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Effect of Storage Period on Some Orange Physical Parameters (*cv*. Valencia)

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ABSTRACT

The proper conservation during storage recovers the production costs. So for continuous market supply, the proper conservation methods should be used. The effect of conservation period on the external and internal changes of fruit can be studied by measuring its physical parameters. To achieve this goal, the effects of storage period and fruit size on some physical attributes of orange (*cv*. Valencia) such as mass, volume, true density, rind ratio and moisture content are investigated. Factorial experiment in the form of randomized design with 32 replications is applied. The result shows that the effect of storage period on all physical parameters is significant at 1% level; and with increasing time, true density increases while all other physical parameters decrease. Also it is found that fruit rind ratio and moisture content increase with increasing fruits size while the true density decreasing.

KEY WORDS: orange, physical parameters, storage period, rind ratio, true density

INTRODUCTION

Fresh fruits and vegetables including citrus fruits, from the beginning of history, have been part of the human diet, and so they have paramount importance in agriculture and they are an important source of revenue for the producing countries. It is believed that citrus fruits are native to tropical, subtropical and humid climate in South East Asia [6]. Citrus cultivation started about 2400 years BC in southern China and Indochina, particularly South Vietnam. According to historical evidence, the Hebrew were familiar with citrus in twentieth century BC. The southern edge of the Caspian Sea is mentioned as the second focus of the expansion of citrus cultivation [10]. Among citrus fruits, oranges are most important economically and industrially, and they are consumed in many forms, including fresh fruits, fruit juice or dried fruits.

Orange production in Iran declined from 2129 tons in 2004 to 1285 tons in 2012 and this corresponds to a drop in ranking from sixth to thirteenth among the world's producing countries [3]. Most of Iran's export of oranges in 2004 were to other coastal countries of Caspian Sea, Turkey and the United Arab Emirates [7].

Despite the existence of advanced fruit processing and packaging facilities in five northern Iranian towns of Ramsar, Shahsavar, Nowshahr, Chalous and Amol, and given long history of orange production in Iran, unfortunately, due to lack of data on the physical properties of agricultural products, especially citrus and orange fruits and also changes in those properties from harvesting to transporting to markets, consumption, and lack of quality control in storage period, and as a result of improper storage of stock, there has been little progress in industrial processing, export quality, and packaging attributes that guarantees the product's marketability. This is the main reason for absence of Iran's orange products in global and international markets.

Production of fruits such as oranges is seasonal in nature, but the demand for them exists throughout the year. The more important matter is related to the costs of production and accurate storage of the product. If it is not possible to implement the correct procedures or storage a large volume of product may be lost in a short time. Therefore, it must storage properly for providing global markets. Respiration, transpiration and other biological activities cause the external and internal changes in harvested product. The orange average rate of respiration production in 5°C is 2-4 $mlCO_2/kg \cdot hr$ (Arpaia & kader,2013). This is the reason for physical and chemical changes in the product; and as the result of dehydration which is followed by sweating, are rapid decline in product quality, decay and shrinkage.

Singh and Reddy (2006), studied the effect of storage time on physical properties of Nagpur Mandarin orange variety and also reported that the oranges had 19.4% and 7.3% weight loss after 17 days of storage at ambient (58% RH and 28° C) and refrigerator (78% RH and 7° C) conditions respectively.

Henriod (2006) studied the characteristics of the Navel oranges after harvesting, during storage period and transporting, in high relative humidity condition. They expressed that the weight loss of oranges in high relative humidity conditions (98%) with the temperature less than 5°C in 55 days storage is about 3 percent. This value is much smaller than the results of Singh et al (2006).

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Camarena et al (2007) studied the parameters which are affected by drying of the Navelina orange variety rind in 84 days of storage. The results showed that during storage period, keeping oranges in ambiance condition (52% -45% relative humidity and a temperature of 20-23° C) fruit rind thickness was reduced from 3.4 to 2.9 mm and the dry material of rind increased from 0.06 to 2.52 $kg.m^{-2}$.

Naturally, there is variation in the physical properties of an agricultural product. These differences can be observed in the collected samples which harvested from the same farm.

Sharifi et al (2007) investigated the physical properties of three sizes of small, medium and large Tompson orange variety and reported that the actual density increased while the size of oranges decreased. They found that the density of small, medium and large oranges, were 1.046, 1.013 and 0.99 $g.cm^{-3}$ respectively.

