Australian Journal of Agricultural Engineering

AJAE

AJAE 2(6):155-159 (2011) ISSN:1836-9448

Some post-harvest properties of Iranian genotype of raspberry (*Rubus ideaus* L.)

Habibeh Nalbandi[*1], Sadegh Seiiedlou[1], Jafar Hajilou[2], Mohammad Adlipour[2]

[1]Department of Agricultural Machinery Engineering, University of Tabriz, Tabriz, Iran
[2]Department of Horticulture of Science, University of Tabriz, Tabriz, Iran

***Corresponding author: habibehnalbandi@yahoo.com; h.nalbadni@gmail.com**

Abstract

In this study, some physical and nutritional properties of Iranian genotype of raspberry were studied. The results of the present study were used to identify optimal configuration of raspberry process equipments as well as design and construct the process equipment. The average values of lightness, redness, yellowness and color density of raspberries were 6.44, -2.22, 0.33 and 2.24, respectively. These values show that the color of raspberries is almost black and could be categorized among black raspberries. Raspberry sphericity is about 92% and could be assumed as a sphere. Raspberry had the lowest and highest static coefficient of friction on plywood and steel, respectively. High sphericity causes the raspberry to roll rather than slid on a specific surface. So the handling of this product could be done using chute. The chute angle could be assumed as the same of tilted surface with wooden sheet. The amount of true density was obtained 1043.61 kg m^{-3}. So raspberries will immerse during the washing process and it is possible to separate them from foreign materials during this process. The amount of bulk density and porosity were obtained 491.93 kgm^{-3} and 52.86%, respectively. The repose angle of raspberries was high (73.5º). The values of length, diameter, equivalent diameter and the nutritional properties such as dry matter, pH, total acidity, TSS, total ash and vitamin C were measured.

Keywords: Color, Density, Nutritional, Physical properties, Porosity, Sphericity.

Abbreviations:

a^*	Redness
b^*	Yellowness
C	Color density
D	Diameter of berry (mm)
d_e	Equivalent diameter (mm)
l	Length of berry (mm)
L^*	Lightness
ϕ	Sphericity of berry (%)
ε	Porosity (%)
ρ_b	Bulk density of berry (kg m^{-3})

Introduction

Raspberry (*Rubus ideaus L.*) is the edible fruit of a multitude of plant species in the genus Rubus, grown as a perennial crop. Raspberries are soft, juicy with a distinct aroma and an excellent source of natural antioxidants, vitamins (C and E), minerals and they are rich in phenolic acids which is the major reason for raspberries' increasing popularity in the human diet (Wang et al., 2009). They are consumed fresh or as processed products such as jams, jellies and syrups. Recognition of its medicinal properties leads to increasing its consumption and marketing. This growing consumption makes it necessary to complete raspberries process operations. When raspberries are used as fresh fruits, it is essential to process the product with the lowest damage that needs high accuracy in the designing of process equipments. Processing raspberries includes several operations namely, washing, foreign material separation, grading, sorting, handling and etc. The quality of processed product depends on some parameters: the quality of primary products, the kind of process operations at the post-harvest stage and appropriate performance of the designed equipment. Designing and construction of raspberry process equipment needs determining its physical and mechanical properties. Additionally, such information can be used in choosing the suitable operations as well as in controlling the quality changes of the product during processes (Nalbandi et al., 2009). In the recent years, many studies have been conducted about determination of the physical, mechanical and nutritional properties of various seeds and fruits such as cornelian cherry (Demir and Kalyoncu, 2003; Tural and Koca, 2008; Yilmaz et al., 2009), orange varieties (Topuz et al., 2005), wild plum (Calisir et al., 2005), caper berries (Zcan and Aydin, 2004), oil palm fruit (Owolarafe et al., 2007), olive fruit (Kilickan and Guner, 2008), apricot (Mirzaee et al., 2009), castor seed (Gharibzahedi et al., 2011) and sunflower seed (Tarighi et al., 2011),. Also some researchers studied the nutritional properties of raspberry.

