Food Science and Engineering
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Review

A Focused Insight into Sumac: Biological, Chemical, Health Benefits and Its Applications in Food Industry

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Received: 30 March 2023; **Revised:** 3 July 2023; **Accepted:** 5 July 2023

Abstract: Sumac Spice is a tangy red-purple powder produced by drying and grinding the hairy clusters of sumac fruit. It is often used in several regions to add a lemony and astringent taste to many dishes. Sumac is considered a valuable plant that governs nutritious elements such as proteins, unsaturated fatty acids, dietary fibers, minerals, vitamins and many polyphenols. Its phenolic content contributes to activating its medical and therapeutic role. Traditionally, sumac was effective in treating several health issues for centuries. Recently, many studies have proven that it has an antibacterial, antiviral, anti-inflammatory, antioxidant, anticancer, cardioprotective, hypolipidemic and hypoglycemic activities. Sumac has succeeded in making its mark in the field of the food industry since it was utilized as a natural food additive such as a preservative, antioxidant and colorant in various food products. It successfully boosts the quality of different food items such as bread, meat, dairy products, tomato paste, barley soup, peanut oil and shrimp. In total, sumac spice is not only a nutritious spice that adds a distinctive taste to many dishes, but also when incorporated in food industry it meets the consumer concern for the "natural label" food products, as well as its valuable role in disease prevention and health promotion.

***Keywords*:** sumac, spice, medicinal plant, food industry, antioxidant, preservative

1. Introduction

Sumac is one of the plants that is used in pharmacology and medicine beside being a tasty spice [1]. Sumac plant could be easily cultivated in moderate regions. Sumac fruit is grounded to obtain red-purple powder that adds a lemony taste to many traditional dishes [2]. It is considered a nutritious spice that contains many nutritious elements such as proteins, unsaturated fatty acids, fibers, vitamins and minerals [3]. Moreover, it consists of plenty forms of phenolic acids and flavonoids which enrich the spice and contribute to activate its medical and therapeutic role [4]. Sumac has been proven to be effective in preventing and treating many health issues. Many studies proved that sumac has antibacterial, antiviral, anti-inflammatory, antioxidant, anticancer, cardioprotective, hypolipidemic and hypoglycemic activities [2]. In addition, it shows to be an important support in relieving neurodegenerative disorders [5], hepatic fibrosis, fatty-liver diseases [6], diarrhea [7], obesity [8], dental caries [1, 9] as well as accelerating wound healing [10]. In food industry, sumac was utilized as a natural food additive, where it was used as natural antioxidant [11], preservative [12] and colorant [13] in different food products. Sumac was applied to bread, meat and dairy products

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and advantageously boosts their qualities. It was also incorporated into tomato [14], tomato paste [15], carrot juice [16], barley soap [17], peanut oil [11] and shrimps [18] and beneficially affect their qualities. As an innovative application, adding sumac to mayonnaise might have positive influence on mayonnaise quality and might add value, excitement and variety to existing mayonnaise products. Recently, sumac has been also used as biodegradable and eco-friendly active food package [19].

This review aims to congregate the chemical and physical properties of sumac, its health benefits and its applications in food industry. It illustrates how it was utilized as natural additive in various food products.

2. Sumac plant overview

Sumac fruit has an outstanding reputation in the world of condiments and spices [20]. Its scientific name is *Rhus coriaria* L., where the *Rhus* genus is classified under the cashew family (Anacardiaceae) that conjoins over 90 species of flowering plants [4]. Sumac extensively grows in Turkey and also is abundant in the Middle East, Asia, Africa and Europe [3]. It can be easily planted in moderate and tropical areas and might grow in poor soils and beside the rivers [2]. Sumac plant is a shrub that might reach 3-4 m in height [21]. Sumac leaves are simple or trifoliate, its flowers are in spikes with different colors (green, creamy white or red) and its fruit (edible part) is reddish hairy clusters that are dried and grounded to produce the tangy red-purple powder "Sumac" [2]. Powdered sumac is often used as a spice in several regions to add a lemony and astringent taste to many dishes such as salads and grilled meat (Figure 1) [9].