Topuz et al (2005) investigated the physical properties of four orange varieties (Alanya, Finike, W.Navel, Shamouti) such as dimensions, volume, geometric mean diameter, projected areas, fruit density, bulk density, porosity, packing factor and coefficient of friction. In their research, Navel variety had the minimum rind ratio with the value of 22.95%. Tabatabaeefar et al (2000) studied the physical properties of ten orange varieties and also they modeled the mass of oranges by fruit dimensions.

According to literature review, there has been little research on the effect of storage time on physical properties of the Valencia orange. So the aim of the present study is to investigate the changes of the physical properties of the Valencia orange fruit during storage period that used to design and optimize storage and transportation systems in order to reduce decay. For this purpose, the effect of storage period on some physical properties of complete orange fruit such as mass, volume, density, rind ratio and moisture content are studied.

MATERIALS AND METHODS

The samples were prepared without any damage in three sizes (small, medium and large) and harvested directly from a garden that is located in Shahsavar city of Iran.

Samples were transported to a GLSZ98V8FWO refrigerator type immediately. They were stored at 5 ° C and relative humidity of 90%-85% condition. The samples were tested in a laboratory at 20 ° C after 2, 32 and 62 storage days. During storage time the oranges were regularly reviewed and they were transferred out of the refrigerator immediately if physiological and physical disorders had been observed in any of them.

a) Statistical Analysis:

To provide information on the physical properties of whole orange fruit during storage in refrigerator, a series of experiment was performed to determine the physical properties of this fruit. Factorial experiment in the form of completely randomized design with 32 replications was used and the effects of size in three levels (small, medium and large groups) and storage time in three levels (2 days, 32 days and 62 days after harvesting) on the physical properties of orange (mass, volume, true density, rind ratio and moisture content) were studied. All calculations, data analysis and Duncan test comparison was performed with MSTATC software.

Table 1. the mass average of used orange samples

	2 days after harvesting		32 days after harvesting		62 days after harvesting	
	Number of samples	Average± standard deviation	Number of samples	Average± standard deviation	Number of samples	Average± standard deviation
Small	32	103.73±18.06	32	99.675±19.90	32	81.230±18.43
Medium	32	161.311±12.83	32	141.244±14.10	32	128.590±12.94
Big	32	205.868±22.61	32	193.961±28.24	32	167.378±25.72

b) Physical properties :

Mass of oranges was measured by an accuracy of 0.1g and their volume was determined by displaced water technique with the mentioned balance. The fruit was immersed in the water of container, located on the balance, by applying pressure on the fruit (because the orange and most crops density is less than density of water and in normal mode, without putting pressure on them, are floating on the water), and the weight of displaced water that represents the volume of fruit was calculated from the following formula:

$$V = \frac{M_d}{\rho_w}$$

Where: V-fruit volume (cm^3), M_d –weight of displaced water (g), ρ_w-water density ($g.cm^{-3}$).

M_d is the balance numerical difference between with container filled by water and fruit dipped in that water of container.(Note that in both cases, the instrument for dipping the fruit in water must be marked and also considered, when reading the value indicated by the balance, and due to impurities in the water, ρ_w is higher than $1g.cm^{-3}$ and is a function of ambient temperature, so testing should be performed at a constant temperature)

Fruit density was obtained as (Mohsenin, 1986):

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

Where M is fruit mass(g) and V is fruit volume(cm^3)

Rind ratio was obtained as (Sharifi *et* al, 2007):

$$R_s = \frac{M_s}{M_f} \times 100$$

where R_s is rind ratio(%), M_s is rind mass (g) (This means that both the albedo and flavedo together) and M_f is fruit mass (g).(Topuz *et al*., 2005).

Moisture content was obtained as:

$$M.C. = \frac{M - M_d}{M} \times 100$$

Where M.C. is moisture content (%), M is mass of fruit (g) and M_d=dried fruit without any water (g).(Mohsenin, 1986)

For drying oranges, they were placed in drier at 60 ° C for 48 hours.

