Comparing physicochemical properties and antioxidant potential of sumac from Iran and turkey

Abstract

Sumac is a medicinal plant that used as a spice. The sour red small epicarps of the fruit are applied in traditional medicine and cookery. In this study, some physical, chemical and antioxidant properties of its aqueous and ethanolic extracts of the sumac fruits of Iran were investigated. The average m1000, bulk density and porosity percentage ranged from 15.9-16.9g, 304.6-306.7 kg/m3 and 68.31-97.26%, respectively. The galvanized sheet with the lowest static friction coefficient was the best surface for the fruit transfer. The mean length, width, thickness and volume were in the range of 4.73-4.98mm, 4.08-4.54mm, 2.33-2.51mm and 17.64-22.46mm3, respectively and the mean sphericity coefficient varied from 0.73 to 0.76. This information is of great importance for the design of the equipment of harvest, transfer and processing of sumac fruit. This study also represent that the antioxidant activity, free radical scavenging and reducing capacity of the ethanolic extract were higher than those of the aqueous one. Moreover, the ethanolic extract had a larger total phenol and anthocyanin content as compared to the aqueous one.

Keywords: antioxidant, chemical, physical properties, sumac, DPPH

Introduction

Spices and aromatic plants are utilized in the food industry, firstly because of the transfer of desirable flavor and aroma and secondly due to having antimicrobial activity which increases the shelf-life of foodstuffs.1

The Genus Rhus is comprised of more than 250 species and are characterized well using phenolics and triterpenes. Rhusglabra L. was traditionally used by Indians, native to North America, to treat bacterial diseases such as Syphilis, Gonorrhea and diarrhea.2 Rhuscoriaria L., known as sumac, is another member of this genus which grows naturally in a vast district, from the Canary Islands (located in the Atlantic Ocean to the Mediterranean coasts, Iran and Afghanistan).3,4

Sumac (Rhuscoriaria L.), a member of the Anacardiaceae family, is a small shrub with a height of 1-5m and leaves comprised of 9-15 leaflets which are jagged and covered with wool. It grows in warm and mild-weather regions.2 The leaves color tends to be red in fall and it is one of the specifications of the plant.3 Sumac has been used as a spice or medicinal plant during hundreds of years.4 The applied part in traditional medicine and Iranian cookery are the sour red small epicarps of the fruit.7

Sumac is employed in the Iranian traditional medicine as an astringent, stancher and ant diarrheal agent. It is also used to eye traichoma, and to prevent the incidence of pox in eye.8,9 The sumac spice is obtained from chopping the fruit of this plant and is used as a seasoning for kebab and various salads due to its sour flavor (pH=2.5) which is caused by the presence of citric acid and malic acid.5

Clinical, food-protective, antimicrobial and physicochemical properties of the sumac extract have been investigated in different researches.12-22 Large amounts of tannins have been observed in the aqueous extract of the dried leaves of sumac (R. coriaria L.).23 Recently, the superoxide radical scavenging activity.24 and the mineral content of sumac leaf and fruit have been examined.25 Recovery of the phenolic compounds from different solvents is influenced by the solvent polarity and the solubility of these compounds in the solvent.26 The polarity range of polyphenols is widespread and consequently, a large number of solvents can be taken into account. Therefore, selection of a proper solvent for the extraction of the phenolic compounds from all samples is difficult.26

Different solvents and numerous extraction techniques can be applied in order to extract antioxidant compounds from plant tissues. The polarity degree of various solvents affects the extraction extent of polyphenolic compounds. The solubility of polyphenolic compounds differs, depending on the type of solvent, degree of polymerization and their interaction with other compounds present in plant tissues. Numerous studies have been carried out on the engineering properties of many seeds, including fenugreek, lentil, guan, cotton, coriander, flaxseed, pomegranate, cress, balangu, basil, plantain, sage, milket, cannabis, grain, sesame, quinoa and sumac.25,27-40