Figure 1. (a) Sumac plant, (b) Dried reddish hairy clusters of sumac fruit, (c) dried and grounded sumac powder (Image taken in Sohmor, Lebanon 2023)

3. Properties of sumac plan

3.1 *Sumac chemical analysis*

Sumac is a valuable plant that governs nutritious elements such as proteins, unsaturated fatty acids, dietary fibers, minerals, vitamins and many polyphenols [22]. Dried sumac fruit might contain ~2.45% protein, 1% essential oil,

~18.4% fiber, ~2.1% ash, 63.8% water-soluble extract, 17.4% fatty oil [23], 10.6% moisture, 4.6% acidity, pH 3.7 and energy 147.8 Kcal/100 g [3]. Minerals detected in sumac are calcium, phosphorus, potassium, magnesium and iron [24]. Sumac comprises of several organic acids such as fumaric, citric, tartaric and malic acids that are responsible for its sour taste. It also constitutes of variant fatty acids such as linoleic, linolenic, myristic, palmitic, oleic, stearic and palmitoleic acids. Sumac is considered a good source of vitamins such as thiamin (B1), riboflavin (B2), nicotinamide (precursor of B3), pyridoxine (B6), biotin (B7), cobalamin (B12), and ascorbic acid (vitamin C). Sumac has plentiful forms of phenolic acids such as gallic, ferulic, gentisic, P-coumaric, chlorogenic, caffeic, cinnamic, vanillic, P-hydroxybenzoic, anisic, sinapic, syringic and benzoic acids, and many flavonoids such as syringaldehyde, vanillin, kaempferol, pyrogallol, epicatechin, taxifolin, quercetin, isorhamnetin, apigenin and catechin [4]. The phenolic content of sumac increases as the fruit gets more ripened. The red color of the ripened fruit reflects its high content of anthocyanidins [25]. Most constituents were detected in sumac fruit, however other parts of the plant such as seeds and leaves also contain a number of phytoconstituents [2]. Over 200 elements were detected in sumac extract to be classified as an abundant source of bioactive phytochemicals. That explains the old and present applications of sumac as a food spice, as well as in health, nutrition and pharmacology [26]. Some important constituents detected in sumac are presented in Table 1.

Table 1. Some important phytoconstituents detected in sumac (Rhus Coriaria L.) [2, 4, 24]

Class	Some Important Phytoconstituents
Phenolic acids	Gallic, ferulic, gentisic, P-coumaric, chlorogenic, caffeic, cinnamic, vanillic, P-hydroxybenzoic, anisic, sinapic, syringic and benzoic acids
Flavonoids	Syringaldehyde, vanillin, kaempferol, pyrogallol, epicatechin, taxifolin, quercetin, isorhamnetin, apigenin and catechin
Tannins	Gallic acid, methyl gallate, di-gallic acid, tri-gallic acid, ellagic acid, galloyl hexose, o-galloyl arbutin
Anthocyanins	Cyaniding, peonidin, pelargonidin, petunidin, coumarate, delphinidin, myrtillin
Minerals	Calcium, phosphorus, potassium, magnesium and iron
Vitamins	Thiamin (B1), riboflavin (B2), nicotinamide (precursor of B3), pyridoxine (B6), biotin (B7), cobalamin (B12), and ascorbic acid (vitamin C)
Fatty acids	Linoleic, linolenic, myristic, palmitic, oleic, stearic and palmitoleic acids

3.2 *Sumac physical analysis*

In studies applied on sumac fruit, the authors gathered some physical properties of samples of sumac fruit that grows in Turkey and Iran. The values of both samples were close and the average is as follow: length (4.78 mm), width (4.1 mm), weight (0.017 g), thickness (2.52 mm), sphericity (0.75) and the average diameter (3.65 mm) [3, 27]. In another study, Physical properties of sumac have been estimated as follow: length (4.70 mm), weight (0.20 g), thickness (2.64 mm), sphericity (0.77) and the average diameter (3.64 mm) [24]. Comparing the values of physical properties of sumac in both studies we notice that they are similar to each other. This type of information is needed for the design of the equipment of harvest, transfer and processing of sumac fruit [27].

4. Sumac health benefits

70-80% of the world population rely on herbal medicine in their major healthcare, a data marked by the World Health Organization [28]. Sumac is one of the spices that was beneficially utilized in the field of medicine, since it has an effective role in preventing and treating many health issues (Figure 2) [1].