Milutinovic et al. (2008) studied pomological properties of eight raspberry cultivars. They identified that there is a significant difference between the weights of cultivars (3.55 to 7.32 g). Also the fruit soluble solids content ranged from 6.0% to 11.1%. Weber and Hai Liu (2002) studied antioxidant capacity and anticancer properties of four raspberry cultivars. They measured the total amount of phenolics and flavonoids of them and the average amount was in the range of 437.6 mg $100g^{-1}$ and 84.6 mg $100g^{-1}$, respectively. They found that the antioxidant activity of each cultivar was directly related to the total amount of phenolics and flavonoids. Bowen-Forbes et al. (2010) determined anthocyanin, antioxidant content and anticancer properties of blackberry and raspberry fruits. The results indicated that the fruits contained superior levels of anthocyanins (146–2199 mg 100 g^{-1} fresh weight). High anthocyanin content and biological activities of these fruits indicate that their consumption would be beneficial to health, and that they may be useful in the production of functional foods containing an efficacious dose of anthocyanins. However no study has been conducted about the physical properties of raspberry genotypes. Designing suitable equipment needs knowledge about the physical properties of raspberries. The objective of this study was to investigate and measure some physical properties such as dimensional and frictional properties and color of Iranian genotype of raspberry. Additionally, some nutritional properties such as dry matter, pH, total acidity, total soluble solids (TSS), total ash and vitamin C were measured. Some nutritional properties could be used in quality sorting. Also this information will be used in comparison of raspberry genotypes in the future study, in order to select the best genotype for processing and future breeding programs. On the other hand, some of these nutritional properties namely total acidity, total soluble solids (TSS) and vitamin C could be used in the nondestructive maturity and ripeness determination methods. Also the value of dry matter, moisture content and total ash are used in calculation of thermal properties of raspberry such as thermal conductivity and specific heat.

Results and discussion

Nutritional properties

The average value of dry matter, pH, total acidity, total soluble solids content (TSS), total ash and vitamin C were represented in Table 1. The average weight of each fruit was 1.5 g. Cekic and Ozgen (2010) studied the nutritional properties of Turkish red raspberry and measured soluble solids (TSS), dry matter and weight of cultivated and wild accessions of red raspberries. They reported that the dry matter content of fruit ranged from 16.6 to 23.3% and the average TSS content of berries was 11.7%. They also showed that the weight of cultivated and wild accessions was 1.7 and 2.5 g, respectively. They also detected small amounts of ascorbic acids (vitamin C). The result of this study showed that the Iranian raspberries compared to Turkish cultivars have lower amount of total soluble solids (TSS), dry matter and weight. Consequently, the results indicated that the Iranian raspberries are excellent source of vitamin C. Considering that there is no information about the Iranian black raspberries, it is impossible to compare the results. However, some of these properties could be used in quality sorting. Also they would be used in the nondestructive maturity and ripeness determination methods as an index such as creating a correlation between the ripeness and the frequency response of ultrasonic methods.

