A CONDIMENT [SUMAC (*RHUS CORIARIA* L.) FRUITS]: SOME PHYSICO-CHEMICAL PROPERTIES

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Abstract. Sumac (*Rhus coriaria* L.) is a perennial edible plant, which is growing wild. In the present research, the proximate physical and chemical properties of sumac fruits along with their mineral constituents were studied. The analyses of sumac fruits showed the following composition: moisture (9.6%), oil (7.4 %), protein (2.6 %), fibre (14.6 %), ash (1.8%) and water-soluble extract (63.8 %). Mineral content of the grown in Turkey sumac fruits was determined by inductively coupled plasma atomic emission spectrometer (ICP-AES). Potassium, calcium, magnesium and phosphorus were found to be predominant elements in sumac fruits. Some physical properties such as length, weight, volume, geometric mean diameter, sphericity, bulk density, projected area, porosity, terminal velocity and static coefficient of friction were measured at 4.79% moisture content levels. The values of length, weight, geometric mean diameter, volume, thickness and sphericity of sumac fruit were determined as 4.72 mm, 0.018 g, 3.64 mm, 19.49 mm^3, 2.64 mm and 0.773, respectively. At the same moisture level, projected area, bulk density, porosity, terminal velocity and static friction of sumac fruits were determined as 0.164 cm^3, 304.25 kg/m^3, 68.52%, 3.52 m/s and 0.482-0.675, respectively.

The knowledge of the nutritional properties and the mineral content of sumac fruit may be useful as a dietary information. Furthermore, it is very important to know the technical properties of the equipment used for harvesting, transportation and processing of sumac fruits.

***Keywords* :** sumac fruits, physical properties, chemical properties

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Nomenclature			
D_g	geometric mean diameter (mm)	T	thickness (mm)
L	length (mm)	V	volume (mm^3)
M	mass (g)	V_t	terminal velocity (m/s)
m_c	moisture content, (%) d.b.	W	width (mm)
A	projected area (cm^2)	$\varnothing$	sphericity
ρ_b	bulk density (kg/m^3)	ε	porosity (%)
p_2	final pressure (kg/cm^2)	μ_s	coefficient of static friction
p_1	initial pressure (kg/cm^2)		

INTRODUCTION

Sumac (*Rhus coriaria* L.), belonging to the Anacardiaceae family, is a small tree or shrub. It grows in Mediterranean countries, North Africa, South Europe, Afghanistan and Iran. In Mediterranean countries, sumac leaves had been used not only as a condiment, but as a mean for tanning leather (4.0%), and the dry fruits - as a remedy for stomach diseases, as well (Baytop,1984; Brunke et al., 1993; Özcan, 2003$_b$). It is a very popular condiment used as a major souring agent. Mixed with freshly cut onions, it is used as an appetizer. It is well known that Turkish fast food specialty döner kebab is sometimes flavored with sumac powder. It is also rubbed on kebabs, fish or chicken. The berries have diuretic properties and are used for bowel complaints, for reducing fever, and as an antiseptic. Dried fruits are also used in cases of diarrhea and in the treatment of dermatitis an (Altınkurt and Heper, 1970; Baytop, 1984).

Studies on the chemical composition of sumac berries are not numerous (Akgül, 1993; Brunke et al., 1993; Mavlyanov et al., 1997). Much more are the studies on the antioxidant effect of sumac and its derivatives, such as the extract (Özcan and Akgül, 1995; Özcan, 2003$_a$; Özcan, 2003$_b$). Mavlyanov et al. (1997) reported that fruits of sumac (*R. coriaria* L.) contain flavonols, phenolic acids, hydrolysable tannins, anthocyans and organic acids. Brunke et al.(1993) also pointed out that the fruits of sumac contain malic, citric and tartaric acids.

The aim of this study is to establish sumac chemical composition and its physical properties such as length, diameter of fruit, volume, geometric mean diameter, sphericity, bulk density, projected area and static coefficient of friction.

MATERIALS AND METHODS

Materials

Fresh wild sumac fruits were collected from sumac trees in Mersin (Büyükeceli-Gülnar), Turkey, in August, 2003. The fruits were transported in polypropylene bags and held at room temperature. Fruits were cleaned by a combination of manual and mechanical procedures to remove all foreign matter and crushed or immature fruits. Moisture content was measured on arrival.

Determination of physical properties

All sumac fruits physical properties were determined after 10 repetitions of the experiment at moisture content of 4.79% d. b.

