

Rhus coriaria (Sumac): A Magical Spice

Thukaa Zuhair Abdul-Jalil

Abstract

Rhus coriaria L. (Sumac) has been used as folk medicine since ancient times. *Rhus* genus has over 91 of accepted species names in the Anacardiaceae family, *Rhus coriaria* L. is the only species in Iraq that growth wildly and/or cultivated near the villages in the north of Iraq. It has a characteristic taste and morphological features, making it to be considered as one of the popular flavoring spice, drink, appetizer, and as acidulant in food recipes, in addition to its role as plant medicine. A scrutiny of literature revealed some notable pharmacological activities of the plant such as antioxidant, anti-ischemic, antimicrobial as well as hypoglycemic and hypolipidemic effects. This chapter attempts to comprise the published obtainable literatures on *Rhus coriaria* with respect to its pharmacognostic characters, ethanobotanical/traditional uses, chemical constituents and summary of its various pharmacological activities, clinical effects, functional food industries and dentistry.

Keywords: spices, *Rhus coriaria* L., traditional uses, chemical constituents, pharmacological activities, functional food industries

1. Introduction

The old say of “Let food be the medicine and medicine be the food,” by Hippocrates over 2500 years ago is gold shinning of the era today, as food interesting personals (scientist, suppliers and consumers) get the point of benefits for specific foods which have ingredients aiding some body functions as do improve health well-being [1].

From historic ages the discovery of spices had main role in the lifestyle of people in the old world. Spices are used for flavoring and coloring as do for food preserving for many millenniums as do its possession of medicinal properties using them in the traditional medicine has been authenticated since ancient times [2]. Today, spices are upgrading not only for their culinary properties but also for their potential health properties, as the advancement in its uses and acknowledgement of their chemistry, active constituent's pharmacodynamics/kinetics and health benefits affecting their investigation thoroughly in last decades. Hundreds of the adjuncts for food had been identified and authenticated by pioneering their health effects by observing research's on animals and human trials for them [3].

Sumac is the widespread name of the *Rhus* genus, which composes 91 of accepted species names in the Anacardiaceae family, represented in Iraq by one species namely *Rhus coriaria* L. which grow wildly and/or cultivated near the villages in the north of Iraq [4]. The “Sumac” name is derived from “summāq”

that refer to “dark red” in Arabian and henceforth applied for the spice product of *Rhus coriaria* which had been utilized in spice mixtures in the Asian traditional medicines since ancient times [5].

Sumac had been implicated as a condiment spice in both pure and combination form spices. In Iraq, traditionally used with famous Iraqi meat dishes like Kabab, grilled meat as well as over salads served with them [4]. The *Rhus coriaria* extracts researched properties up-to-date revealed a promising potential furnishing renewable bio-products with desirable bioactivities like antimicrobial, antifungal, antiviral, antimalarial, antimutagenic, antioxidant, antimigratory, anti-ischemic, hypoglycemic and hypolipidemic affections [6].

In this chapter, a workup had been done to encompass the published literatures dealing with *Rhus coriaria* focusing on its pharmacognostic characters, ethanobotanical/traditional uses, and chemical constituents with summarizing its health promoting activities, clinical effects, applied functional foods industries and dentistry.

2. Taxonomical classification

Kingdom: Plantae
Sub kingdom: Tracheobionta
Super division: Spermatophyta
Division: Magnoliophyta
Subclass: Rosidae
Order: Sapindales
Family: Anacardiaceae
Genus: *Rhus*
Species: *Rhus coriaria* Linn
Vernacular Names.

Sumac (fruit of *Rhus coriaria* Linn) is known by different names worldwide including:

Persian: Samaka, Samak, Sumaq
Hindi: Tatrak, Tatri
Arabic: Timtima, Tamtam, Sumak, Sumac
Urdu: Sumaq
English: Sumach, Sumak
Bengali: Sumok
Kashmiri: Samak [7].

