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Comparative Study on the Chemical Composition of Syrian Sumac (*Rhus coriaria* L.) and Chinese Sumac (*Rhus typhina* L.) Fruits

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Abstract: In this article, two different sumac species, namely Syrian sumac (*Rhus coriaria* L.) and Chinese sumac (*Rhus typhina* L.) were investigated in order to determine and compare the chemical compositions of their fruits. The proximate analysis revealed a significant difference ($p<0.05$) between the two sumac species, with Chinese sumac exhibiting higher contents in ash, protein, fat and fiber. Gas Chromatography (GC) revealed that Chinese sumac contains higher percentage of total unsaturated fatty acids than that of Syrian sumac, with oleic and linoleic acids being predominant. The amounts of potassium and calcium were found to be higher in the fruit of Syrian sumac than in that of Chinese sumac. However, both sumac fruits exhibited also appreciable quantities of magnesium, phosphorous, sodium and iron. Syrian sumac contained much more vitamins than that of Chinese sumac, which in contrast exhibited higher amounts of essential and non-essential amino acids than that of Syrian sumac. High-Performance Liquid Chromatography (HPLC) indicated that Syrian sumac contains higher concentrations of organic acids than Chinese sumac and malic acid is the most abundant. Results from this study suggested that both Syrian and Chinese sumac fruits are potential sources of food ingredients and/or additives.

Key words: Chemical composition, *Rhus coriaria, Rhus typhina,* sumac fruit

INTRODUCTION

The Anacardiaceae (or sumac family) consists of trees, shrubs, or woody vines belonging mainly to the genus *Rhus*, with about 250 species, which occur mostly in the tropics and subtropics but also into the temperate areas of the world (Encyclopedia Britannica, 2008). The sumac name is derived from “sumaga”, meaning red in Syriac (Wetherilt and Pala, 1994). They have stems with milky or resinous juice; simple or compound leaves; small flowers, with parts in fours or sixes and small dry, one-seeded, often hairy, sometimes highly colored fruits, usually in dense clusters.

Syrian sumac (*Rhus coriaria* L.) is famously used in the Mediterranean region and Middle East as a spice, sauce and drink. The spice, produced by grinding dried fruits with salt, is used as a condiment and sprinkled over fish, chicken, grilled meat and the salad often accompanying these dishes (Shelef, 1983). The fruits have been reported to possess antimicrobial and antioxidant activities (Nasar-Abbas and Halkman, 2004; Fazeli *et al*., 2007; Kosar *et al*., 2007; Özcan, 2003). In addition, they are also used as a remedy for reducing fever, diarrhea, dermatitis and stomach diseases (Brunke *et al*., 1993).

Chinese sumac (*Rhus typhina* L.), indigenous to the Eastern area of North America, is now extensively cultivated in China's North, Northwest and many other regions such as Lanzhou, Beijing, Hebei, Shanxi, where it is usually called “huojushu”. This species can grow under a wide array of conditions, but is most often found in dry and poor soil on which other plants cannot survive. In North America, the fruits are used to make a beverage termed “sumac-ade” or “Indian lemonade” or “rhus juice” (Peterson, 1977). The plant serves also as a traditional medicine, which has pharmacological functions such as antihaemorrhoidal, antiseptic, blood purifier, diuretic, stomachic and tonic (Foster and Duke, 1990; Moerman, 1998).

Up to now, no reports exist on the nutritional properties of either Syrian sumac or Chinese sumac. The aim of this study was to determine and compare the chemical compositions of both sumac species with regard to their extensive utilization in the food industry.

MATERIALS AND METHODS

Plant materials: Mature and dry fruits of Syrian sumac (*Rhus coriaria* L.) and Chinese sumac (*Rhus typhina* L.) were collected in autumn from Latakia (Syria) and Lanzhou (China), respectively. Before chemical analysis, the fruits were ground into powder using a household flourmill (Tianjin, China) and stored at 5°C for further use.

