American-Eurasian J. Agric. & Environ. Sci., 3 (3): 343-346, 2008
ISSN 1818-6769

Some Mechanical and Nutritional Properties of Two Varieties of Apple (*Malus domestica Borkh* L.) in Iran

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Abstract: Iran has an apple production of 2.66 million tons, seventh largest in the world. But in comparison to this production the export of apples is very small (0.19 million tons) which these circumstances may be attributed to some problems involved in postharvest practices. An awareness of some engineering properties can be helpful in proper designing the latter practices. For this purpose, two different varieties of Iranian apples were selected for this study, Redspar and Delbarstival. Some mechanical and nutritional properties of the studied varieties were determined and compared using standard methods. In the case of Redspar cultivar, the coefficient of static friction on plastic, plywood and galvanized iron, flesh firmness, failure stress and strain, modulus of elasticity were found to be 0.28, 0.31, 0.31, 18.53 N, 0.43 MPa, 0.20 mm/mm and 2.53 MPa, respectively. The corresponding values for Delbarstival cultivar were obtained as 0.467, 0.33, 0.41, 14.15 N, 0.24 MPa 0.15 mm/mm and 0.24 MPa, respectively. Total dry matter, TSS, PH and titratable acidity, were 17.2%, 10.73, 3.91 and 0.021, respectively while the corresponding values were found to be 18.16%, 12.54, 3.61 and 0.034, respectively.

Key words: Apple · redspar · delbarstival · mechanical properties · nutritional properties

INTRODUCTION

Fruits are attractive and nutritional foods, because of their color, shape, unique taste and smell, enriched minerals, vitamin and other beneficial components [1]. The apple is a tree and its pomaceous fruit, of species *Malus domestica* Borkh. In the rose family Rosaceae, is one of the most widely cultivated tree fruits. There are more than 7,500 known cultivars of apples [2]. In spite of 2.66 million tons of Iranian annual apple production, exportation of that is low [3]. One of the most important problems limiting exportation increase is realized loss of postharvest operations.

Postharvest evaluation gives possibilities for delivering a high quality product and a basic understanding of apple texture is necessary for the development of technology for postharvest evaluations [4]. Mechanical properties of the tissue, which are affected by factors such as ripening stage and water status, also determine the susceptibility to mechanical damage that can occur during harvest, transport and storage and that eventually leads to a profound reduction in commercial value [5]. Mechanical properties such as failure stress and strain as well as modulus of elasticity can also be used to evaluate the behavior of the fruits mechanically under the static loading. Firmness or hardness is another important attribute of fruits and it is often used for fruit quality assessment [6]. An important characteristic of agricultural products is their sensitivity to injury and damage, which depends on their strength characteristic and also on their biological properties. The occurrence of damage must be counted primarily during harvesting, handling, sizing and transporting of the crops [12]. Hence, mechanical properties are important to reduce mechanical damage by designing the elements of the machine performing an operation in a way such that the forces acting on the material be lower than failure forces of agricultural products and carrying out harvesting operations too, when the state of the product is such that its mechanical strength is sufficient to render it less sensitive to damage.

Information regarding chemical properties of fruit is crucial in processing it into different foods [6]. Fruit weight and dry matter can be used in order to determine

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the best time to harvest fruits. Considering postharvest operations of apples, some mechanical and nutritional properties of those are more important in both machinery and equipment design and also in controlling the actual process procedure. Therefore, in the current study, the mentioned properties of apple fruits, by comparing the two apple varieties, newly grown in Iran and then establishing a convenient reference table for apple mechanization and processing.

MATERIALS AND METHODS

Two apple cultivars namely, Redspar and Delbarstival, new-planted varieties in Iran, were randomly hand-picked in 2007 summer season from orchard located in Horticultural Research Center, Department, Faculty of Agriculture, university of Tehran, Karaj. The two cultivars are also late season. Redspar is red-color variety with large size but Delbarstival is bicolor variety with medium size. As is well-known, they are very sweet and delicious in taste. The 40-50 fruits of each harvested variety were transferred to the laboratory in polyethylene bags to reduce water loss during transport. The initial moisture content of fruits was determined by using dry oven method. The remaining material was kept in cold storage in 4°C until use. All of the experiments were carried out at room temperature (25°C) in Biophysical laboratory and Biological laboratory of university of Tehran, Karaj, Iran.