3. Habitat and distribution

The plant is wildly and/or cultivated in temperate and tropical regions of the continents with ability to grow on river sides lands. *Rhus coriaria* have superficial pervasion roots that can decrease ground drift and can be implanted on poorly eroded soils. Sumac commercially grown type is *Rhus coriaria* in the Mediterranean and Middle East, had been cultivated for several centuries to produce a material of high quality for tanning, also wildly in the territories from the Canary Island to the Mediterranean beaches to Afghanistan as it is municipal to the Mediterranean and the Southeastern territory of Turkey [6, 8]. While in Iraq, it's mostly found in North, North East and North West of it in areas of an altitude more than 540 m

above sea level. Most researches with sumac interest say that *Rhus coriaria* grow in mountain environments especially in Amadia, Sinjar, Rawandowz and Sulimania which are the most prevalent territories [4].

4. Botanical description

Rhus coriaria is a small tree (shrub) with a height of up to 10 m (**Figure 1a**), its leaves are spirally coordinated with pinnately compound, with trifoliate or simple leaves in some species (**Figure 1b**). Its flowers are in spikes or dense panicles of 5–30 cm long, usually very small, with different colors (greenish, creamy white or red), with five petals (**Figure 1c**). It has small dark brown, laterally compressed

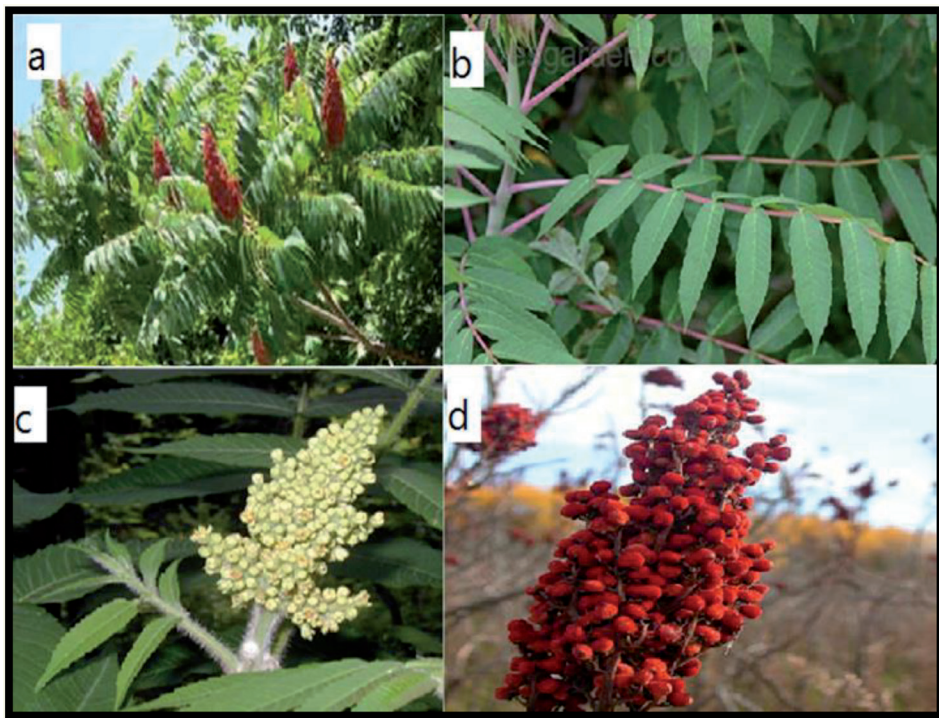


Figure 1.
Photo of *Rhus coriaria* different parts: (a) shrub; (b) leaves; (c) flowers and (d) fruits.

hard and hairy drupe fruits of diameters (length 3.5–4.0 cm and width 2–2.5 cm) permanent calyx, configuring dense panicles of reddish drupes clusters (**Figure 1d**) called sumac. The dried clusters are usually ground to produce a tangy purple spice. The seeds are little hard, brown colored with diameters (length 0.3–0.5 cm and width 0.2–0.3 cm) and good odor spicy [5, 6, 9].