Engineering properties have a special importance in post-harvest processes.27 For instance, the seed dimensions and shape influence the selection of the suitable sieve mesh. Angle of repose and frictional properties are used in the design of silos, storage tanks and conveyors. Although literature review shows that many researchers have been conducted on the physical properties of food and agricultural products and even on the sumac of other countries, no research has been performed up to now on the engineering properties of the Iranian sumac. Shape and size, bulk density, particle density, porosity, weight, static and dynamic friction coefficients are of the most important physical properties which are functions of moisture. The physical properties of agricultural products are needed for the design and manufacture of the equipment of transfer, processing, sorting, grading and qualitative assessment of such products.42 In another research carried out by Özgüven F et al.43 on the physical, mechanical and aerodynamic properties of pine nut, some properties, including the cracking force, frictional properties such as the static friction coefficient and the dynamic angle of repose of the seed, core
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The aim of this study was to determine and investigate the physical properties, including the dimensions, m1000, particle density, bulk density, porosity and static friction coefficient, in addition to the chemical properties such as the chemical composition of the sumac fruits of Iran. We also aimed to measure the total phenol content, total anthocyanin content, reducing power and the DPPH free radical scavenging power of the aqueous and ethanolic extract of sumac Epicarp and seed and compare it with the sumac of Turkey and Syria.

Materials and methods

Materials

Sumac clusters were supplied from the gardens of Gonabad, Ferdows and Zoshk (Khorasan, Iran) and cleaned up manually and separated from other plant residues. The physical tests of the sumac seeds were performed at the moisture content of 5.0±0.2%. For the chemical tests, the fruits were ground into a coarse-particle powder using a pestle and mortar and separated from the seeds using a sieve. The epicarp and seeds were milled and passed through a 60 mesh screen. The separation performance of the epicarp and whole seed was calculated using the following equation:

\[
\text{separation efficiency (\%) } = \frac{A}{B} \times 100
\]

Where A represents the Epicarp and the whole seed, and B denotes the whole seed and the sumac clusters.

Physical properties

Dimensions: In order to determine the length, width and thickness of the sumac fruits, 50 seeds were selected randomly and their dimensions were measured with a caliper.

\[m_{\text{mop}} \text{ and particle density: } \frac{m_{\text{mop}}}{100} \text{ seeds were chosen randomly and weighed using a digital balance. } m_{\text{mop}}\text{ was obtained through multiplying the measured mass by 10. The true density was measured through the pycnometer method using toluene. In this method, the true density (} \rho_{t} \text{) was calculated using equation (2):} \]

\[
\rho_{t} = \frac{m}{V_{l}}
\]

Where m is the mass of the poured seeds (kg) and \(V_{l}\) stands for the volume of the displaced liquid (\(m^3\)).

Bulk density and porosity: In order to determine the bulk density (\(\rho_{b}\)), the seeds were poured from a height of 15cm with a constant rate into a container with a certain volume. Then, the container was weighed and the bulk density was computed by equation (3):\[2\]

\[
\rho_{b} = \frac{m}{V_{b}}
\]

Where m is the seed weight (kg) and \(V_{b}\) denotes the container volume (\(m^3\)).

The porosity percentage (\(\varepsilon\)) was calculated through the Mohsenin equation (equation 4):\[32\]

\[
\varepsilon = \left( \frac{\rho_{t} - \rho_{b}}{\rho_{t}} \right) \times 100
\]

Static friction coefficient: A ramp with an adjustable slope was applied to determine the static friction coefficient. A fiberglass box with the dimensions of \(40 \times 10 \times 15\) cm was placed on the frictional surface and filled with the seeds. The applied surfaces were made of multi-layered rubber, plywood and galvanized iron sheet. First, the box was lifted a little from the respective surface to prevent any contact between the box and the surface. The frictional surface is a part of the apparatus which has a joint at one end so that the non-hinge end could be lifted gently using a bolts and nuts system and consequently, the slide angle (\(\alpha\)) was considered as the friction angle. Finally, the static friction coefficient was calculated using equation (5):\[32\]

\[i_{s} = \tan \alpha\]