Mechanical properties of apples were evaluated using 20 cylindrical specimens of each variety, taken in radial direction with diameter as 14 mm and height as 18 mm and then Universal Testing Machine (Santam, MRT-5), as shown in Fig. 2. This machine has three main components, which are a stable forced and moving platform, a driving unit (A C electric motor, electronic variator and reduction unit) and a data acquisition (load cell, PC card and software) system. The machine was equipped with a load cell of 500 N at a compressive rate of 25 mm/min. Failure stress and strain of apples are expressed in terms of the change in compression force and compact area and deformation and initial length, respectively as [6]:

$$\sigma_f = \frac{\Delta F}{\Delta A} \quad (8)$$

$$\varepsilon_f = \frac{d}{l_i} \quad (9)$$

Fig. 1: Apparatus to determine coefficient of static friction

Fig. 2: A Universal Testing Machine (Santam, MRT-5). to determine failure properties of fruits

where σ_f, ΔA, ε_f and l_i are designated as failure stress, cross section, failure strain and specimen length of fruits. ΔF is failure force and d is failure deformation of samples in the failure point (B point in Fig. 3 [7]).

Modulus of elasticity value (MPa) was calculated as the slope of the line from the origin (0:0) to 50% of failure point and failure energy was also considered as the total area in failure point [8].

The coefficient of static friction was determined with respect to different surfaces: plywood compacted plastic and galvanized iron. A hollow cubic (Fig. 1) open at both ends was filled with the fruits placed on adjustable titling surface such that the metal cylinder did not touches the surface. Then the surface was raised gradually until the filled cylinder just started to slide down [9].

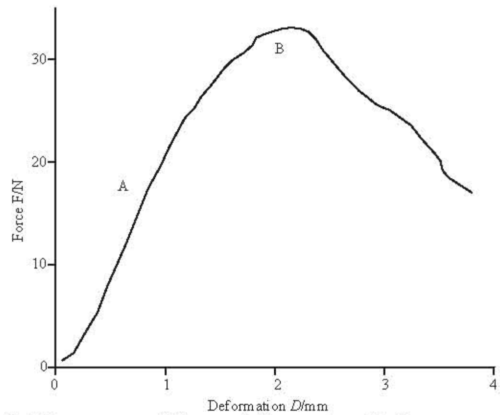

Fig. 3: The curve of force-deformation [14]

The nutritional composition of the apple fruit juices were studied as explained following: Total dry matter was determined according to AOAC, [10]. The total titratable acidity was determined by titration with sodium hydroxide (0.1 N) and expressed as a % of malic acid. The pH value was measured using a Macroprocessor PH meter (iHANNA pH211, Made in Italy). Total soluble solids (TSS) were measured as°Brix a Neerveld 14-B22550, GETI (Belgium) refractometer.

Lastly, all data were statistically analyzed using the analysis of variance (ANOVA) test and means were compared using Duncan's multiple ranges test.

RESULTS AND DISCUSSION

Several mechanical and nutritional properties of the Redspar and Delbarstival, with 82.80 and 81.16% moisture content (wet basis), are given in Table 1. As seen in Table 1, all the failure properties such as stress, strain and energy and modulus of elasticity were found to have statistically significant difference at the 1% probability level. The mean values of the failure stress and strain for the Redspar variety were 0.43 MPa and 0.20 mm/mm, respectively. This values were greater than those of Delbarstival variety that were 0.24 MPa and 0.15 mm/mm, respectively. Similar study was undertaken and reported by Masoudi *et al.* [11] for Red Delicious (0.13 MPa and 0.07 mm/mm), Golden Delicious (0.28 Mpa and 0.13 mm/mm) and Grani Smith (0.34 MPa and 0.11 mm/mm). Failure energy values of variety resulted in different means 127.59 and 51.06 N.mm. Also, the Redspar had more module of elasticity (2.53 MPa) than that of Delbarstival (1.77MPa) and according to Masoudi *et al.* [11] Red Delicious (1.53) and Golden Delicious (1.92 MPa) but less than that of the Grani Smith (2.84 MPa). The firmness parameter for each apple variety was found to have

