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Some nutritional and physical properties of crab apple (*Malus silvestris* Mill.) fruit

İbrahim Gezer[1], Mehmet Musa Özcan[2*], Haydar Hacıseferoğulları[3] and Sedat Çalışır[3]

1- Inonu University, Technician Training Center, Programme of Agricultural Machinery, 44100 Malatya, Turkey
2- Department of Food Engineering, Faculty of Agriculture, University of Selçuk, 42031 Konya, Turkey
3- Department of Agricultural Machinery, Faculty of Agriculture, University of Selçuk, 42031 Konya, Turkey

Corresponding author Email: *mozcan@selcuk.edu.tr*

ABSTRACT: Some nutritional and physical properties of crab apple (*Malus silvestris* Mill.) growing wild in Ermenek (Karaman) location were established. The mineral contents of fruit were established by ICP-AES. The major minerals were 2549.3 mg/kg Ca, 96.3 mg/kg Fe, 866.6 mg/kg Mg, 2814.0 mg/kg Na and 2562.4 mg/kg P. Also, physical properties such as length, mass, sphericity, fruit density, bulk density, porosity, projected area and fruit hardness were measured. The static and dynamic coefficients of friction for crab apple fruit were determined with respect to iron sheet and galvanized steel surfaces. The coefficient of dynamic friction decreased compared with the coefficient of static friction of fruits. These results show that crab apple fruit may be useful for the evaluation of dietary information in important food crops. Also, it is important to know the physical properties of equipment used in planting, harvesting, transportation, storage and processing of crab apple fruits.

***Keywords*:** crab apple, Malus silvestris, proximate analysis, minerals, physical properties

INTRODUCTION

Crab apple is the fruit of *Malus silvestris* Mill. in the family of Rosaceae. It grows poorly in frost-free areas, and on rocks and in poor soils. This plant grows wild in various locations in South Anatolia of Turkey (Davis, 1972)**.** Diferent cultivars of apples have a distinct different taste, and this can be separated into two separate factors of flavour and texture. Apples can be canned, juice, and optionally fermented to produce apple juice, cider, vinegar, and pectin. It is an important ingredient in many winter desserts, for example apple pie, apple crumble, apple crisp and apple cake (Anonymous, 2007). Apples are one of the most requently consumed fruits. It constituents an important part of the human diet, as they are a source of monosaccharides, minerals, dietary fibre, and various biologically active compounds which are known to act as natural antioxidants (Lee & Mattick, 1989; Miler & Rice-Evans, 1997; Wu et al.,2007). Apples for direct consumption should be rich in biologically active compounds, such as ascorbic acid, and phenolic compounds, particularly flavanols, including catechins and proanthosyanidins. Furthermore, free aminoacids and fatty acids, which are nutritive components of many fruit and vegetables also play important roles in human health and maintaining fruit quality (Schieber, Keller, Carle, 2001; Wu et al.,2007). On the other hand, biochemical studies of fruits indicate that levels of organic and amino acids, fatty acids, phenolic compounds, sugars and soluble solids are the primary quantitative parameters (Wu et al.,2007).

No comprehensive data have been reported on the some chemical composition of physical properties of crab apple wild growing in Turkey. Especially, the physical properties of equipment used in planting, harvesting, transportation, storage and processing of crab apple fruit must be known. Therefore, this research is focused on analyses and physical properties of crab apple.

MATERIALS AND METHODS

Material

Fresh crab apple fruit samples were collected from wild apple trees from Ermenek (Karaman) in Turkey in August 2007 year. The fruits were transportation in polypropylene bags and held at room temperature. Moisture contents were immediately measured on arrival.

Chemical analysis

The chemical properties (moisture, crude protein, crude fibre, ash, acidity and pH) were determined according to Cemeroğlu (1992). Nitrogen was established by Kjeldahl analyses, multiplied by 6.25 and determined as protein. The total fat oil content was determined in accordance with AOAC (1984) method. Crude oil was obtained from finely dried crushed fruit (ca 20 g) extracted with petroleum ether (Merck-Darmstadt) in a Soxhlet apparatus; the remaining solvent was removed by vacuum distillation.