5. Ethanobotanical and traditional uses

Rhus coriaria is a natural traditional medication fountain in many world dietary cultures, it is seasoning and flavoring used agent as a main pole in the municipal

traditional remedies all over the globe. *Rhus coriaria* is a tempting ancient cooking in and over foods. About 2000 years ago, the “De Materia Medica” (“Of Medical Matters”) a voluminous Greek physician book by the Pedanius Dioscorides (40–90 A.D.) had between its folds plentiful healthy merits of Sumac, mainly described as an anti-flatulent, stomach tonic and a diuretic. *Rhus coriaria* has been used commonly in the remedy of ulcer, anal piles, hepatic disease, diarrhea, animal bites, and pain management. Also for treatment of pharynx cold inflammations and seizing hemorrhage like hematemesis, hemoptysis, hemorrhoids and dysentery, it had been prescribed for ocular diseases like conjunctivitis, leucorrhea and ophthalmia. Conventional medicinal practice use *Rhus coriaria* for cholesterol reduction and in gynecology as an abortifacient. Others also report its use in improving wound healing and as an antimicrobial. Different parts of *Rhus coriaria* had been used in different recipes in indigenous herbal medicine.

Rhus coriaria bark powder is an effective teeth cleaning agent, while its infusion is useful in viral eye infections treatment while the water bruised is applied on the forehead for the first-aid treatment of epistaxis. Powdered fruits are sparsed on boiled eggs and eaten for the treatment of diarrhea. A fruits decoction is set and given orally (150 cc) trice daily for the treatment of hepatic diseases, urinary system disorders and diarrhea till improvement occurs [5, 6, 9–11].

6. Chemical constituents of *Rhus coriaria*

Until now, over 200 compounds have been identified from the *Rhus coriaria* and most of them are physiologically active. These chemical constituents can be assigned to various classes of the hydrolysable tannins, phenolic acids, conjugated phenolic acids, anthocyanins, flavonoids, organic acids, coumarins, xanthenes, terpenoids, steroids, essential oils, and other groups of constituents have been reported. Summarization of the proportion of different chemical constituents of *Rhus coriaria* is shown in Figure 2 [12].

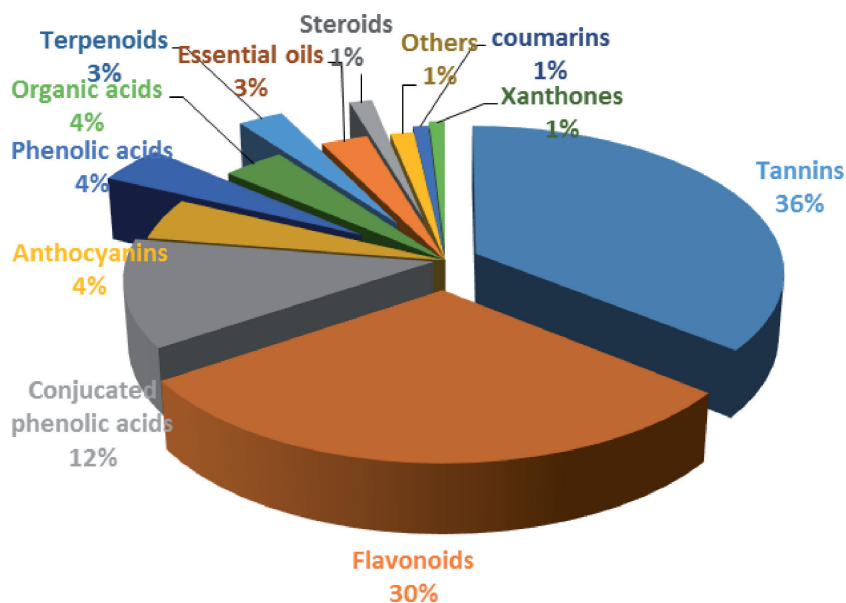


Figure 2. Different subtype's comparison of the 200 constituents reported from *Rhus coriaria*.

Several phytochemical investigations for the constituents of *Rhus coriaria* and different part of the plant had been studied. Fruits are the most well researched part in which most of the chemical constituents had been detected. *Rhus coriaria* parts like leaves and seeds were also documented to hold a number of phyto-constituents as shown in **Table 1**.