To determine the size of the fruits, ten groups of samples consisting of 100 fruits were selected randomly. From each group 10 grains were taken, and their linear dimensions - length, width, thickness and projected areas, were measured. Linear dimensions were measured using a micrometer with the accuracy to 0.01mm.

Projected area of fruits was determined using a digital camera (Kodak DC 240) and Sigma Scan Pro 5 program (Trooien & Heerman, 1992; Ayata, Yalçin & Kirisçi, 1997).

Fruits mass was measured using an electronic balance with the accuracy to 0.001g.

Bulk density (ρ_b) was determined with a hectoliter tester, which was kg per hectoliter calibrated (Desphande, Bal & Ojha, 1993; Suthar & Das, 1996; Jain & Bal, 1997). The fruits were dropped down into a bucket from a height of approximately 15 cm. The excess fruits were removed by sweeping the surface of the bucket. The sumac fruits were not compressed in any way.

The terminal velocities of sumac fruits were measured using an air column. For each test, a sample was dropped into the air stream from the top of the air column, up which air was blown to suspend the material in the air stream. The air velocity near the location of the fruits suspension was measured using an electronic anemometer reading minimum 0.1 m/s (Joshi, Das & Mukherji, 1993; Hauhout-O'hara, Criner, Brusewitz & Solie, 2000).

Bulk porosity (ε) was measured using a porosity device (Day, 1964; Çarman, 1996). It consists of two identical tanks, one containing air under pressure (p_1) and the other one containing fruit samples. When the valve between the two tanks opens, the air pressure in the two tanks equalizes to a value p_2. Porosity was calculated using the following equation:

$$\varepsilon = (p_1 - p_2)/p_2 . 100$$

Geometric mean diameter (D_g), sphericity ($\varnothing$) and fruit volume (V) values were found using the following formula (Mohsenin, 1970; Jain & Bal, 1997):

$D_g = (LWT)^{0.333}$
$\varnothing = (LWT)^{0.333} / L$
$V = \pi B^2 L^2 / 6(2L-B)$,
where:
$B = (WT)^{0.5}$

The coefficient of static friction (μ_s) was measured using iron sheet, galvanized iron sheet, plywood and rubber surfaces. For this measurement one end of the friction surface was attached to an endless screw. Fruits were placed on the surface and were gradually raised by the screw. Vertical and horizontal height values were read from the ruler when the fruits started sliding over the surface, then using the tangent value of that angle the coefficient of static friction was found. Baryeh (2001), Dutta, Nema & Bhardwaj (1988), Suthar and Das (1996) have used similar methods.

Statistical evaluation was done using MINITAB package program (Minitab, 1991)

Chemical properties

Moisture, crude oil, crude protein, crude energy, ash, non soluble ash in HCl, crude fiber, water-soluble extract, pH, acidity were measured according to Cemeroğlu (1992) and AOAC (1984).

Determination of mineral content

0.5 g dried and ground sample was put into a burning cup and 10 ml pure HNO_3 was added. The sample was incinerated in MARS 5 Microwave oven at 200° C under 170 psi, and the solution was diluted to the volume of 25 ml with water. Samples were filtered through a filter paper, and were determined with an ICP-AES (Skujins, 1998).

ICP-AES operation characteristics:

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)
Auxiliary 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)

RESULTS AND DISCUSSION

Physical Properties

Dimensional size properties of sumac fruits are given in Table 1. The frequency distributions of the dimensional properties are given in Figure 1. In terms of moisture content of 10.90%, 92% of sumac fruits are between 4.25 and 5.0 mm in length, 88% of them are between 3.50 and 4.50 mm in width, and 90% are between 2.30 and 3.0 mm in thickness.

Table 1.Dimensional properties of sumac fruits at 4.79% m.c.d.b.

Length, (mm)	4.72±0.030
Width, (mm)	3.90±0.028
Thickness, (mm)	2.64±0.025
Weight, (g)	0.018±0.001
Geometric mean diameter, (mm)	3.64±0.023
Volume (mm^3)	19.49±0.442
Sphericity (-)	0.773±0.003