Physical properties

Mean of length, diameter, equivalent diameter and sphericity of raspberries were presented in Table 2. As the results show, the raspberries' shape is about sphere (ϕ =92%) and their equivalent diameter equals 16.32 mm. Consequently, the shape and dimensions of screen mesh in designing initial scalper should be sphere with the lowest diameter of 18-19 mm. Similar investigation was done for Strawberry. Ozcan and Haciseferogullari (2007) reported that the length, diameter and equivalent diameter of strawberry was 8.51, 10.7 and 9.91 mm, respectively. The static coefficient of friction of samples on different surfaces, especially on steel and galvanized iron, is a very important factor in designing handling equipment. The result of variance analysis of the surface material effects on the static coefficient of friction are shown in Table 3. It shows that the effect of surface material on the static coefficient of friction was significant at 1% probability level. In addition, the mean comparison of static coefficient of friction values is represented at Fig 2. The static coefficient of friction of raspberry on steel, galvanized iron and plywood sheets was about 0.591, 0.487 and 0.412, respectively. Raspberry had the lowest and highest rolling resistance on plywood and steel, respectively. The static coefficient of friction can be assumed as the rolling resistance of samples. Several factors influence the rolling resistance of raspberry, such as shape, moisture content, sphericity and surface properties. Although raspberry had high moisture content and sticky surface, its shape or sphericity had significant effect on the rolling resistance. Raspberry sphericity is about 92% and could be assumed as a sphere. High sphericity causes the raspberry to roll rather than slid on a specific surface. So the handling of this product could be done using chute equipped with the surface material on which raspberry had the minimum rolling resistance. On the other hand, the chute angle could be assumed as the same of tilted surface with wooden sheet. Such low angle decreases the probability of bruising and impact damage of raspberries at the end of chute. However another way of reducing the damage is to use water as a carrier in the handling process especially when raspberries are used as fresh fruits. The true and bulk density along with the porosity values of raspberries are regarded as important factors in designing hopper, handling and cleaning systems. The average amount of true density, bulk density and porosity of raspberries were in the range of 1043.61 kg m^{-3}, 491.93 kg m^{-3} and 52.86%, respectively. However the true density, bulk density and porosity of strawberry were found as 1146.43, 602.233 kg m^{-3} and 46.69%, respectively (Ozcan and Haciseferogullari, 2007). In the processing of agricultural products, air or water can be used to separate the product from the foreign materials (Mohsenin, 1978). Hydro-sorting is one of the grading and sorting mechanisms that is based on the differences between the true densities of bulk material. By using such mechanism several steps of raspberry processing could be done simultaneously. Considering that the true density of raspberries is higher than that of water and other foreign materials such as leave and branch-lets, it is possible to separate them from each other during washing, handling and sorting process. Such simultaneous processing operations lead to reduction in the operation costs and optimize the process. Considering that the most of nutrition components of fruit are soluble, the hydro-sorting system should operate quickly. The angle of repose of raspberry was 73.5º. The size, shape, moisture content and orientation of the particles influence the angle of repose (Mohsenin, 1978). According to

Table 1. Mean of nutritional properties of raspberry.

Property	Dry matter (%)	PH	Total acidity (%)	Total soluble solids (%)	Total ash (%)	Vitamin C (mg/100g)
Mean	14.02	2.5	2.42	7	0.475	173.33
Standard deviation	0.51	0	0.054	0	0.064	8.16

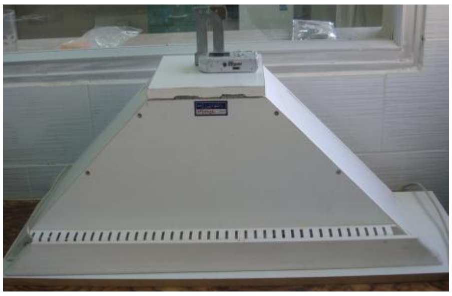

Fig 1. The color test instrument

this study results, raspberries have high moisture content (85.98%) and sphericity (92.56%). These properties cause these fruits to have high angle of repose. Also raspberry is known as a soft fruit and its sticky surface leads to increase the adhesion between them.