Classes	Some important phyto-constituents	Parts of plant
Hydrolysable tannins	Gallic acid, methyl gallate, digallic acid, tri-gallic acid, ellagic acid, galloylhexose, O-galloylnorbergenin, O-galloyl arbutin.	Fruits ,leaves, seed
Phenolic acids	Protocatechuic acid syringic acid coumaryl-hexoside, caffeoylquinic acid <i>p</i> -benzoic acid, vanillic acid.	Fruits
Conjugated phenolic acids	Galloyl-hexose-malic acid, digalloyl-hexose malic acid, kaempferol hexose-malic acid, Myricetin-hexose malic acid, quercetin-hexose malic acid. Isorhamnetin hexose-malic acid	Fruits
Anthocyanins	Cyaniding, peonidin, pelargonidin, petunidin, coumarates, delphinidin, Myrtillin and cysanthemin.	Fruits
Flavonoids	Quercetin, Isoquercitrin, quercitrin, Rutin, Kampferol, Myricetin ,apigenin Isorhamnetin, isovitexin, rhamnetin, ampelopsin	Leaves, fruits, seed
	Isoflavonoids: Glycitein-O-glucoside, oxoglycyrrhetinic acid.	Fruits
	Flavonoid dimers Amenthoflavone,agathisflavone ,hinokiflavone and sumafavone	Fruits, leaves
Organic acids	Malic acid, Citric acid, Tartaric acid, Linoleic acid, Oleic acid, Linolenic acid, Palmitic acid and Stearic acid	Fruits ,Seed
Coumarins	Umbelliferon	Fruits
xanthoness	2, 3-dihydroxy-7-methyl xanthone, 2, 3, 6-trihydroxy-7-hydroxymethylene xanthone-1-carboxylic acid and 2- methoxy- 4- hydroxy-7-methyl-3-O-beta-D-glucopyranosyl xanthone-1, 8-dicarboxylic Acid.	Seeds
Terpenoids	betunolic acid, A-tocopherol ,tocopherol mannoside, farnesylacetate, pentadecanal, hexadecanal, , deacetylforskolin, Oxoglycyrrhetinic acid	Leaves, Fruits
Steroids	β - sitosterol	Fruits, seed
Essential oils	(E)-Caryophyllene ,n-nonanal , cembrene, α -pinene (2E,4E)-decadienal nonanoic acid, (2E)-decenal, p-anisaldehyde, (Z)-2-decenal and caryophyllene oxide	Fruits
Others		
Butein	chalconoid derivative	Fruits
Minerals	Potassium, calcium, magnesium ,sulfur, cadmium, phosphor, lead, titanium, vanadium, copper, silicon, barium, chromium, lithium, brome, aluminum, chloride, manganese, iron, sodium, zinc, strontium, and nitrogen	Fruits

Table 1.
 General reported phyto-constituents of *Rhus coriaria* and their parts of plant [12–22].

7. Health promoting activities of *Rhus coriaria*

Rhus coriaria is an important flavoring spice with a wide range of health promoting activities (**Figure 3**). The plant exhibits antimicrobial, antioxidant, hypoglycemic, hypolipidemic, antimutagenic, antimigratory and anti-ischemic activities which are presented below.

7.1 Antimicrobial activities

Rhus coriaria poses antimicrobial activity against various bacterial and fungal species. Radmehr and Abdolrahimzade revealed the effectiveness of ethanol extract of sumac decreasing the minced meat total microbial count and salmonella, in which a potential antimicrobial significance was shown compared to controls [23]. Motaharinia et al. also examined the plant extract's antibacterial activity against *Brucella*, in which the MZG (mean zone of growth) inhibition for *Rhus coriaria* containing disks of 40 mg/ml was 22.55 mm, and MIC (minimum inhibitory concentration) of 3.26 mg/ml, while the MBC (minimum bactericidal concentration) was 9.03 mg/ml [24]. Furthermore, Shabir demonstrated an important *Rhus coriaria* fruit methanolic extract antibacterial activity against four different bacteria *Bordetella bronchiseptica*, *Bacillus pumilus*, *Staphylococcus epidermidis*, and *Klebsiella pneumonia*, utilizing agar well-diffusion method [10]. Kirmusaoğlu et al. evaluated in their study the *Rhus coriaria* antibacterial effect on the *Staphylococcus aureus* biofilm formation where significant differences between varying concentrations of extracts on several strains of methicillin resistant/sensitive *Staphylococcus aureus* were observed leading to the dose-related plant extracts diminishes the slime formation noted in bacteria with a clue that reduction of the biofilm formation which is a cornerstone playing factor in staphylococcal infections can be done with them [25]. Ali-Shtayeh et al. compared in their study the antimicrobial activity of *Rhus coriaria* among the 50 Palestinian medicinal plants against acne vulgaris, It was revealed from their result that the ethanolic extract of *Rhus coriaria* show a hard evidence inhibitory effect and found to be between the main active plant