Proximate composition: Sumac fruit samples were analyzed for moisture, ash, crude protein, fat and fiber contents using the methods described by AOAC (1990) and results were expressed on a dry weight basis.

Fatty acids: Fatty acids were converted into their methyl esters (FAME) according to the method of Hartman and

Lago (1973) with some modifications. A gas chromatography system (GC-2010, Shimadzu, Japan) equipped with a flame ionization detector was used; 0.5 µl of FAME sample were injected and separation was carried out on a capillary column (CP-WAX 52 CB; 30 m x 0.32 mm x 0.50 µm). The carrier gas was nitrogen and the column flow rate was 2.5 ml/min. The oven temperature was held initially at 180°C for 1 min, increased by 3°C/min up to 220°C and then maintained at 220°C for 20 min. The temperatures of the injection port and detector were 250°C and 260°C, respectively. FAME samples were identified by matching their retention time data with those of standards from Sigma. The percentage of each fatty acid was calculated from the ratio of individual peak area to total definable peak area.

Minerals: For the analysis of mineral elements such as potassium, magnesium, calcium, phosphorous, iron, zinc, copper, sodium and manganese, samples were digested with pure HNO_3 in a microwave oven (MARS, CEM, USA). The oven temperature was initially set and held at 100°C for 5 min, then increased and held at 150°C for 10 min and finally increased and maintained at 170°C for 10 min. The concentration of each element was determined with an atomic absorption spectrometer (Spectra AA 220, VARIAN, USA).

Vitamins: Vitamins were analyzed using the method described by Erbas *et al.* (2005) with slight modification. Three grams of sample were mixed with 5 ml *n*-hexane and 20 ml HPLC grade water. The mixture was first homogenized by vortex and then centrifuged at 12,000 rpm for 30 min. The aqueous phase was filtered through filter paper and 0.45 µm membrane filter sequentially. The supernatant (10 µl) was injected into HPLC system (Agilent 1100 Technologies, USA) equipped with a UV-Vis detector, which was set to 260 nm in absorbance mode. Peaks were verified by adding the standard vitamins to samples and individual peak area was calculated according to the peak area of corresponding standard vitamin. Results were calculated on a dry weight basis.

Amino acids: Amino acids were determined following the method described by He and Xia (2007). The hydrolysis was carried out with 6M HCl at 110°C for 24 h, except for tryptophan analysis, using 6M NaOH separately, in vacuum hydrolysis tubes. Filtered hydrolyzate was dried in a vacuum desiccator and redissolved in 0.1 M HCl containing sarcosine and norvaline as internal standards. One microliter of the solution was injected directly into an amino acid analyzer (Agilent 1100, USA) with reverse phase column (4 x 125 mm) C_{18} at 40°C, a UV detector at 338 nm and a fluorescence detector at 450 nm, using (a) 20 mM sodium acetate buffer, pH 7.2, containing 0.018% triethylamine and 0.3% tetrahydrofuran and (b) 100 mM sodium acetate buffer, pH 7.2 containing 40% acetonitrile and 40% methanol, both of HPLC grades. Double pre-derivatization of the amino acids was achieved by reacting with Orthophtaldialdehyde (OPA), except for proline which was derivatized with 9-fluorenylmethyl chloroformate (FMOC). The carrier gas was maintained at a flow rate of 1.0 ml/min in a gradient of buffer a to buffer b. The identification of the amino acids in the samples was carried out by comparing their retention times with those of the standards from Sigma.

Organic acids: Organic acids (malic, citric, tartaric and fumaric) were determined according to the method described by Usenik *et al.* (2008). Sumac fruit samples (10 g) were dissolved with 50 ml of HPLC grade water and left at room temperature for 30 min. The mixture was centrifuged at 12,000 g for 7 min at 10°C (Eppendorf 5810 R centrifuge, Hamburg, Germany). The supernatant was filtered through a 0.45 µm cellulose ester filter and transferred into a vial.

