Prospects of use of *rhus typhina* l. (anacardiaceae r.br.) in food and medical industry

Nikolay A Trusov¹, Ekaterina V Solomonova², Tatiana D Nozdrina³, Vladimir N Sorokopudov⁴, Ibragim M Bamatov⁵

¹Tsytisin Main Botanical Garden of Russian Academy of Science, Moscow, Russian Federation
²Moscow educational complex WEST, Moscow, Russian Federation
³Moscow State University of Food Production, Moscow, Russian Federation
⁴Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, Moscow, Russian Federation
⁵V.V. Dokuchaev Soil Science Institute, 7, Pyzhevskiy pereulok, Moscow, 119017, Russia

E-mail: ibragim-1991@mail.ru

Abstract. Dried and powdered fruits of sicilian sumac (*Rhus coriaria* L., family Anacardiaceae R.Br.) have been used in Asian countries and some others for a very long time as seasoning (spices «sumac», «zatar»). The research is aimed at an assessment of prospects for use of fruits of staghorn sumac (*Rhus typhina* L.), growing in the middle zone of the Russian Federation, as a spice, having medicinal properties. The morphological and anatomical, dimensional and weight characteristics of *Rh.* typhina’s fruits, collected in the arboretum of Tsytsin Main Botanical Garden of the Russian Academy of Sciences (MBG RAS), having medicinal properties, were studied. The content of absolutely dry matter and vitamin C in them was determined. For comparison of biochemical parameters, seasoning «sumac» (*Rh.* coriaria), purchased on open market, was evaluated. It was established that surface of *Rh.* typhina’s fruit is covered with multicellular trichomes of two types (covering long single-row and glandular capitate on two-celled pedicle); pericarp is differentiated, its structure as a whole is similar to that, described in the literature; the content of absolutely dry matter in air-dry matter (90.5%) and vitamin C (62.0 mg%) in *Rh.* typhina’s fruits is slightly less than those for *Rh.* coriaria’s fruits– 96.5% and 64.6 mg%, respectively. Mass of 1000 fruits *Rh.* typhina (about 12 g) in MBG RAS arboretum is 1.5 times exceed the according to the literature. Thus, *Rh.* typhina’s fruits may be recommended for further study as an alternative to *Rh.* coriaria’s fruits, which are traditionally used for making spices.

1. Introduction
Since ancient times, people have begun to use various kinds of spices and seasonings, preparing them both from some mineral substances and from objects of wildlife, most often plants. Such seasonings were added to food in different ways with several purposes, including for change flavoring properties and for increase the period, during which storage and consumption of food are possible. Most widespread and development of use of different seasonings received in Asia and North Africa. One of the main reasons for this climate. All year round or almost year-round, high temperature values, as
well as humidity, remain, creating very good conditions for reproduction and vital activity of bacteria, fungi and other organisms that can cause food spoilage. Consequently, the task of maintaining the maximum duration of products freshness has always been faced by people living in these territories. One way to solve this problem was the use of spices and seasonings.

Popular spice, used mainly in Asian and Caucasian cuisines, is sumac. This spice is a burgundy-red powder, obtained by grinding fruits of sicilian sumac Rhus coriaria L., a representative of Anacardiaceae R.Br. family.

Dried and powdered fruits of Rh. coriaria have been used as seasoning in Asian countries and some others for a very long time. In countries of the Middle East, they are used both separately and as a part of popular spice mix «Zatar» [1]. Mature fruits of Rh. coriaria have been known to Europeans since the time of ancient Romans, until appearance of lemons, and were used in salads due to sour taste. Dioscorides and Theophrastus mentioned about use of these plant fruits, and Solon wrote about it in the VI century BC [2]. The spice gained such popularity not only due to sour, astringent shade of taste, which allows it to be used as a marinade or as a substitute for lemon, but also due to its pronounced preservative properties, which can greatly increase shelf life of food products. Flavor of this spice is not expressed. Sumac is used in preparation of dishes from meat (barbecue, other types of frying over an open fire), fish, rice (pilaf), in baking, as a part of salad dressings. Seasoning, which is made from sumac, is one of most powerful antioxidants, used in food [3].