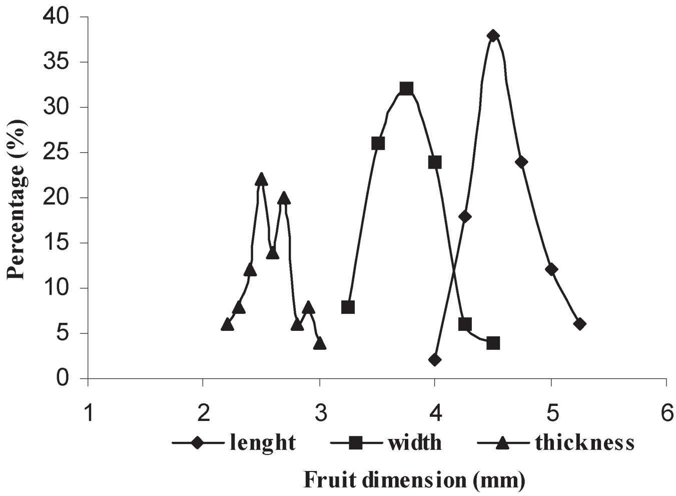

Figure 1. Sumac fruits dimensions distribution at an equal moisture content (10.90%)

Comparing fruit length, width, thickness, weight, geometric mean diameter, sphericity and volume, relationship between them was established. This relationship was found to be as follows:

$$L=1.210\text{x}W=1.788\text{x}T=262.22.M=1.297D_g=6.106\text{x}\ \varnothing=0.242\text{x}V$$

The correlation coefficients (Table 2) show that the *L/W, L/T, L/M, L/Dg L/∅* and *L/V* ratios were highly significant. Some physical properties of sumac fruit studied in the experiment are shown in Tables 1 and 3. Similar results were reported by Demir, Doğan, Özcan & Hacğseferogulları (2002); Gezer, Hacıseferoğulları & Demir (2002); Çarman (1996); Joshi, Das & Mukherji (1993). This indicates that the length, width, thickness, mass, geometric mean diameter, sphericity and volume of the sumac fruits are closely related to their diameter.

Table 2. Correlation coefficient of sumac fruits

Particulars	Ratio	Degrees of freedom	Correlation coefficient
L/W	1.210	98	0.674**
L/T	1.788	98	0.292**
L/M	262.22	98	0.766**
L/Dg	1.297	98	0.817**
L/ ∅	6.106	98	-0.612**
L/V	0.242	98	0.730**

**P>0.01

The static coefficients of friction for sumac fruit determined using an iron sheet, galvanized iron sheet, plywood, and rubber surfaces, respectively, and some of its physical properties are presented in Table 3. Our findings differed from the previously reported galvanized steel values, and the results on plywood and rubber surfaces were higher than those of authors cited (Demir *et al*., 2002; Marakoğlu *et al*., 2004; Akıncı *et al*., 2004). This could be due to the lower moisture contents and the hairy nature of the sumach fruits. At all moisture contents of sumac fruit, the static coefficients of friction were greatest when using rubber, and least when using galvanized sheet metal. Gupta and Das (1997) reported a similar result. It was observed that surface material has a stronger effect on the static coefficient of friction than the

Table 3. Some physical properties of sumac fruits at 4.79% m.c.d.b

Projected area (cm^2)	0.164±0.005
Bulk density (kg/m^3)	304.25±1.364
Porosity (%)	68.52±0.578
Terminal velocity (m/s)	3.52±0.128
Coefficient of static friction	
iron sheet	0.532±0.036
galvanized iron sheet	0.482±0.022
plywood	0.607±0.068
rubber	0.675±0.334

moisture content. When compared to other fruits, the sumac fruit coefficient of friction was found to resemble that of the cherry laurel fruits (Calısır and Aydın, 2004), *Juniperus drupacea* fruits (Akıncı et al., 2004), orange fruits (Topuz et al., 2004), terebinth fruit (Aydın & Ozcan, 2002) and rose fruit (Demir & Ozcan, 2001). The knowledge of the physical properties of sumac fruits is necessary for the initial design of the equipment for handling, collecting, transport, processing and storaging the crops. Similar evaluations of rose fruit projected area, bulk density, porosity, terminal velocity and coefficient of static friction, have been made by Demir and Özcan (2001), and for hackberry fruits – by Demir, Doğan, Özcan & Hacıseferoğulları (2002).

Chemical properties

Chemical properties of sumac (*Rhus coriaria* L.) fruit from Mersin area (Büyükeceli-Gülnar), Turkey, were determined and their potential uses were investigated (Table 4). Moisture, crude protein, crude oil, crude fibre, crude energy, ash, water-soluble extract and acidity of ripe fruits were measured. Mineral contents were determined, as well (Table 5).