Organic acids were analyzed with HPLC system (Agilent 1100, USA), using a diamonsil column C_{18} (4.6 x 250 mm) and a UV detector set at 210 nm and were identified by their retention time characteristics. The concentrations were expressed as mg per kg dry weight.

Statistical analysis: Results were subjected to the analysis of variance (ANOVA) using the SAS System for Windows, Version 8.0. Duncan's multiple-range test was used to compare means at a significance level of 5%.

RESULTS AND DISCUSSION

Proximate composition: The proximate composition of Syrian and Chinese sumac fruits is presented in Table 1. A significant difference ($p<0.05$) was found between the two sumac species, with Chinese sumac showing higher contents in protein, fat, fiber and ash (4.31, 11.56, 32.90 and 5.37%, respectively). However, the fiber and fat contents exhibited by Syrian sumac were higher than those reported by Özcan and Haciseferogullari (2004) and Akinci *et al.* (2004) on *Rhus coriaria* and *Juniperus drupacea*, respectively. Results showed that both sumac species can be considered as potential sources of dietary fiber which is helpful in alleviating gastro-intestinal disorders.

Fatty acid composition: The fatty acid composition of Syrian and Chinese sumac fruits is given in Table 2. Most of the fatty acids were unsaturated and saturated fatty acids (mainly palmitic acid) contributed little to the total fatty acids. In both plant materials, the percentage of total unsaturated fatty acids was higher than that of total saturated fatty acids. Moreover, Syrian and Chinese

Table 1: Proximate composition of Syrian and Chinese sumac fruits (%, dry weight)

Components	Syrian sumac	Chinese sumac
Moisture	11.80 ± 0.53^a	6.64 ± 0.03^b
Protein	2.47 ± 0.12^b	4.31 ± 0.27^a
Fat	7.51 ± 0.44^b	11.56 ± 0.66^a
Fiber	22.15 ± 0.14^b	32.90 ± 0.89^a
Ash	2.66 ± 0.33^b	5.37 ± 0.14^a

Data are means of three determinations±SD. Means with different superscripts within the same row are significantly different ($p<0.05$)

Table 2: Fatty acid composition of Syrian and Chinese sumac fruits (% total fatty acids)

Fatty acid	Syrian sumac	Chinese sumac
Myristic acid ($C_{14:0}$)	0.36 ± 0.07^a	0.19 ± 0.05^b
Palmitic acid ($C_{16:0}$)	27.41 ± 0.55^a	16.28 ± 0.16^b
Palmitoleic acid ($C_{16:1}$)	0.68 ± 0.23^b	2.11 ± 0.10^a
Stearic acid ($C_{18:0}$)	2.92 ± 0.37^a	2.60 ± 0.13^a
Oleic acid ($C_{18:1}$)	36.95 ± 0.28^b	52.31 ± 0.10^a
Linoleic acid ($C_{18:2}$)	30.38 ± 0.54^a	25.57 ± 0.20^b
Linolenic acid ($C_{18:3}$)	1.27 ± 0.15^a	0.94 ± 0.16^a
TUFA	69.28 ± 1.20	80.93 ± 0.56
TSFA	30.69 ± 0.99	19.07 ± 0.32

TUFA = Total Unsaturated Fatty Acids, TSFA = Total Saturated Fatty Acids. Data are means of three determinations ± SD. Means with different superscripts within the same row are significantly different ($p<0.05$)

Table 3: Mineral elements of Syrian and Chinese sumac fruits (mg/kg)

Mineral	Syrian sumac	Chinese sumac
K	7441.25 ± 0.07^a	5576.00 ± 0.68^b
Na	101.04 ± 0.15^b	183.00 ± 0.26^a
Mg	605.74 ± 0.51^b	871.00 ± 0.42^a
Ca	3155.53 ± 0.41^a	3098.00 ± 0.52^b
Fe	174.15 ± 0.18^b	180.00 ± 0.67^a
Cu	42.68 ± 0.45^a	9.56 ± 0.19^b
Zn	55.74 ± 0.38^a	17.20 ± 0.38^b
Mn	10.57 ± 0.39^b	11.60 ± 0.35^a
P	327.70 ± 0.35^b	1032.00 ± 0.21^a