Chemical properties

The chemical composition (moisture, ash and fat) of sumac was determined according to AOAC (A.O.A.C., 1990). The protein content was measured through the Kjeldal method.\[44\]

Extract preparation: The aqueous and ethanolic extracts of epicarp and seed were prepared using distilled water and ethanol 96% through percolation. The extraction procedure was as follows:

The ethanolic extract was obtained after 24h of immersing 10g of the epicarp powder or the sumac seed in 100ml of ethanol 95% at ambient temperature.\[45\] The aqueous extract was acquired after 1h of immersing 10g of the epicarp powder or the sumac seed in 100ml of distilled water at ambient temperature.\[45\] The obtained extracts were separated from the solid matter by centrifugation and concentrated using a rotary evaporator and dried at 40°C with a drier. The dry powders resulted from the samples were stored at -18°C until use.

The measurement of the total phenol content, total anthocyanin content, reducing power and free radical scavenging were carried out on the extracts mixture.

The extraction efficiency (w/w) was calculated using the following equation:

\[
\text{Efficiency (\%) } = \frac{A}{B} \times 100
\]

where A represents the weight of the aqueous or the ethanolic extract and B stands for the weight of the epicarp or seed.

Determination of the total phenol content of the extracts: The total phenol content of the extracts was measured through the Folin-Ciocalteu micro-method.\[47\] 20µl of the reaction solution was mixed with 1.16ml of distilled water and 100µl of Folin–Ciocalteu reagent. After 1-8min, 300µl of Na₂CO₃ solution (20%) was added to the above solution. The obtained mixture was kept at 40°C for 30min

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The physical properties of the sumac seed

The physical properties of the sumac fruits harvested from Iran are shown in Table 1. In most cases, the reported values were nearly similar to each other and to those reported for the Turkish sumac fruit.

The m_{0,00} of this sumac ranged from 15.9 to 16.9mg. This range was less than that obtained for the Turkish sumac. The bulk density and porosity were in the range of 304.6-306.7kg/m³ and 68.31-97.26%. The average bulk density and porosity were more than those reported for the Turkish sumac.

The range of the static friction coefficient was determined as 0.67-0.69 for rubber, 0.60-0.63 for plywood and 0.48-0.51 for galvanized iron sheet. The mean static friction coefficient of rubber and plywood was higher and these two surfaces are inappropriate for transfer. The lowest coefficient pertained to the galvanized iron sheet. The friction coefficient of agricultural products generally depend on the properties of the foodstuff, moisture content, surface properties, slide speed and the surface material on which the food product moves. Under the same conditions, the surface properties of the seed are the major factor in terms of the slide speed, surface material and the moisture content.

These properties cause the difference between the friction coefficients of various seeds.

Chemical properties of the sumac seed

The approximate contents of the chemical components of sumac fruits are summarized in Table 2. The results indicated that the different compounds of different ecotypes of sumac (Rhus coriaria) were similar. However, these results were a little different from those of Özcan M et al. for the Turkish sumac and Kossah et al. for the Syrian one. The pH of the Syrian sumac has been reported to be equal to 3.7³⁰ while the pH of this sumac varied from 2.68 to 2.76.