In tradition medicine, the fruits of Rh. coriaria are used as an astringent, wound healing, anti-inflammatory, antidiarrheal, diuretic, for treatment of hypertension, stomach ulcers, rheumatism, hemorrhoids, leucorrhea, tonsillitis, conjunctivitis, liver diseases, burns and quenching thirst. Scientific medicine recognizes the antiviral, antibacterial, antifungal, antimutagenic, chondroprotective, hepatoprotective, cytotoxic, anti-ischemic, antifibrinogenetic, antithrombotic, vasorelaxant, hypoglycemic and leukopenic properties of Rh. coriaria. It is believed that this spectrum of medicinal properties of sumac fruits is mainly due to high content of tannins [4 - 8].

In addition, it is traditionally believed that sumac fruits have lipid lowering effect, was proved by clinical studies. It was established that Rh. coriaria increases serum apolipoprotein-A1 and high-density lipoprotein cholesterol levels: a double-blind placebo-controlled randomized clinical trial [9].

Sumac fruits – drupes, reddish-brown, spherical, small (up to 6 mm in diameter), pubescent by dry and glandular trichomes, contain one seed. Pericarp is three-layered. Exocarp is monolayer, its cells have thickenings with pitted surface. Mesocarp is parenchymal, contains vascular bundles, oil-containing cavities and receptacles, surrounded by sclereides, the inner layer is formed by small cells with large calcium oxalate crystals [10]. The mesocarp of Rhus typhina L. consists of 5-6 layers of parenchymal cells, the lower layers are often destroyed, and 1 layer of isodiametric sclereides [11]. Endocarp is four-layer: between two layers of large palisade cells, with thickened cell walls, there are a layer of small palisade cells, with thickened cell walls, and a layer of microsclereides. Sometimes the outer palisade is represented by two layers. Cells of the inner layer are small; their cell walls have spiral thickenings. Cells contain calcium oxalate crystals. Seed coat is two-layer [12].

The natural habitat of Rh. coriaria is quite wide: Southern Europe, North Africa, Near and Middle Asia, including the Crimean Peninsula, the Caucasus and Pamir-Altai mountains.

The plant cannot be grown under conditions, where temperature drops to -20°C [13]. Thus, its cultivation in the middle zone of the Russian Federation is impossible.

It is also known, that in the arboretum of Tsytysin Main Botanical Garden of the Russian Academy of Sciences (MBG RAS) another species of sumac Rh. typhina has been introduced since 1938. In severe winters plants freeze, but quickly recover. They bear fruit annually, from 6 years old [14]. According to the literature, diameter of Rh. typhina’s fruits is up to 4 mm; their number in 1 kg is 130 thousand. The natural habitat of staghorn sumac is the north-eastern part of North America.

Traditionally, the Rh. typhina’s fruits were used in preparation of pies and refreshing lemonade-like drinks [15].
Rh. typhina’s fruits is used in traditional medicine as an astringent and blood-purifying agent, for angina, diarrhea and enuresis [16, 17]. Studies have confirmed the antibacterial, antifungal, antioxidant and antiproliferative properties of the Rh. typhina fruits [18 - 20].

Currently, Rh. typhina is considered mainly as ornamental plant for temperate climate [21, 22].

The aim of this study is an assessment of prospects for use of Rh. typhina’s fruits, growing in the middle zone of the Russian Federation, as a spice, with medical properties.

2. Material and methods
The morphological and anatomical, dimensional and weight characteristics of Rh. typhina’s fruits, collected in the arboretum of the MBG RAS, were studied. The content of absolutely dry matter and vitamin C in them was determined. For comparison of biochemical parameters, seasoning «sumac» (Rh. coriaria), purchased on open market, was evaluated.

The material for morphological and anatomical studies was fixed in a 70 % ethanol solution. The longitudinal and transverse sections of fruit were performed manually using a Gillet razor blade. The water and glycerin unpainted preparations made from them were studied with the use of a Biolam LOMO light microscope with camera attachments as light modifiers. The observation results were documented by the pictures taken using a Canon EOS 650D camera with a Sigma 150 mm 1: 2.8 APO Micro DG HSM macro lens.

The morphometric parameters of the objects (the fruit length and diameter) were measured using calipers at the most prominent points on their surface.

The content of air-dry and absolutely dry matter in fruits was investigated on the standard methodology [4]. The samples were weighed on an electronic Pocket scales ML-A03, ground in an electric grinder (ECMO model IPZO) and dried in a SUPRA DFS-211 drying oven. Due to the fact that Rh. typhina’s fruits are very light, they were weighed by 5 fruits, in 30-fold repetition.

