6. Diagram of density changes after impact test and storage in room temperature.

As can be seen in Figure 6, density of persimmon fruit changes exponentially over the time. It was 1.26 $\frac{gr}{cm^3}$ on the first day and increased to 1.32 $\frac{gr}{cm^3}$ and 1.41 $\frac{gr}{cm^3}$ respectively, after impact test and storage within 3 and 6 days.

Conclusion

Bruise surface has been changed with changing of height and impact surface material. Bruise surfaced was increased with increased height from 15 to 30 and 45 cm and also with changing impact surface material from plastic to wood and steel. Physical properties of product were changed with storage after impact test. After six days of persimmon storage in room temperature, length changed from 74.44 to 71.16 mm, width from 72.82 to 69.14 mm. thickness from 48.87 to 45.09 mm, mass from 175.95 to 165.23 g, arithmetic mean diameter from 65.38 to 61.80 mm, geometric mean diameter from 64.20 to 60.51 mm, sphericity ratio from 0.86 to 0.85, area from 129.74 to 115.27 $cm^{2,}$ volume from 139.35 to 116.72 cm^3 and density from 1.26 to 1.41 $\frac{gr}{cm^3}$. The amount of damage to product will be minimum possible with selecting proper surface and height.

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