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Table 1 Biophysical properties of the Iran sumac

| Region      | Length (mm) | Width (mm) | Thickness (mm) | Geometric mean diameter (mm) | Weight of m1000 (g) | Volume (mm^3) | Sphericity (-) | Bulk density (kg/m^3) | Porosity (%) | Coefficient of static friction | Reference |
|-------------|-------------|------------|---------------|-------------------------------|---------------------|---------------|---------------|-----------------------|--------------|-------------------------------|-----------|
| Gonabad*    | 4.98        | 4.54       | 2.51          | 3.84                          | 16.3                | 22.46         | 0.76          | 306.7                 | 68.31        | 0.68                          | 0.61      |
| Ferdows*    | 4.83        | 4.08       | 2.33          | 3.58                          | 16.9                | 17.64         | 0.73          | 304.6                 | 97.26        | 0.69                          | 0.63      |
| Zoshk*      | 4.73        | 4.21       | 2.36          | 3.6                           | 15.9                | 18.44         | 0.75          | 305.4                 | 91.16        | 0.67                          | 0.48      |
| Turkey      | 4.72        | 3.9        | 2.64          | 3.64                          | 18                  | 19.49         | 0.77          | 304.25                | 68.52        | 0.675                         | 0.482     |

*Gonabad, Ferdows and Zoshk are regions of Iran.

Table 2 The compounds of sumac

| Reference | pH     | Ash (%) | Protein (%) | Fat (%) | Moisture (%) | Regions |
|-----------|--------|---------|-------------|---------|--------------|---------|
| This study| 2.68   | 2.0±0.2 | 2.6±0.1     | 7.1±0.3 | 9.6±0.4      | Gonabad*|
| This study| 2.76   | 1.8±0.2 | 2.4±0.1     | 7.2±0.4 | 10.2±0.5     | Ferdows* |
| This study| 2.71   | 1.8±0.2 | 2.3±0.1     | 7.0±0.4 | 9.9±0.5      | Zoshk*  |
| Kossah et al. | -   | 2.66±0.33 | 2.47±0.12 | 7.51±0.44 | 11.8±0.53 | Syrian |
| Kossah et al. | -   | 6.64±0.03 | 11.56±0.66 | 4.31±0.27 | 5.37±0.14 | Turkey |
| Özcan M et al. | - | 3.7 | 1.8±0.4 | 2.6±0.2 | 7.4±1.6 | 10.6±1.1 | Turkey |

*Gonabad, Ferdows and Zoshk are regions of Iran.

Table 3 The separation performance of the whole seed, epicarp and extract (w/w) of the sumac of different regions

| Region      | Extraction efficiency (%) | Epicarp efficiency (%) | Fruit efficiency (%) | Reference |
|-------------|---------------------------|------------------------|----------------------|-----------|
|             | Ethanolic | Aqueous | Ethanolic | Aqueous | Ethanolic | Aqueous | Ethanolic | Aqueous | Ethanolic | Aqueous | Ethanolic | Aqueous |
| Gonabad*    | 3.57±0.5  | 3.65±0.4 | 55.8±2.9  | 63.45±2.1 | 59.28±3.1 | 92.8±1.1 | This study |
| Ferdows*    | 3.59±0.4  | 3.68±0.6 | 56.96±2.5 | 65.20±3.4 | 56.17±2.8 | 94.1±2.3 | This study |
| Zoshk*      | 3.52±0.5  | 3.62±0.3 | 52.24±1.8 | 62.54±2.7 | 54.87±2.3 | 91.9±1.6 | This study |
| Syrian      | -         | -       | 55.23    | -       | -         | -       | Kossah et al. |
| Turkey      | -         | -       | 63.8±4.2 | -       | -         | -       | Özcan M et al. |

*Gonabad, Ferdows and Zoshk are regions of Iran.

Assessment of the antioxidant activity

DPPH free radical scavenging assay: Scavenging free radicals is one of the most known mechanisms through which antioxidant compounds could prevent lipids oxidation. In this assay, the scavenging of DPPH is followed by monitoring the decrease in absorbance, which occurs due to the reduction by the antioxidant. The results of the free radical scavenging activity of the aqueous and ethanolic extracts are illustrated in Figure1. As observed, as the extract concentration increased, the extent of free radicals scavenging increased, too. The ethanolic extract showed a higher anti-radical activity at all concentrations.