Fruits contained 7.4% oil, 2.6% protein, 1.81% ash and 14.6% fibre. Fruits containing about 14.6% crude fibre may be considered as a dietary fibre source which could be helpful in reducing gastrointestinal disorders. Moisture, oil, protein, ash, fibre and energy contents were found to be different from those of caperberry seeds, reported by Akgül and Özcan (1999) and Özcan and Akgül (2000), from those of *Juniperus drupacea* fruits, reported by Akıncı et al (2004), from those of caper buds, reported by Özcan et al. (2004), and from the ones of terebinth fruits, determined by Özcan (2004).

Table 4. Chemical composition of sumac (*Rhus coriaria* L.) fruits

Properties	Values
Moisture (%)	10.6±1.1
Crude oil (%)	7.4±1.6
Crude protein (%)	2.6±0.2
Crude fibre (%)	14.6±0.4
Crude energy (Kcal/100 g)	147.8±7.3
Ash (%)	1.8±0.4
Water-soluble extract (%)	63.8±4.2
Acidity (%)	4.6±0.2
pH	3.7±0.3

*means ; **standard deviation ; n :3

Table 5. Mineral contents of sumac (*Rhus coriaria* L.) fruits

Minerals	Values (ppm)	Minerals	Values (ppm)
Al	125.47±11.04	Mg	855.95±17.63
B	25.72±1.86	Mn	10.49±1.32
Ba	0.52±0.12	Na	114.06±3.65
Ca	3661.57±25.71	Ni	1.07±0.03
Cd	0.03±0.01	P	1238.74±37.82
Cr	1.03±0.07	Pb	0.52±0.03
Cu	3.73±0.14	Se	0.47±0.02
Fe	144.53±3.76	V	6.43±0.67
K	7963.35±47.85	Zn	10.93±0.84
Li	1.40±0.13		

* means ; **standard deviation ; n : 3

The concentrations of minerals are given in Table 5. Potassium, calcium, magnesium and phosphorus were the predominant elements in the sumac fruits, followed by Al, Fe, Na, B and Zn. Potassium content in sumac fruits (7963.4 ppm) is higher than that in most of the other fruits. In terebinth fruit it is about 801.88 mg/Kg (Özcan, 2004a), in sumac skin - 7600 ppm (Özcan, 2004b), and in orange varieties - 1011 mg/L to 1364 mg/L (Topuz et al., 2004). Potassium content of sumac fruits was lower than that of blackthorn fruits which contain about 18706.98 mg/Kg (Marakoğlu et al., 2004). Cupper, iron and zinc are essential elements for human body and their daily requirement for adults is 2-3 mg, 18 mg and 15 mg, respectively (Clydesdale and Francis, 1985). Calcium is the major component of bone and assists in teeth development (Brody, 1994). Mg, Fe and P levels are essential, too. Other inorganic elements which contribute to the biological processes, but which have not been established as essential, are barium, bromine, cadmium, lead and lithium (Macrae et al., 1993_a). Cadmium and lead are best known for their toxicological properties. Decreasing of these toxic element contents is an advantage (Macrae et al., 1993_b). Our findings indicate that sumac could contribute partially to the overall daily dietary intake of those elements. Data on sumac fruits minerals content have not been reported in the literature. As a result, the differences in the chemical properties of fruits having the same size were probably due to environmental conditions in conjunction with the analytical methods used (Gül et al., 1988). In addition, moisture, protein, ash, fibre and oil contents of fruits are affected mainly by the varieties of species and the growth conditions. These findings may be useful as dietary information which requires prior knowledge of the nutritional composition of sumac fruit used as condiment. The consumption of sumac fruit is rising around the world due to the increasing popularity of natural products. Future studies could include amino acids and vitamin contents of the sumac fruits.

CONCLUSION

Physical properties such as length, width, thickness, weight, geometric mean diameter, volume, sphericity, projected area, bulk density, terminal velocity and static coefficient of friction were measured at 4.79% moisture content level. Sumac fruit length, weight, geometric mean diameter and volume values were established as 4.72 mm, 0.018 g, 3.64 mm and 19.49 mm^3, respectively. At the same moisture content, projected area, bulk density, porosity, terminal velocity were determined as 0.164 cm^2, 304.25 kg/m^3, 68.52 % and 3.52 m/s, respectively. The analytical values revealed the nutritional properties and mineral cotents of sumac fruit. These findings may be useful in the dietology. Furthermore, it is very important to know the technological properties of the equipment used for harvesting, transporting and processing of the sumac fruit.

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