The content of ascorbic acid in air-dry fruits was determined by the iodometric method in accordance with GOST 7047-55 by the titrating with a potassium iodide solution (KIO3) of the samples of plant raw material hydrochloric extracts (2 % HCl) mixed with the 1 % potassium iodide solution and 0.5 % starch solution [23].

The number of counting repeats was not less than 4 in the experiments. All the obtained material was processed by the methods of variation statistics [24]. The chemicals were commercially available as pure chemicals.

3. Results and discussion
Rh. typhina’s fruits, collected in the arboretum of the MBG RAS, are spherical in shape, about 4 mm in diameter (figure 1, b, c), which corresponds to the according to the literature [25]. Infructescence contains about 400 fruits on average (figure 1, a).

Figure 1. The infructescence and fruit of Rhus typhina in the MBG RAS arboretum. a – the infructescence of Rhus typhina; b – the plan view of the fruit of Rhus typhina; c – the side view of fruit of Rhus typhina; f – fruit; p – peduncle; s – sepal. Scale bar A – 1 mm, B-C – 0.1 mm.
The mass of 5 Rh. typhina’s fruits is 0.0607 ± 0.0051 g (M ± tm)

A coefficient of variation (V) amounts to 22.46 % (high variability of parameter), experience accuracy indicator (P) – 4.1 % (reliability of research results). The mass of 1000 fruits are about 12 g. When recalculating of the literature data on number of fruits of staghorn sumac in 1 kg [21], it turns out, that the mass of 5 Rh. typhina’s fruits is 0.038 g, which is almost 1.5 times exceed than at the according to the literature.

The surface of Rh. typhina’s fruit is tuberous, covered with trichomes of two types: 1 – covering, multicellular, single-row, long (aerial surface hairs) (figure 2, c); 2 – glandular, capitate, multicellular, small, on two-cell pedicle (glandular trichomes) (figure 2, d). In the literature, the pedicle of the glandular hairs of Rh. typhina is described as three-celled [26].

Figure 2. Anatomical structure of the pericarp of Rhus typhina in the MBG RAS arboretum (cross-sections). a, b – the pericarp of Rhys typhina; c – the aerial surface hairs of Rhus typhina; d – the glandular trichome of Rhus typhina. aeresch – aerial surface hairs; coxc – calcium oxalate crystal; end – endocarp; ex – exocarp; gt – glandular trichome; mes – mesocarp. Scale bar A – 1 mm, B-D – 0.1 mm.

The pericarp of Rh. typhina is three-layered (figure 2, a, b). Exocarp is single-layered, consists of small cells with thickened cell walls. Mesocarp is from 7-8 layers of parenchymal cells. Conducting vascular bundles, oil-containing receptacles, surrounded by sclereides, are observed in it. The inner layer is formed by small cells with large crystals of calcium oxalate. Such structure of mesocarp is typical for majority of representatives of the genus. The layer of isodiametric sclereides was not found by us. Endocarp is six-layered, consists of layer of large palisade cells, layer of small rounded cells with thickened cell walls, layer of small cubic cells, layer of cells with thickened cell walls (sclereides), layer of small palisade cells, two layers of large palisade cells. In general, the structure of endocarp is similar to that, described in the literature [10].

According to biochemical studies, in Rh. typhina the content of absolutely dry matter in air-dried fruits is 90.5 %, which is slightly below this indicator in crushed spice «sumac» Rh. Coriaria – 96.5 %. The content of ascorbic acid is comparable, but also slightly lower in Rh. typhina’s fruits – 62.0 mg%, against 64.6 mg% in Rh. coriaria’s fruits.

4. Conclusions
Rh. typhina grows well, abundantly and annually bears fruit in conditions of the middle zone of the Russian Federation. Its fruits have antibacterial, antifungal, antioxidant and antiproliferative properties. The weight of 1000 fruits are about 12 g, which is 1.5 times exceed than at the according to the literature. The diameter of fruit of staghorn sumac is about 4 mm. The pericarp is differentiated, its structure as a whole is similar to that, described in the literature. Long single-row multicellular covering trichomes (aerial surface hairs) and glandular capitate multicellular trichomes on a two-celled pedicle (glandular trichomes) are described. The content of absolutely dry matter in air-dry matter (90.5 %) and vitamin C (62.0 mg%) in Rh. typhina’s fruits is slightly less than those for spice «sumac» Rh. coriaria – 96.5 %
and 64.6 mg%, respectively. Thus, Rh. typhina’s fruits may be recommended for further study as an alternative to spice, having medicinal properties, which is obtained from Rh. coriaria’s fruits.

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