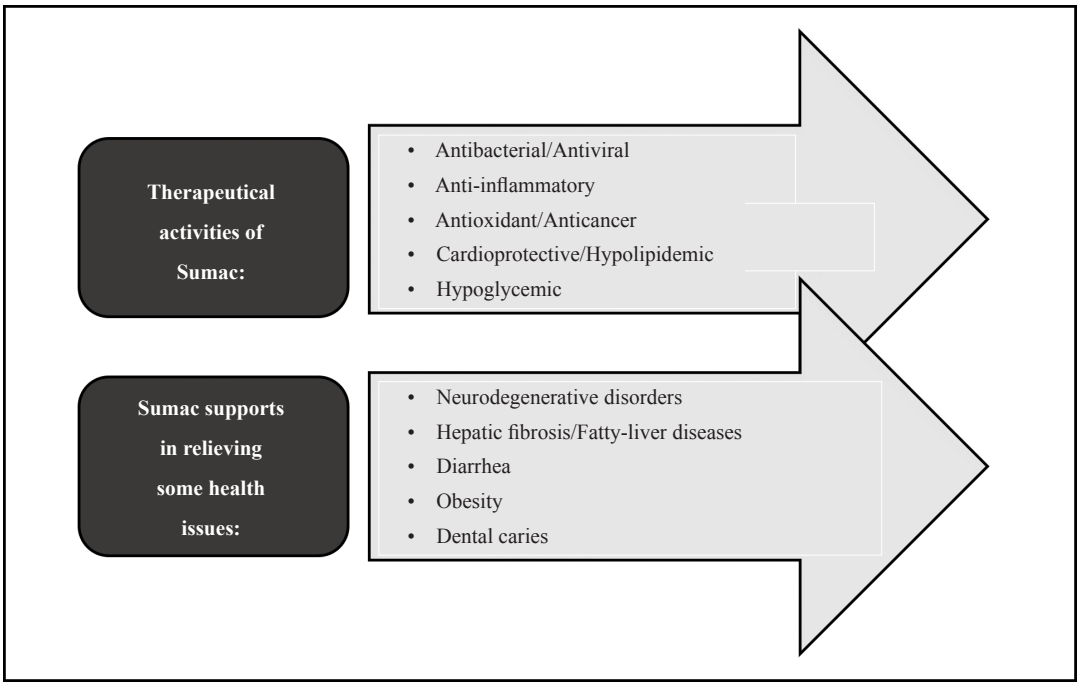

Figure 2. The main health benefits of sumac (Scheme done by the authors of the manuscript)

4.1 *The traditional medicinal uses of sumac*

The medicinal value of sumac was noted 2,000 years ago when Pedanius Dioscorides (Greek physician) indicated in his writings the benefits of sumac as a diuretic and anti-flatulence plant [2]. Different parts of sumac plant have been used in different recipes in herbal medicine [2]. Traditionally, sumac powder was effective in treatment of dental caries, while its infusion was effective in viral eye infections. Also, its powder was consumed with boiled egg for treating diarrhea [9]. Its boiled water fruit extract was administered orally for the treatment of hepatic diseases and urinary system disorders [2], in addition to its topical use to treat skin burns or eczemas and accelerate wound healing [29]. In Ayurvedic, generally sumac powder was mixed with charcoal powder and applied as a paste in the treatment of unhealthy ulcer [30]. As reported in Unani literature, sumac provides many health benefits such as treatment of nausea and diarrhea, stomach and intestinal irritations, hemorrhage, dysentery and many other health issues [31].

4.2 *Therapeutical activities of sumac*

4.2.1 *Anti-bacterial and anti-inflammatory activities*

Many foodborne pathogens such as: *Klebsiella, Shigella dysenteriae, Shigella sonnei and Shigella flexneri, Escherichia coli, and Staphylococcus aureus*, were suppressed by methanol extracts of sumac [12]. The presence of some flavonoids, tannins and other phenolic compounds in sumac might be responsible for its effectiveness against some bacteria [32]. In addition, sumac extract shows an anti-inflammatory effect against *H. pylori* bacterium, and could be used as an ingredient for food supplements to prevent inflammatory-based gastric diseases induced by *H. pylori* [33]. Moreover, a study suggests sumac as a new treatment option for preventing intestinal injury due to its anti-inflammatory activity in rat necrotizing enterocolitis model [34].

4.2.2 *Antiviral activity*

The antiviral activity of sumac was tested on some respiratory and herpes viruses and it was observed that sumac bioflavonoid components were responsible for the inhibitory action against those viruses [35]. Another research

tested 14 sumac phytochemical components. Among the studied components, two phytochemicals (Hinokiflavone and Myricetin) show higher antiviral action against Covid-19 [36]. Moreover, a study examined the characteristics of covid-19 infection and reveals that sumac phytochemicals are advantageous against coronavirus beside the existing treatment protocol applied by the WHO [37].