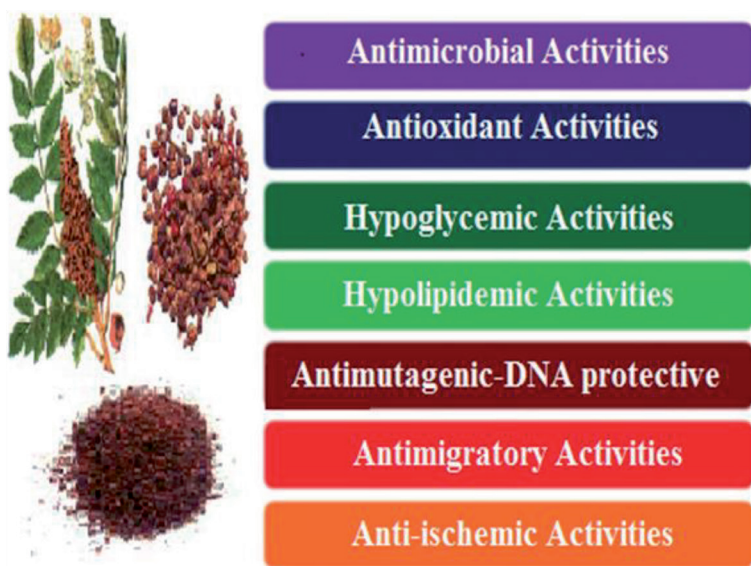


Figure 3.
Different health promoting activities of *Rhus coriaria*.

extracts against most bacterial strains tested including, *P. acnes*, and Gram-negative strains of aerobic bacteria [26]. Raodah et al. studied the *Rhus coriaria* extracts antimicrobial activity against three Gram-negative and three Gram-positive strains. The *Bacillus subtilis* was the most sensitive Gram-positive with MIC of 0.5 mg/ml, while higher concentrations of sumac were needed against Gram-negative bacteria with extracts concentrations ranging 10–20 mg/ml. Among bacteria, the inhibitory effects were shown to have positive relationship as an increased of *Rhus coriaria* fruit extracts concentration from 0.1 to 20 mg/ml lead to increasing the inhibitory effect [27]. It is valuable to mentioning that in vitro antimicrobial activity of *Rhus coriaria* extracts has been strongly suggested to the presence of tannins [28].

From another point of view, studies achieved on antifungal activity revealed that the alcohol extract of *Rhus coriaria* own a high antifungal activity to *Candida albicans* which is contributed to presence of coriariaic acid, coriorianaphthyl ether and coriarianthracenyl ester in plant seeds [18, 29].

7.2 Antiviral activity

Monavari et al. manifested in their study that the *Rhus coriaria* aqueous extract show a potentially activity against viruses like adenovirus type 5 and HSV-1 at non-toxic concentration [30]. This activity related to presence of biflavones in *Rhus coriaria* leaves and fruits [5].

7.3 Antioxidant activity

Several studies have proven antioxidant activity of *Rhus coriaria*. Shafiei et al. studied the antioxidants and free radical scavengers as well as lipid peroxidation inhibition effects of methanol *Rhus coriaria* fruits and also indicated chronic diseases prevention such as atherosclerosis by the plant extract [31]. Aliakbarlu et al. demonstrated in their study the antioxidant potential ability of *Rhus coriaria* aqueous extract among other spices. Their study outcomes revealed that the aqueous extracts of the plant exhibit one of the highest antioxidant potential among the extracts studied [32]. *Rhus coriaria* is proved to have a significant antioxidative property due to its richness in phenolic compounds, especially, gallic acid and its derivatives [33]. Gabr et al. demonstrated that phenols derived from *Rhus coriaria* fruits had strong scavenging activities in vitro on β -carotene-linoleic acid and 2,2-diphenyl-1-picryl-hydrazyl-hydrate (DPPH) scavenging power assessment when compared to glycosides, alkaloids and terpenoids respectively [34].