Overall, the rise in the total phenolic content causes the ability of different extract in free radical scavenging to increase. At higher concentrations of phenolic compounds, the probability of hydrogen donation to free radicals and subsequently the scavenging ability of the extract increases because of the increase in the number of the hydroxyl groups present in the reaction medium. Scavenging of various extracts depends greatly on the number and position of hydroxyl groups and the molecular weight of phenolic compounds. The hydroxyl groups are more easily accessible in lower-molecular-weight phenolic compounds. In addition, phenolic compounds change into phenoxyl free radicals after donating their hydrogen. The stability of these radicals can influence the antioxidant capacity of phenolic compounds, as the less stable phenoxyl radicals compete with DPPH radicals in donating the hydrogen atoms and thus, the scavenging percentage of DPPH free radicals is reduced.

Reducing power: Extraction of antioxidant compounds from plant materials can be conducted through various techniques with different solvents, due to the difference in the chemical nature of these compounds and their unique distribution in the plant tissue. Application of organic and aqueous solvents is the most common...
method to extract antioxidant compounds from plant tissues. The extracts with electron-donating activity, can end the radical chain and change the active free radicals into more stable products.\(^{60}\)

Owing to their reducing power, antioxidant compounds reduce Fe (III) to Fe (II). This reduction could be determined through measuring the formation of blue color at 700nm.\(^{64}\) In this method, the soluble yellow color of the sample changes into green or blue, depending on the antioxidant or reducing power of the sample. A higher absorbance value displays a higher iron-reducing power.

\[
K_3\text{Fe} \left(\text{CN}\right)_6 + \text{Reductiveagent} = \text{Fe} \left(\text{CN}\right)_4^{4-} \\
\text{Fe} \left(\text{CN}\right)_4^{4-} + \text{FeCl}_3 \rightarrow \text{Fe}_4 \left[\text{Fe} \left(\text{CN}\right)_6\right]_3^{2-}
\] (9)

As observed in Figure 2, the iron-reducing activity increased as the sumac and BHT concentration increased. According the results of the present study, the ethanolic extract had a slightly better inhibitory effect compared with BHT; however, the aqueous one was approximately the same as BHT. Furthermore, the iron-reducing power and the total phenol content of the ethanolic extract were higher than those of the aqueous one. The total phenol content and the iron-reducing power are associated with each other. Reduction of Fe (III) is often used as an index for electron donating activity, which is the important mechanism for the evaluation of the antioxidant activity of phenolic compounds.\(^{65}\)

**Figure 1** The percentage of DPPH free radical scavenging by BHT and the aqueous and ethanolic extracts of Iran sumac.

**Figure 2** The reducing power of BHT and the aqueous and ethanolic extracts of Iran sumac.

**Conclusion**

Some of the physical and chemical properties of the sumac fruits of Iran as well as the antioxidant properties of its aqueous and ethanolic extracts were studied. In this study, some engineering properties of sumac fruit were measured. The average \(m_{\text{bulk}}\), bulk density and porosity percentage ranged from 15.9-16.9g, 304.6-306.7kg/m\(^3\) and 68.31-97.26\%, respectively. The galvanized sheet with the lowest static friction coefficient was the best surface for the fruit transfer. The mean length, width, thickness and volume were in the range of 4.73-4.98mm, 4.08-4.54mm, 2.33-2.51mm and 17.64-22.46mm\(^3\), respectively and the mean sphericity coefficient varied from 0.73 to 0.76. This information is of great importance for the design of the equipment of harvest, transfer and processing of sumac fruit. The present study also exhibited that the antioxidant capacity, free radical scavenging and reducing capacity of the ethanolic extract were higher than those of the aqueous one. Moreover, the ethanolic extract had a larger total phenol and anthocyanin content as compared to the aqueous one.

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**Conflict of interest**

The author declares no conflict of interest.

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