4.2.3 *Antioxidant and anti-cancer activity*

There is an increased and renewed interest in using plants as a natural antioxidant source to counteract reactive oxygen and nitrogen species responsible for oxidative stress diseases [1]. A study provides evidence that sumac extract demonstrates an important antioxidant activity by scavenging superoxide radicals [38]. In comparing acetone extracts and ethanol extracts of sumac, the antioxidant activity was more potent in acetone extracts due to its higher content of polyphenol [39]. Furthermore, a study shows that the consumption of sumac extract for 90 sequential days increased the total antioxidant status (TAS) in adult male rabbits [40]. Many researches prove that sumac, as many other medicinal plants, is beneficial against various types of cancers such as breast, colon, uterus, cervix and retinoblastoma cancer [9].

4.2.4 *Cardioprotective and hypolipidemic activity*

Sumac was demonstrated to be powerful in preventing atherosclerotic cardiovascular diseases due to its flavonoids content [41]. A study noted that the presence of polyphenols in sumac reduces the absorption of lipids from the gastrointestinal tract which lowers blood cholesterol and low density lipoprotein (LDL) [42]. In addition, dyslipidemia was treated among obese adolescents by daily consumption of sumac powder for 1 month, where the medical examinations showed remarkable reduction of blood total cholesterol, LDL, and triglyceride [43].

4.2.5 *Antidiabetic and hypoglycemic activity*

Sumac has a hypoglycemic role due to its flavonoid content which improves glucose tolerance in diabetic patients. It is favorable in reducing serum levels of blood glucose and insulin beside the existing protocol treatment of diabetes [44]. In a study conducted on rats with type II diabetes, raised levels of blood sugar and insulin was treated by daily oral supplements of sumac for 5 weeks [45]. Another study revealed that daily intake of sumac powder led to significant reduction in fasting serum insulin level in type II diabetic patients [9].

4.2.6 *Other beneficial effects*

According to many studies, authors conclude that dental diseases could be averted or managed by sumac supplements [9]. Sumac is considered a natural anticariogenic in dentistry, also, it was able to suppress the activity of *Streptococcus mutans* (bacteria responsible for dental biofilm formation) without affecting dental normal flora [2]. Sumac fruit extract is also effective in wound healing. In a study conducted on injured Wistar male rats, it was marked that sumac supplements speed up the wound healing process [10]. In addition, Sumac was marked to be functional against diarrhea and fluid buildup caused by oils, to be classified as an antidiarrheal and antisecretory supplement [7]. Moreover, some enzymes associated with neurodegenerative disorders were inhibited by various sumac plant extracts [5]. Another study reveals that 2 g/day of sumac powder for 3 months had a favorable therapeutic effect on hepatic fibrosis and fatty liver diseases [6]. Finally, a trial showed that sumac might be consumed as a supplement beneficial in managing obesity by reducing oxidation [8].

5. Application of sumac in food industry

Although herbs and spices are low-cost ingredients, they have been considered important additives in food industry for centuries. Herbs and spices have been incorporated into food products as supplements, thus increasing the acceptability of foodstuffs and promoting their nutritional qualities [28]. Sumac is one of the spices that left its mark in the field of food technology.