Color

In the Hanter lab model, high b* indicates yellow direction, high a* indicates red direction and L* values represent lightness. The average values of lightness, redness, yellowness and color density of raspberries were 6.44, -2.22, 0.33 and 2.24, respectively. These values show that the color of raspberries is almost black. Considering these values, the examined raspberries could be categorized among black raspberries. According to Bowen-Forbes et al. (2010), black raspberries have the highest anthocyanin content compared with other raspberries. They also found that black raspberries possess higher anthocyanin contents (up to 400 mg $100g^{-1}$) than red raspberries (20–60 mg $100g^{-1}$), followed by orange raspberries (0.3–8.7 $mg100g^{-1}$) and finally, yellow raspberries (0–3.4 $mg100g^{-1}$) (Bowen-Forbes et al., 2010). In terms of raspberries' color, Cekic and Ozgen (2010) reported that the variation in b* was higher than those of L* and a* related to red raspberries. The average of a*and b* values were 38.2 and 19.3, respectively. Weber and Hai Liu (2002) reported that the color of the raspberry juice correlated well to the total phenolic/flavonoid content. They showed that the cultivar with the highest a / b colorimeter ratio and the darkest colored juice had the highest phenolic/flavonoid content, as well as the highest total antioxidant activity. Their finding proposed that the color of raspberry fruit could be used as an index of their phenolic/flavonoid content and antioxidant activity.

Materials and methods

Sample preparation

Iranian raspberries that were evaluated in this study were obtained from the northwest region of Iran. The harvesting time of Iranian raspberries was the maturity stage that the fruits were fully colored and not crumbled, also when the fruits separated readily from the stems. The fruits were stored at 4ºC for 24 hours. The experiments were started after 4 hours of stabilization of samples at the libratory ambient temperature (21-24 ºC). The initial moisture content of samples was determined using vacuum oven at 70 ± 1 ºC until a constant weight was attained. Three replications were conducted to obtain a reasonable average (AOAC, 1990). The moisture content of raspberries was 85.98 % w.b.

Physical properties

The length (L) and diameter (D) of 20 raspberries were measured using a digital caliper (resolution: ± 0.01 mm). The equivalent diameter and the sphericity were calculated according to Eq. (1) and (2), respectively (Mohsenin, 1978).

$$d_e = \left(L \times D^2\right)^{1/3} \quad (1)$$

$$\phi = \left(\frac{L}{D}\right) \times 100 \quad (2)$$

The bulk density of raspberries was measured using a graduated cylinder. The cylinder was filled and tapped 10 times to cause the samples to settle. A sharp edge flat was used to remove excess berries to level the surface at the top of the cylinder (Jain and Bal, 1997). The bulk density was calculated using Eq. (3). The experiment was replicated three times.

$$\rho_b = \frac{m}{v} \quad (3)$$

The true density of each fruits was measured by toluene displacement method (Chakraverty and Paul, 2001). Porosity of raspberries was calculated using Eq. (4) (Mohsenin, 1978). These experiments were also replicated three times.

$$\varepsilon = (1 - \frac{\rho_b}{\rho_t}) \times 100 \quad (4)$$

The static coefficient of friction of raspberries was determined on plywood, steel and galvanized iron sheets using one sample. The surface with the berry resting on it was inclined gradually with a screw device until the berry

Table 2. Mean of dimensional characteristics of raspberry

Property	Length (mm)	diameter (mm)	Equivalent diameter (mm)	Sphericity (%)
Mean	15.51	16.74	16.32	92.56
Standard deviation	1.55	1.005	1.11	6.6

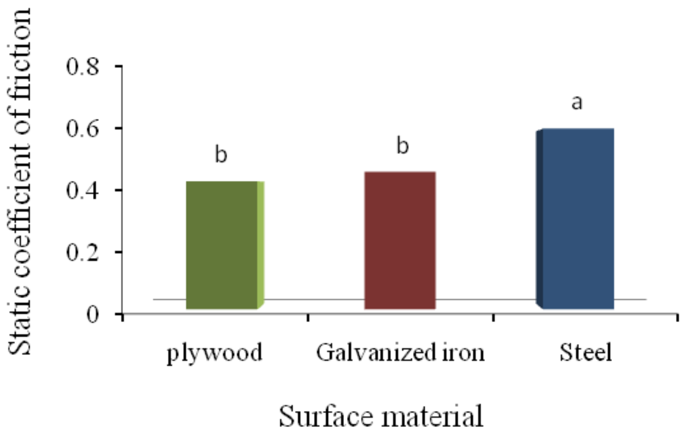

Fig 2. The static coefficient of friction values of raspberry on different surface

Table 3. Summary of ANOVA for the static coefficient of friction of raspberry.