Data are means of three determinations±SD. Means with different superscripts within the same row are significantly different ($p<0.05$)

Table 4: Vitamin content of Syrian and Chinese sumac fruits (mg/kg)

Vitamin	Syrian sumac	Chinese sumac
Thiamin (B_1)	30.65 ± 0.57^a	23.99 ± 0.54^b
Riboflavin (B_2)	24.68 ± 0.42^a	24.41 ± 0.33^a
Pyridoxine (B_6)	69.83 ± 0.31^a	20.28 ± 0.28^b
Cyanocobalamin (B_{12})	10.08 ± 0.24^a	3.51 ± 0.37^b
Nicotinamide (PP)	17.95 ± 0.28^a	2.39 ± 0.13^b
Biotin (H)	4.32 ± 0.23^a	1.13 ± 0.08^b
Ascorbic acid (C)	38.91 ± 0.27^a	13.90 ± 0.20^b

Data are means of three determinations±SD. Means with different superscripts within the same row are significantly different ($p<0.05$)

sumac fruits differed significantly ($p<0.05$) with regard to their composition in fatty acids. Indeed, the total amount of unsaturated fatty acids (80.93%) in Chinese sumac was higher than that found in Syrian sumac (69.28%). The levels of total unsaturated fatty acids exhibited by sumac species growing in Syria and China are comparable with those reported by Dogan and Akgül (2005) on sumac growing in Turkey. Results indicated that either Syrian or Chinese sumac can be good sources of unsaturated fatty acids.

Mineral elements: The content in minerals of Syrian and Chinese sumac fruits are shown in Table 3. In both sumac species, potassium was the most abundant mineral, followed by calcium. However, the amounts of potassium and calcium in Syrian sumac were significantly ($p<0.05$) higher than those in Chinese sumac. On the other hand, the contents in phosphorous, magnesium and sodium of Chinese sumac were significantly ($p<0.05$) higher than those of Syrian sumac. Many dietary essential minerals, such as iron, zinc, copper and manganese were found in both sumac species. Moreover, copper and zinc contents in Syrian sumac were significantly ($p<0.05$) higher than those in Chinese sumac. Nevertheless, the concentrations of iron, zinc and copper exhibited by sumac growing either in Syria or in China seemed to be higher than those reported on sumac growing in Turkey (Özcan and Haciseferogullari, 2004). Similarly, the amounts of calcium and iron contained in both sumac species were found to be higher than those observed for wolfberry (Wikipedia, 2008). Results showed that both Syrian and Chinese sumac fruits could be used in the human diet to supply the required mineral elements.

Vitamin content: The vitamins of Syrian and Chinese sumac fruits are presented in Table 4. In Syrian sumac, pyridoxine was the most abundant, followed by ascorbic acid, thiamine and riboflavin, respectively. In contrast, the most abundant vitamin in Chinese sumac was riboflavin, followed by thiamine, pyridoxine and ascorbic acid, respectively. Among water-soluble vitamins, the B group including B_1, B_2, B_6 and B_{12} are the most important (Moreno and Salvado, 2000). The amount of pyridoxine in Syrian sumac was found to be higher than those observed for spices such as chili, cayenne, paprika and garlic (Leonard *et al.*, 2001). Moreover, both sumac species contained other vitamins, including cyanocobalamin, nicotinamide and biotin in considerable quantities. In general, the amount of vitamins detected in Syrian sumac was significantly ($p<0.05$) higher than that in Chinese sumac.