RESULTS AND DISCUSSION

Orange physical properties such as mass, volume, fruit density, rind ratio and moisture content after three storage times are shown in Table 2. According to Table 2, the large size of oranges after 2 days storage with mass of 205.87 g, volume of 235.04 cm^3 and rind ratio of 30.28% has the biggest mass, volume and rind ratio, and the small size of oranges after 62 days storage with mass of 81.23 g, volume of 84.20 cm^3 and rind ratio of 21.07% has the smallest mass, volume and rind ratio.

The highest fruit density belongs to small size of oranges after 62 days storage with magnitude of 0.965 $g.cm^{-3}$ and the lowest fruit density belongs to big size of oranges after 2 days storage with magnitude of 0.878 $g.cm^{-3}$. The big size of oranges after 32 days storage with 83.8% of moisture content has the highest magnitude of this parameter and the small size of this fruit after 62 days storage with magnitude of 78.8% of moisture content has the lowest one in comparison with other samples and times.

Table2.Orange physical parameters after three storage times after harvesting

Orange size	Storage time (days)	Mass (g)	Volume (cm^3)	Fruit density ($g.cm^{-3}$)	Rind ratio (%)	Moisture content (%)
Small	2	103.73	111.280	0.934	25.118	82.422
	32	99.675	106.143	0.941	22.813	80.071
	62	81.230	84.203	0.965	21.072	78.812
	Avrage	94.88	100.54	0.947	23.001	80.435
Mediume	2	161.311	179.429	0.900	29.579	82.113
	32	141.244	156.021	0.906	24.805	80.781
	62	128.590	140.271	0.918	21.193	80.585
	Avrage	143.72	158.57	0.908	25.192	81.160
Big	2	205.868	235.036	0.878	30.277	83.531
	32	193.961	218.114	0.890	25.552	83.799
	62	167.378	186.874	0.896	24.331	81.618
	Avrage	189.07	213.34	0.888	26.720	82.983

To investigate the factors of storage period and orange size on orange physical properties, analysis of variance was performed and the results are reported in Table 3. Analysis of variance shows that the effect of the fruit size and storage period factors on the magnitudes of mass, volume, fruit density and moisture content, are significant. Since the interaction of factors on the fruit density, rind ratio and moisture content is not significant, by comparing the means of these properties it can be concluded that in any storage period, the big size oranges have lower density and higher moisture content and rind ratio (see fig 1) which is agree with the study results of Sharifi et al (2007) who found that fruit density of oranges (Var. Tompson) decreased and rind ratio increased with increasing fruit size. Reduction of the fruit rind ratio with increasing duration of storage is because of the exit of moisture from rind of orange; and increasing the fruit density with increasing duration of storage showed that volume is more affected by exit of moisture than the fruit mass of oranges. Therefore, the orange storage period should be chosen so that the reduction in product volume or changes in its appearance will not interfere with the marketability of the fruit.

Table3.Anova results of the effect of size and storage period on orange physical parameters

Factors	Degree of freedom	Means of squares				
		mass	volume	True density	Rind ratio	Moisture content
Time	2	10576.97^{**}	151911.29^{**}	0.039^{**}	177.69^{**}	32.99^{**}
Size	2	2945.53^{**}	5764.36^{**}	0.006^{**}	259.80^{**}	20.38^{**}
Time*size	4	866.67^{ns}	2010.08^{ns}	0.01^{ns}	77.00^{ns}	19.05^{ns}

****significant difference at level 1% , * significant difference at level 5% , ns means no significant.**

Decrease in rind ratio with increasing storage time can be observed in Figure 1. Because the total mass of orange in all three sizes during storage time decreases as shown in Table 2, therefore from decreasing rind ratio during storage time it can concluded that exit of moisture from fruit begins first with fruit shell. From Figure1 it is also seen that fruit moisture content decreases as storage time increases. Similar result was reported by Singh and Reddy (2006). The finding here also shows that bigger oranges have more decrease in the moisture content as seen in Figure1. This result is probably due to the larger size of the orange side that is exposed to the air, because the moisture exchange occurred from the surface of the fruit rind.