The antioxidant capacities of ripened fruits of *Rhus coriaria* were estimated using DPPH and vanishment of dark violet color assays by Mahdavi et al. Their study revealed that *Rhus coriaria* had relatively high antioxidant capacity [8].

7.4 Hypoglycemic activity

The hypoglycemic activity of *Rhus coriaria* has been studied by numerous research groups. Mohammadi et al. studied the role of the ethanol extract of *Rhus coriaria* fruits upon glycaemia homeostasis and insulin resistance using alloxan induced diabetic rats as a model and significant hypoglycemic activity was observed [35]. Anwer et al. evaluated the effect of *Rhus coriaria* methanol extract on rats with diabetes mellitus non-insulin-dependent type. According to them, methanol extract of *Rhus coriaria* plant is able to improve insulin sensitivity, delaying the hyperinsulinemia onset and glucose intolerance [36]. In the first clinical trial, the effects of *Rhus coriaria* fruits in type 2 diabetic patients on the resistance of insulin, high sensitive CRP, malondialdehyde, and paraoxonase 1 activity were evaluated by Rahideh

et al., presuming that daily intake of 3 g *Rhus coriaria* for 3 months may have a beneficial outcome on patients with diabetes mellitus decreasing their susceptibility for cardiovascular disease [37]. From all of above, the penta-galloylglucose (gallo-tannins) which was frequently conveyed in *Rhus coriaria* plant announced to have an antidiabetic effect, manifesting their activity by inhibiting the PTP1B enzyme [38].

7.5 Hypolipidimic activity

Many researches in this field indicated the positive effects of *Rhus coriaria* consumption on blood cholesterol level in animals and human beings. Their results showed the significant reduction in the triglyceride, cholesterol and low density lipoprotein-cholesterol (LDL) levels with protective effect against some risk factors caused by tissues fat overflow stress such as atherosclerosis, oxidative stress and hepatic enzymes dysfunction [31, 39–41].

7.6 Anti-mutagenic and DNA protective activity

Chakraborty et al. suggested the strong *Rhus coriaria* DNA migration reduction after 30% H₂O₂ treated cells. Endogenous production of oxidized pyrimidines and purines due to DNA-migration also decreased significantly by 36 and 52% respectively, especially in hepatic and lymphocyte damage which was the most significant decrease as the *Rhus coriaria* exhibit a protection capability against genotoxic carcinogens that are degraded by specific enzymes, specifically the GST (glutathione S-transferase), GST- α and GST- π which were enhanced by 40, 52 and 26% sequentially [33].

7.7 Anti-migratory activity

Zargham and Zargham demonstrated anti-migratory activity of *Rhus coriaria* fruits extract on rat carotid vascular smooth muscle cells using transmembrane migration assay. The biological assay showed that *Rhus coriaria* extracts considerable vascular smooth cell migration reduction by 62%, thus owning a strong anti-migratory potential, with a possible atheroprotective activity [42].

7.8 Anti-ischemic activities

The cardiovascular protective effect of *Rhus coriaria* leaves extracts was evaluated by measuring different factors such as RFS (free radical scavenging), TNF- α (tissue necrosis factor- α) inhibition, cyclooxygenase pathway activation and NO (nitric oxide) endothelial synthase activation in isolated rabbit heart and thoracic aorta preparations by Baretta et al. Their results suggest that *Rhus coriaria* possesses interesting substances (hydrolysable gallotannins) which act as anti-ischemic agents [43].

The neuroprotective and anti-neuroinflammatory properties of *Rhus coriaria* ethanol fruits extract was assessed against ischemic optic neuropathy in mice by Khalilpour et al. with outcomes providing a hard evidence scientific cornerstone for the neuroprotective activity of the ethanol *Rhus coriaria*, identifying linoleic acid as one of the main constituents responsible for such effect and leading the way for new treatment windows for optic neuropathy [44].