Determination of mineral contents

About 0,5g of dried and ground crab apple fruits was put into burnig cup with 15 ml of pure NHO_3. The sample was incinerated in a MARS 5 microwave oven at 200 ^oC. Distilled deionized water and ultrahigh-purity commercial acids were used to prepare all reagents, standards, and walnut samples. After digestion treatment, samples were filtrated through whatman No 42. The filtrates were collected in 50 ml Erlenmayer flasks and analysed by ICP-AES. The mineral contents of the samples were quantified against standard solutions of known concentrations which were analysed concurrently (Skujins, 1998)

Working conditions of ICP-AES:

Instrument	:ICP-AES (Varian-Vista
RF Power	: 0,7-1,5 kw (1,2-1,3 kw for Axial)
Plasma gas flow rate (Ar)	: 10,5-15 L/min. (radial) 15 " (axial)
Auxilary gas flow rate (Ar)	:1,5 "
Viewing height	: 5-12 mm
Copy and reading time	:1-5 s (max.60 s)
Copy time	: 3 s (max. 100 s)

Determination of physical properties

All physical properties of crab apple were determined using 20 repetitions at moisture content of 77.83 % d.b.

To determine the size of the crab apple, ten groups of samples consisting of 100 fruits have been selected randomly. 10 fruits have been taken from each group and their linear dimensions - length, diameter and projected areas have been measured. A micrometer measured linear dimensions to an accuracy of 0.01mm.

Projected area (P_a) of crab apple was determined by using a digital camera (Canon A 200) and Sigma Scan Pro 5 program (Trooien & Heermann, 1992). The weights of fruits mass (M) were measured by an electronic balance to an accuracy of 0.001g.

The bulk density (ρ_b) was determined with a hectoliter tester, which was calibrated in kg per hectoliter (Desphande, Bal, & Ojha, 1993). The crab apple were dropped down into a bucket from a height of approximately 15 cm. The excess crab apple was removed by sweeping the surface of the bucket**.** The fruits were not compressed in any way.

The crab apple volume (V) and its fruits density **(ρ_f),** as a function of moisture content, were determined by using the liquid displacement method. Toluene (C_7H_8) was used instead of water because grains to a lesser extent absorb it. Also, its surface tension is low, so that it fills even shallow dips in a grain and its dissolution power is low (Sitkei 1976; Mohsenin 1970).

The porosity (ε) was determined by the following equation:

$$\varepsilon = 1-\rho_b/\rho_f$$

In which ρ_b and ρ_f are the bulk density and the fruit density, respectively (Mohsenin 1970; Thompson & Isaacs 1967).

Forces applied measured hardness values of crab apple. Hardness of crab apple, were determined with Test Instrument of Biological Materials using the procedure described by Aydın and Öğüt (1991) (Fig.1). The device has three main components, which are stable up and motion bottom of platform, a driving unit (AC electric motor and electronic variator) and the data acquisition (Dynamometer, amplifier and XY recorder) system. Hardness force of crab apple was measured by the data acquisition system. The fruit was placed on the moving bottom platform and was pressed with stationary platform. Probe used in experiment with 1.20 mm diameter was connected to dynamometer. Experiment was conducted at a loading velocity at 50 mm/min.

Geometric mean diameter (D_g) and sphericity ($Ø$) values were found using the following formula; (Mohsenin 1970).

$$D_g = (LD^2)^{0.333}$$

$$Ø = (LD^2)^{0.333}/L$$

The coefficient of friction of crab apples was measured using a friction device modified by Tsang-Mui Chung, Verma & Wright (1984) and improved by Chung & Verma (1989). Also, both the static and dynamic coefficient of friction with an applied torque was measured and calculated using the equation (Chung & Verma, 1989).

$$\mu_s = Ta / W.q$$

$$\mu_d = Tm / W.q$$

Where μ_s equals static coefficient of friction, T_a equals beginning value of torque, μ_d equals dynamic coefficient of friction, T_m equals average value of the torque, q the length of torque arm, and W is the weight of fruits to calculate the dynamic and static coefficients of friction, the average value of the torque during the rotation of the disk and the maximum value of torque obtained as the disk started to rotate were used the rotating surface.

The statistical evaluations were made by using MINITAB package program (Minitab, 1991).