Source of variation	Degree of freedom	Mean Squares
Surface material	2	0.036**
Error	9	0.002

** Significant difference at 1% probability level, n.s Non significant.

began to slide. At this moment, the angle of the table surface with horizon was read by the goniometer. This angle was used as the static coefficient of friction of raspberries on that surface (Jain and Bal, 1997). The statistical analysis of data was based on a completely randomized design (CRD) in three replications and sheets with different materials were the main factors. The angle of repose was measured using a wooden box full of berries mounted on a tilting table. The table was tilted until the top berries in the box began to move and leave an inclined surface. At this moment the angle of the table surface was measured as the angle of repose of samples (Mohsenin, 1978 and Nalbandi et al., 2010). These experiments had three replications.

Nutritional properties

General nutritional composition was measured by the official method of analysis (AOAC, 1990). The dry matter of samples was measured by heating in a vacuum oven at 70 °C until a constant weight was obtained. pH value was measured with a pH meter; total acidity was measured with 0.1 M NaOH up to pH 8.2 and expressed as percentage of citric acid. The measuring of soluble solids content was conducted by a refractometer. In order to determine the total ash, samples were kept in a burner at 525 °C. Then the weight of samples was measured after they totally turned into ash. Ascorbic acid (Vitamin C) contents were estimated by the method presented in AOAC (1990). All of experiments were repeated three times.

Color characteristics

To define the color of raspberries, L^*, a^*, b^* model was used. L^*, a^*, b^* model is an international standard for color measurement. This model consists of a lightness component (L^* value), along with two chromatic components from green to red (a^*) and from blue to yellow (b^*). The color test instrument was designed and constructed based on recommendations by Yam and Papadakis (2004) in the department of agricultural machinery engineering, university of Tabriz, Tabriz, Iran (Fig.1). It consists of a chamber with a trapezoidal cross section that was equipped by two D65 (daylight) lamps as the light source for illumination of sample. An analog camera (PR-565S, Proline, Lancashire, U.K.) was used to record the images. At first, a cornelian cherry was put in the chamber. After zooming the lens and focusing, the images were taken by camera. The frame grabber transferred the recorded image signals into digital signals and saved them in the hard disk of personal computer. Photoshop software was used to display the images on the computer screen and values of L^*, a^* and b^* of each image were determined by means of this software (Nalbandi et al., 2011).

Conclusion

In this study the physical and nutritional properties of Iranian genotype of raspberries were measured. The color of raspberries was almost black, so that they might have higher anthocyanin contents.

Raspberries were also an excellent source of vitamin C. High sphericity value of raspberry indicated that the scalping and handling process of this product could be done using sieves and chute, respectively. The true density of raspberry was higher than the true density of water and other foreign materials along with fruits. Using hydro-sorting mechanism, several steps of raspberry processing could be done simultaneously. It makes the processing of raspberries more economical. In addition, it is suggested to measure anthocyanin, phenolic, flavonoid content and antioxidant activity of the Iranian raspberries to find their exact correlation whit the color. This correlation could be used as an index of maturity and harvest time of raspberry via nondestructive methods.

References

AOAC (1990) Official Method of Analysis. Association of Official Analytical Chemists (No.934.06), Washington, DC.

Bowen-Forbes CS, Zhang Y, Nair MG (2010) Anthocyanin content, antioxidant, anti-inflammatory and anticancer properties of blackberry and raspberry fruits. J Food Composition and Analysis 23: 554-560.

Calisir S, Haciseferogullari H, Ozcan M, Arslan D (2005) Some nutritional and technological properties of wild plum (*Prunus spp*.) fruits in Turkey. J Food Eng 66: 233–237.