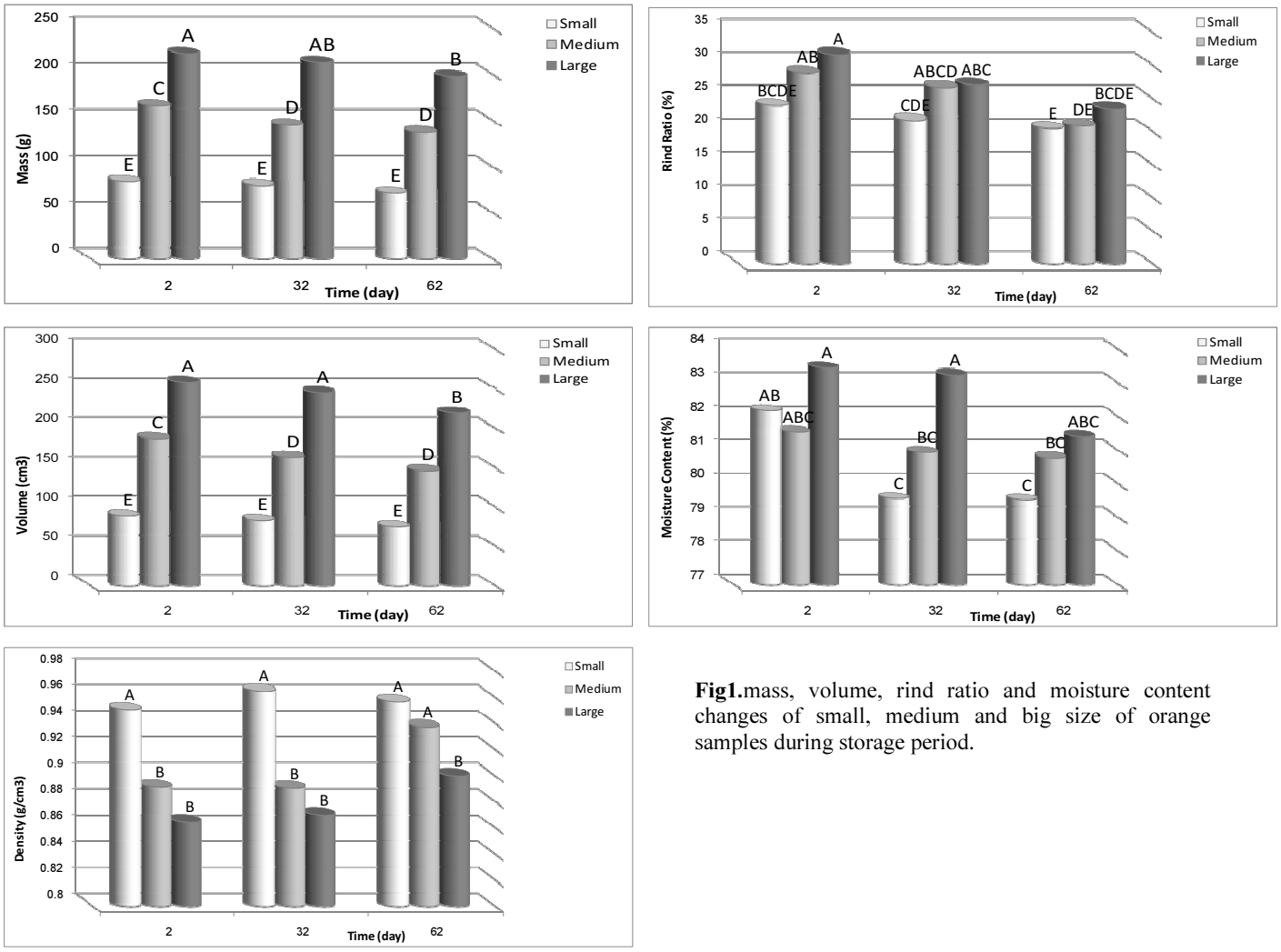

Fig1.mass, volume, rind ratio and moisture content changes of small, medium and big size of orange samples during storage period.

Also as seen in Figure1 with increasing storage time, moisture content is decreasing. This result corresponds to Dalton's law of exchange of fruit moisture with air. Based on Dalton's law, the rate of exiting moisture from fruit is proportional to the fruit surface area which is contacted to the air (Sitkei, G., 1986).

Conclusion

The values of mass, volume, density, rind ratio and moisture content were obtained for the whole orange fruit. Results show that rind ratio increased but the fruit density decreased with increasing fruit size. Also all physical parameters except fruit density decreased with increasing storage time. The increase in fruit density with increasing storage time shows that fruit volume reduction is more affected by the fruit moisture loss than the fruit mass reduction.

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