RESULTS AND DISCUSSION

Chemical parameters

The chemical compositions of crab apple fruit are given in Table 1. The chemical characteristics are very important because the physico-mechanical and functional properties are strongly dependent to these parameters. The average moisture, crude oil, crude protein, crude fibre, ash, acidity and pH were determined 77.83%, 0.19%, 0.23%, 2.6%, 2.44%, 0.87% and 4.1, respectively. Also, Ca (2549.3 mg/kg), K (18780.8 mg/kg), P (2562.4 mg/kg), Mg (866.6 mg/kg) and Na (2814.0 mg/kg) were established as major minerals in fruits. Calcium is the major component of bone and assists in teeth development (Brody,1994). Crude oil, crude protein and crude fibre contents of crab apple were found to be lower compared with those of myrtle, apricot, rosa and wild medlar (Demir and Özcan,2001; Hacıseferoğulları Özcan, Sonmete, Özbek,,2005; Aydın and Özcan,2007; Hacıseferoğulları, Özcan, Sonmete, Özbek, 2007). Hacıseferoğulları Özcan, Sonmete, Özbek, (2005) also reported that oil, protein, moisture, fibre and ash of wild medlar fruit were 4.9%, 3.7%, 72.2%, 11.4% and 2.0%, respectively. The crude protein content of many edible wild fruits is usually lower than 5%, and varies considerably (Cemeroğlu and Acar,1986). The reference moisture content of the plant material here is important because many of the physical properties of fruit are known to vary with moisture content (Ajisegiri,1987; Omobuwajo, Omobuwajo, Sanni, 2003). Some mineral content of crab apple fruits were found to be higher than thse reported for rosa fruit, wild medlar, myrtle and hackberry fruits (Demir and Özcan,2001; Demir, Doğan, Özcan, Hacıseferoğulları,2002; Hacıseferoğulları Özcan, Sonmete, Özbek,2005; Aydın and Özcan, 2007; Hacıseferoğulları,Özcan, Sonmete, Özbek, 2007). Consequently, the differences in chemical properties of fruits having about the same size were probably due to environmental conditions in conjunction with the analytical methods used (Guil, Gimenez, Tarija 1998). In addition, moisture, crude protein, fibre, oil and ash contents of fruits are affected chiefly by variety and growth conditions. These results may be useful for dietary information, which requires prior knowledge of the nutritional composition of edible wild fruits.

Physical properties

The size dimensional properties of crab apple are given in Table 2. The frequency distributions of the dimensional properties are given Fig 2. 96 percentage of fruit is between 7.54 and 16.59 g in terms of moisture content of 77.83 % in weight, 95 % of them is between 23.37 and 33.86 mm in diameter, 97 % of them are between 20.14 and 28 mm length.

The following general expression can be used to describe the relationship among the average dimensions of the fruits at 77.83 % (d. b.) moisture content:

$$D = 1.170\text{x } L = 2.486\text{x } M = 1.054\text{x } D\text{g} = 26.072 \text{ x } Ø$$

The coefficients of correlation (Table 3) show that the *D/L*, *D/M*, *D/Dg* and *D/Ø* rations were found highly significant. Partly similar results were found for hackberry, rose, wild plum and strawberry fruits by Demir, Doğan, Özcan, Hacıseferoğulları (2002), Demir and Özcan (2001), Çalışır, Özcan, Hacıseferoğulları, Arslan (2005), Özcan and Hacıseferoğulları (2007) respectively. This indicates that the length, mass, the geometric mean diameter and sphericity are closely related to the diameter of fruit. Some technological properties of crab apple used in experiment are shown in Table 4. Similar investigations have been made to evaluate the projected area, volume, bulk density, fruit density and terminal velocity by Demir and Özcan (2001) for rose fruits. The static and dynamic coefficients of friction for crab apple fruit determined with respect to iron sheet and galvanized steel surfaces are represented in Table 5. While the fruit density, porosity and projected area values of medlar fruits were established high, bulk density value was found low according to literature value (Demir & Özcan 2001). In addition, volume and projected area values of medlar fruits were found higher than those of Demir, Doğan, Özcan, Hacıseferoğulları (2002). At the same moisture contents, both the static and dynamic coefficients of friction were greatest for strawberry fruits on iron sheet.

Nomenclature			
D	diameter of crap apple	q	torque arm (cm) (10.5 cm)
D_g	geometric mean diameter (mm)	T_a	beginning value of the torque (Ncm)
L	length of crap apple (mm)	T_m	average value of the torque (Ncm)
M	mass of crap apple (g)	V	volume of crap apple (cm^3)
m_c	moisture content, (%) d.b.	W	sample weight (10N)
ε	porosity of crap apple (%)	$Ø$	sphericity of crap apple
P_a	projected area (cm^2)	μ_s	static coefficient of friction
ρ_b	bulk density (kg/m^3)	μ_d	dynamic coefficient of friction
ρ_f	fruit density (kg/m^3)		

Table 1. Chemical properties and mineral contents of crab apple fruit

Properties	Concentrations
Moisture (%)	77.83
Crude oil (%)	0.19
Crude protein * (%)	0.23
Crude fibre (%)	2.6
Ash (%)	2.44
Acidity (%,malic)	0.87
pH	4.1
Minerals (mg/kg):	
Al	154.6
B	66.4
Ca	2549.3
Cu	5.9
Fe	96.3
K	18780.8
Mg	866.6
Mn	4.8
Mo	0.9
Na	2814.0
Ni	1.1
P	2562.4
Pb	0.5
Se	0.9
Zn	15.0

*Nx6.25

Table 2. Dimensional properties of crab apple at 77.83 % m.c.d.b.