Cekic C, Ozgen M (2010) Comparison of antioxidant capacity and phytochemical properties of wild and cultivated red raspberries (*Rubus idaeus* L.). J Food Composition and Analysis 23: 540-544.

Chakraverty A, Paul SR (2001) Post Harvest Technology: Cereals, Pulses and Vegetables. Sci. Publ., India.

Demir F, Hakki Kalyoncu I (2003) Some nutritional, pomological and physical properties of cornelian cherry (*Cornus mas* L.). J Food Eng 60: 335–341.

Gharibzahedi SMT, Mousavi SM, Ghaderijani M (2011) A survey on moisture-dependent physical properties of castor seed (*Ricinus communis* L.). Aust J Crop Sci. 5(1): 1-7.

Jain R K, Bal S (1997) Properties of pearl millet. J Agri Eng Res 66: 85–91.

Kilickan A, Guner M (2008) Physical properties and mechanical behavior of olive fruits (*Olea europaea* L.) under compression loading. J Food Eng 87: 222–228.

Milutinovic MD , Milivojevic J , Dakovic G , Milutinovic MM , Miletic R, Novakovic M (2008) Pomological Properties of introduced raspberry cultivars grown in west Serbia. IX International Rubus and Ribes Symposium.

Mirzaee E, Rafiee S, Keyhani A, Emam Djom-eh Z (2009) Physical properties of apricot to characterize best post harvesting options. Aust J Crop Sci 3(2): 95-100.

Mohsenin NN (1978) Physical Properties of Plant and Animal Materials. Gordon and Breach Sci. Publ. New York.

Nalbandi H, Ghassemzadeh HR, Seiiedlou S (2010) Seed moisture dependent on physical properties of *Turgenia Latifolia*: criteria for sorting. J Agri Tech 6(1): 1-10.

Nalbandi H, Seiiedlou S, Hajilou J, Moghaddam M, Adlipour M (2011) Physical properties and color characteristics of Iranian genotypes of Cornelian cherry. J Food Process Eng 34:792-803.

Owolarafe OK, Olabige MT, Faborode MO (2007) Physical and mechanical properties of two varieties of fresh oil palm fruit. J Food Eng 78: 1228–1232.

Ozcan MM, Haciseferogullari H (2007) The Strawberry (*Arbutus unedo L*.) fruits: Chemical composition, physical properties and mineral contents. J Food Eng 78: 1022–1028.

Wang S Y, Chen CT, Wang CY (2009) The influence of light and maturity on fruit quality and flavonoid content of red raspberries. Food Chem 112: 676–684.

Tarighi J, Mahmoudi A, Karami Rad M (2011) Moisture-dependent engineering properties of sunflower (var. Armaviriski). Aust J Agri Eng 2(2): 40-44.

Topuz A, Topakci M, Canakci M, Akinci I, Ozdemir F (2005) Physical and nutritional properties of four orange varieties. J Food Eng 66: 519–523.

Tural S, Koca I (2008) Physico-chemical and antioxidant properties of cornelian cherry fruits (*Cornus mas* L.) grown in Turkey. Scientia Hort 116: 362–366.

Weber C, Hai Liu R (2002) Antioxidant capacity and anticancer properties of red raspberry. VIII International Rubus and Ribes Symposium.

Yam KL, Papadakis SE (2004) A simple digital method for measuring and analyzing color of food surfaces. J Food Eng 61: 137–142.

Yilmaz KU, Ercisli S, Zengin Y, Sengul M, Kafkas EY (2009) Preliminary characterisation of cornelian cherry (*Cornus mas* L.) genotypes for their physico-chemical properties. Food Chem 114: 408–412.

Zcan MO, Aydin C (2004) Physico–mechanical properties and chemical analysis of raw and brined Caper berries. Biosystems Eng 89 (4): 521–524.