8. Applications of *Rhus coriaria* in food industrial safety and technology

There is a rising care for plant extracts investment in lipid oxidation control by natural preservatives in food industry as till now collected data goes with the

application of *Rhus coriaria* as an oily foods natural antioxidant [45]. The plant extract had been used to enhance sausage total quality by preventing lipid oxidation, as it is more effective when compared with BHT (butylated hydroxytoluene) that has a carcinogenic and toxic properties, plant extract enhances the parameters of the fermented sausage quality [46]. Aqueous extracts of *Rhus coriaria* exhibit a powerful antibacterial activity with antioxidant power against pathogenic food-borne bacteria assuming their use as effective and natural industrial food preservatives [32], and these are also very useful delaying the food taste and aspect deterioration by the oxidative process [46].

An Italian study, Perna et al. had cogitate the sumac leaves powder application as a fortifier in the yogurt milk of goat taking the advantage of its antioxidant property. The *Rhus coriaria* goat milk fortified yogurt revealed a considerable increase in total phenolic compounds as compared with non- fortified goat milk yogurt. This raise the potential capability of using goat milk for the commercial production of the fermented fortified products allowing the evolution of nutraceutical fortified foods [47].

The antimicrobial growth properties of extracts in food are similar to the synthetic ones commonly used in food industry for the prevention of food microbiological degradation with quality maintenance and shelf life for more time [48].

The food additives were banned in many countries manufacturing and trading legislations, thus making the *Rhus coriaria* extracts one of the good alternatives for food decontamination compensating for banned synthetic and chemical antimicrobials used due to its properties of low prices, natural and as a safer alternative product increasing the shelf life and maintaining its quality with a good color in the score of sensory evaluation in the poultry processing [49]. Also the pure extract powder of the *Rhus coriaria* added carrier (maltodextrin) had been developed for spray drying [50]. Sumac had been used in feed additive in laying and broiler chicken to improve their quality [51].

Rhus coriaria use as colorant, as the sumac anthocyanins (main phenolic compound) are considered one of the pigmenting compounds in it with stability, are increased by intermolecular pigmentation after other polyphenolic addition interacting without covalent bond formation with the molecules preventing the nucleophilic attack by water molecule, making a more stable water mixed colorant agent extract [52].

9. Applications of *Rhus coriaria* in dentistry

Rhus coriaria is documented by many researchers to be a very food industry versatile material that is used in many fields leading the way for its use in other industries because of its components in the powder, aqueous and methanolic extracts that can be integrated in a wide ranged industrial fields to treat steel greenish color inhibition in moist environment like that in the mouth. This phenomenon attributed to specific ingredients found in sumac, which have the capability to adsorb with the steel metal ions forming ferrous organic molecule complexes [53]. Furthermore, this property of *Rhus coriaria* has a role in the medicinal applications such as a natural anticariogenic in the dentistry, as the aqueous extract has the ability to reduce the orthodontic wire bacterial biofilm formed on by the pathogenic bacterial species like: *Streptococcus sanguinis*, *Streptococcus sobrinus*, *Streptococcus salivarius*, *Streptococcus mutans* and *Enterococcus faecalis* [54]. *Rhus coriaria* also has the ability to decrease dental biofilm formation by *Streptococcus mutans* through the three GTF genes down-regulation without the suppression of the buccal bacteria growth [55].

10. Conclusions

Rhus coriaria is an important resourceful plant (Magical spice) in modern era due to its promising functional ingredients for nutraceuticals potential sources with various desirable medicinal properties and bioactivities with a reliable application of *Rhus coriaria* pharmacology and functional food preservative industries. There is consensus about its broad spectrum of biological activities as evident from this chapter. It possesses a broad range of phytochemical constituents such as hydrolysable tannins, phenolic acids, conjugated phenolic acids, anthocyanins, flavonoids, organic acids, coumarins, xanthenes, terpenoids, steroids and essential oils demonstrated that it possess antimicrobial, antioxidant, hypoglycemic, hypolipidemic, antimutagenic, antimigratory and anti-ischemic activities. Overall contradicting evidence exist on the role of *Rhus coriaria* as a magical spice in the food industry as do for pharmaceuticals, playing a role that needs further delineation with encouraging evidence for its modulation needing further elucidation in human studies getting use of its synergizing effects in multiple fields making usefulness of its properties.

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