Table 1: Several mechanical and nutritional properties of the two apple varieties

Static coefficient of friction on:	Redspar	Delbarstival	Significant level
Plywood, deg	0.31±0.00	0.33±0.01	**
Galvanized iron, deg	0.31±0.00	0.41±0.04	ns
Compressed plastic, deg	0.28±0.00	0.47±0.03	**
Failure stress, kPa	0.43±0.05	0.24±0.06	**
Failure strain, mm/mm	0.20±0.03	0.15±0.03	**
Elasticity module, kPa	2.53±0.47	1.77±0.79	**
Failure energy, kPa	127.59±26.40	51.06±17.21	**
Firmness, N	18.55±3.45	14.15±3.80	**
Dry matter	17.2±1.17	18.6±2.37	**
PH	3.91±0.14	3.61±0.16	**
Titratable acidity	0.025±0.01	0.041±0.01	**
TSS	10.73±1.53	12.54±2.23	ns

nsNonsignificant ** Significant (1% level)

different means as 18.55 for Redspar and 14.15 for Delbarstival. Considering above information on Redspar and Delbarstival apples, can be concluded that Redspar variety is more endurable than Delbarstival variety under static lauds. The depths of boxes include Redspar apples are more than that of Delbarstival apples, according Sitkei, [12] damage increases with increasing in depth of packaging boxes.

The coefficient of static friction for Redspar and Delbarstival fruits was determined on the compacted plastic, plywood and galvanized iron. These coefficient values varied from 0.28 to 0.31 and 0.34 to 0.44, respectively. On the plywood surface, the coefficient of static friction of the Redspar and Delbarstival was not very different (0.31 and 0.34, respectively). This value for the Redspar fruits was found to be 0.31 on the galvanized iron that was less than that of Delbarstival as 0.37. The coefficient of static friction of the Redspar fruits, with a mean of 0.28 was significantly smaller than that of the Delbarstival. Can be concluded that the highest coefficient of friction for both varieties was found over plywood and the lowest of that was found over compressed plastic. This result is against with the finding of Chowdhury *et al.* [13] It may be due to biological differences between different cops.

The values of all the chemical properties of apple juices were statistically different with respect to the varieties. Also, the cultivar of Redspar has the smaller dry matter (17.2%) than Delbarstival (18.12%). In the case of the TSS, as shown in Table 1, there were non significant differences between the studied cultivars. For Delbarstival variety, the average value of the TSS was 12.54 whereas

10.73 obtained for Redspar variety, but Ragni and Berardinelli, [14] reported this value as 14.3, 13.7, 14.3 and 12.9 for Golden Delicious, Stark Delicious, Grani Smith and Rome Beauty, respectively. The juice of Redspar cultivar also represented the higher ratio of. PH, 3.91, compared with Delbarstival, 3.61. Eventually, titrable acidity value found for Delbarstival variety in this experiment was 0.034 that was higher than 0.021 for Redspar variety.

CONCLUSION

This paper concludes with information on engineering properties of Redspar and Delbarstival varieties which may be useful in designing much of the equipment used for post harvest processing. It is recommended that other engineering properties be measured or calculated to provide fairly comprehensive information in design parameters.

- The sample of Delbarstival apples was, except pH, found to be higher sources of nutrition characters than Redspar.
- Many mechanical properties of the two apple varieties, as, for example; the coefficient of static friction on plastic, plywood and galvanized iron, flesh firmness, failure stress and strain, energy and modulus of elasticity were found to be statistically significant at the probability level (1%), with the exception that the were found to be insignificant.

ACKNOWLEDGMENTS

The authors would like to thank University of Tehran for full support and Horticultural Research Center, Department, Faculty of Agriculture, university of Tehran karaj, Iran for providing the fruits for this project Karaj, Iran, for providing the fruits for this project. Special thanks to Dr. Delshad, Eng. Sepahvand and Eng. Rahimi for his helps.

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