Amino acid profile: The amino acid profile of protein in Syrian and Chinese sumac fruits is given in Table 5. Both sumac species were found to contain eighteen amino acids including eight essential amino acids (leucine, isoleucine, lysine, methionine, threonine, phenylalanine, valine and tryptophan) and ten non-essential amino acids. Results showed that the amount

Table 5: Amino acid profiles of Syrian and Chinese sumac fruits as compared to the FAO/WHO/UNU reference pattern (mg/g protein)

Amino acid	Syrian sumac	Chinese sumac	FAO/WHO/UNU
Essential			
Leucine	1.25±0.16^b	3.16±0.19^a	19
Isoleucine	0.63±0.08^b	1.79±0.17^a	13
Lysine	0.98±0.02^b	2.65±0.07^a	16
Phenylalanine	0.75±0.13^b	2.00±0.13^a	19
Threonine	0.70±0.08^b	1.57±0.06^a	9
Methionine	0.15±0.07^a	0.05±0.02^a	17
Valine	0.71±0.06^b	2.24±0.30^a	13
Tryptophan	0.51±0.18^b	3.10±0.15^a	5
Non-essential			
Arginine	1.09±0.10^b	2.79±0.25^a	
Histidine	0.68±0.01^b	1.03±0.12^a	
Cysteine	0.18±0.04^a	0.10±0.03^a	
Aspartic acid	1.70±0.34^b	3.68±0.49^a	
Glutamic acid	2.45±0.15^b	7.46±0.40^a	
Serine	0.93±0.17^b	2.26±0.16^a	
Glycine	0.60±0.26^b	2.17±0.12^a	
Alanine	0.96±0.26^b	1.98±0.18^a	
Tyrosine	0.51±0.33^b	1.27±0.19^a	
Proline	1.43±0.27^b	2.26±0.24^a	

Data are means of three determinations±SD. Means with different superscripts within the same row are significantly different ($p<0.05$)

Table 6: Organic acid content of Syrian and Chinese sumac fruits (mg/kg)

Organic acid	Syrian sumac	Chinese sumac
Malic acid	1568.04±0.05^a	377.59±0.26^b
Citric acid	56.93±0.35^a	30.54±0.54^b
Tartaric acid	2.15±0.13^a	1.20±0.06^b
Fumaric acid	3.40±0.46^a	0.41±0.07^b

Data are means of three determinations±SD. Means with different superscripts within the same row are significantly different ($p<0.05$)

of amino acids in Chinese sumac was significantly ($p<0.05$) higher than that in Syrian sumac. Nevertheless, the amount of each essential amino acid in both Syrian and Chinese sumac fruits was found to be lower than that reported by FAO/WHO/UNU (1985). Both sumac species contained non negligible amounts of amino acids, especially leucine, arginine, aspartic acid, glutamic acid and proline.

Organic acid content: The content of organic acids in Syrian and Chinese sumac fruits is shown in Table 6. The fruit of Syrian sumac contained higher amounts of organic acids than that of Chinese sumac. Moreover, the predominant acid in both species was malic acid, whose quantity was found to be lower than that present in white grapes (Soyer *et al*., 2003). Furthermore, the fruits of Syrian and Chinese sumac exhibited moderate amounts of citric acid with relatively small concentrations of tartaric and fumaric acids. Results revealed that Syrian sumac fruit is more acidic than Chinese sumac fruit.

Conclusion: Results from this study indicated that Syrian and Chinese sumac fruits are significantly different from each other in terms of chemical composition. Chinese sumac was found to be rich in protein, fat, fiber and ash. In addition, its oil can be regarded as a potential source of unsaturated fatty acids, especially oleic acid. On the other hand, Syrian sumac was found to contain appreciable amounts of minerals and vitamins. Furthermore, the content of individual organic acids was higher in Syrian sumac fruit than in Chinese sumac fruit, with malic acid being the major organic acid. The two sumac species can be considered as good sources of additives and/or ingredients for the food industry. These findings would be useful for food scientists and nutritionists interested in the nutritive value of non-conventional plants such as sumac.

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