Properties	Values
Mass (g)	11.64±0.28
Diameter (mm)	28.94±0.27
Length (mm)	24.72±0.22
Geometric mean diameter (mm)	27.45±0.24
Sphericity	1.11±0.005

Table 3. The correlation coefficient of crab apple

Particulars	Ratio	Degrees of freedom	Correlation coefficient
D/L	1.170	98	0.737**
D/M	2.486	98	0.650**
D/Dg	1.054	98	0.974**
D/ Ø	26.072	98	0.386**

**significant at 1% level

Table 4. Some technological properties of crab apple at 77.83 % m.c.d.b

Properties		Values
Volume (cm^3)		13.25±0.74
Fruit density (kg/m^3)		915.10±20.81
Bulk density (kg/m^3)		486.05±1.2
Porosity (%)		43.86±4.74
Projected area (cm^2)		7.47±0.27
Fruit hardness (N)		
	Sap	8.19±0.28
	Orta	9.23±0.33
	alt	8.94±0.25

Table 5. Relationships between friction coefficients and moisture content of crab apple for various material surfaces

Materials	Static friction coefficient	Dynamic friction coefficient
Galvanized steel	0.291±0.071	0.251±0.061
Iron sheet	0.324±0.081	0.281±0.076
Wood	0.329±0.095	0.298±0.094

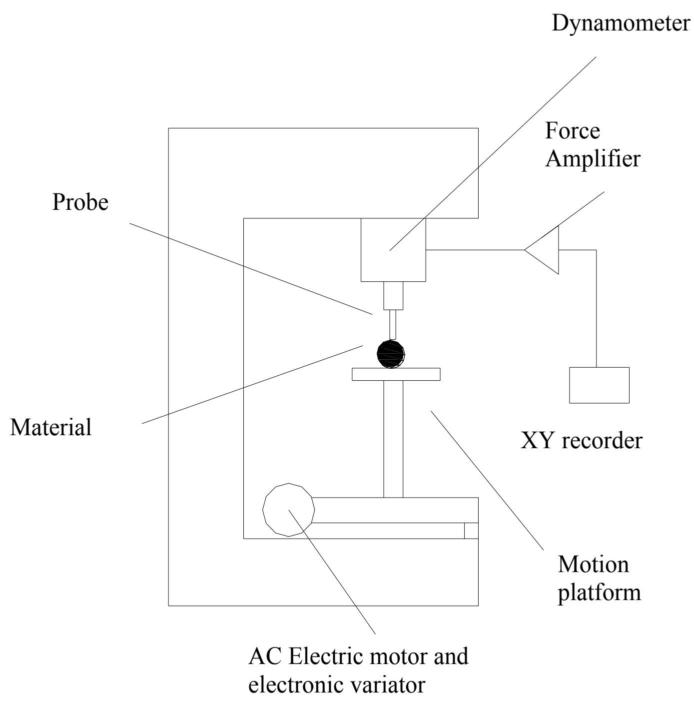

Figure 1. Biological material test unit (B.M.T.U.)

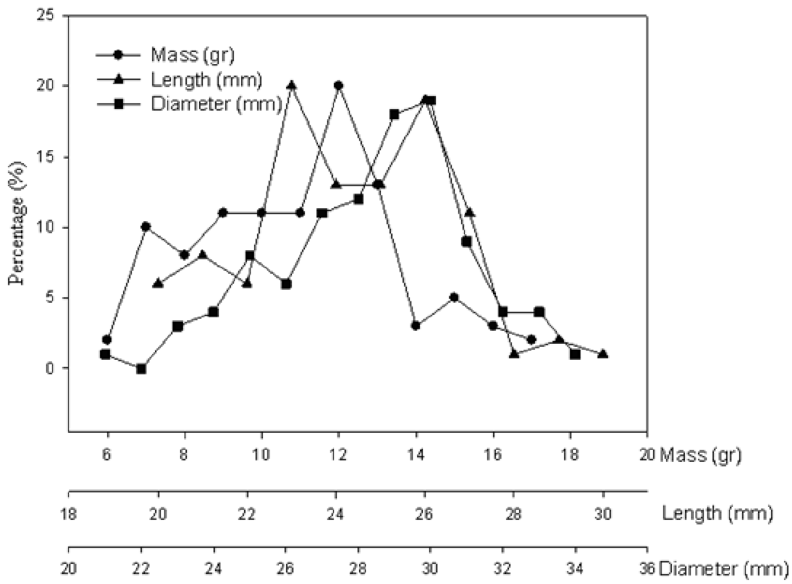

Figure 2. Frequency distribution curves for diameter, length and mass of crab apple at a moisture content of 77.83% d.b

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