5.1 *Sumac application as a natural food additive*

5.1.1 *Natural preservative*

The anti-microbial and anti-fungal activities of sumac cleared before are not only important in therapeutical applications but also valuable in food industry. Using natural preservatives against synthetic ones is greatly supported and desired by consumers and health care organizations [46]. A study exhibited the high potent of sumac as a natural antimicrobial agent that controls foodborne pathogens and substitutes chemical preservatives. Sumac greatest activity was against the food pathogen *Staphylococcus aureus* [12]. Another study investigated the antimicrobial power of five medicinal plants: sumac, tamarind, rosemary, roselle and lemon, against six pathogens: *Escherichia coli, Pneumonia aeruginosae, Bacillus subtilis, Staphylococcus aureus, Penicillium* species and *Aspergillus niger* [15]. Among the five plants, sumac extracts produced the widest inhibition zone, showing the best antibacterial activity against all tested microorganisms, in addition, it was utilized as a natural preservative extending the shelf-life of tomato paste [15]. Moreover, sumac fruit extracts inhibited the growth of *Colletotrichum acutatum* responsible for the anthracnose disease in tomato [14]. Isolated xanthone compounds from the seeds of sumac possess antifungal activity against *Aspergillus flavus* [47]. A study discussed the effect of some spices on 8 foodborne pathogens (FBP) and their biogenic amines (BA). The study shows that sumac and cumin extracts proved to be the most effective antimicrobials and BA formation inhibitors [48]. Sumac was also incorporated into fresh carrot juice, the enrichment of juice with 3% sumac extract inhibits the growth of microorganisms during storage, improving the juice preservation and shelf-life [16]. The finding of a study done on commercial barley soup shows that water extract of sumac at 0.3%, 0.1%, 1% and 2.5% concentrations have an effect against *Bacillus cereus* in soup and can be considered as a natural preservative [17]. In total, sumac could be utilized as a natural food preservative and may improve food products qualities and shelf-life.

5.1.2 *Natural antioxidant*

Oxidation reaction is the prime cause of spoilage and deterioration of high lipid food products during processing and storage, resulting in undesirable changes in flavor, texture, appearance, and nutritional quality [49]. Antioxidants protect against oxidative degradation by controlling rancidity, maintaining nutritional quality and extending shelf-life of food items [49]. Increasing evidence suggests that synthetic additives used in food have adverse effects on health and some of them are carcinogenic [50]. Therefore, natural antioxidants obtained from spices and herbs are of great interest [51]. In other research, authors reveal that applying sumac extract to peanut oil prevents its oxidation and increases its shelf-life [11]. The findings of another study assure that sumac can be used as a natural antioxidant since a good correlation was found between its total phenolic content and free radicals scavenging activity. This study shows that sumac ethyl acetate extracts displayed higher antioxidant effect than the artificial antioxidants BHT and BHA [52]. Furthermore, Tannin-rich sumac extracts were known to enhance the oxidative stability of food products from animal origin such as milk and meat [53]. Also, sumac exhibits a notable antioxidant activity due to its anthocyanin content where it shows high potential in monitoring the shelf life and spoilage of shrimps [18]. Due to previous studies, sumac may successfully act as an antioxidant during manufacturing of many food items.

5.1.3 *Natural food colorant*

The first impression taken from the consumer toward a food product is related to the product appearance and color. The color of a product is associated with its safety, quality and flavor. Synthetic food colorants are usually used in food industry due to their high stability and low cost, however, there is an increasing demand for natural food colorants due to safety issues [54]. Sumac was considered to be similar to wine in its colorant ability, its red-like pigmentation is due to its content of hydroxyphenyl pyran anthocyanins compounds [13]. Studies have shown that copigmentation interactions with colorless molecules are used to stabilize and strengthen the color of anthocyanins, because it is sensitive to light, heat, oxygen and pH conditions [54]. Due to the sumac attractive red-purple color, its powdered spice is used as decorative garnishes that adds a bright color to several dishes [9].

5.2 *Application of sumac in bread*

The average global consumption of bread is 59-70 kg/capita/year to be considered a common consumed product

with a valuable source of energy [55]. Many additives are used during bread production such as potassium bromate, iodate, chlorine, peroxides and others to increase bread volume, enhance crumb texture and hold good characteristics and qualities. However, some additives were prohibited or reduced because of their toxicological effects or their adverse effect on bread components especially on vitamins. Therefore, using natural additive can enhance the bread quality and improve the bakery industry in a safer way [56]. Fortification of bread with less than 4% of sumac extract increased its phenolic content and prolonged its shelf-life [57]. In one research, when a specified amount of sumac flour was added to wheat bread, the phenolic and fiber content of the enriched bread was increased and the salt content was decreased because sumac provides a mild salty taste, however, sumac flour in wheat bread should not exceed 3 g/100 g for sensory acceptance [58]. The preparation of pan bread with 3% and 5% concentrations of water sumac extract enhances the acceptability of this type of bread, in addition to the improvement of its rheological properties and quality characteristics [59]. For that, sumac succeeded as being a natural food additive as it added a lot of improvements in the bakery industry.

5.3 *Application of sumac in dairy products*

Dairy products are among highly consumed food all over the world. They include milk and milk derivative products including fermented milk products such as yogurt and cheese. The high consumption rate of dairy products motivates their fortification as a process to improve their nutritional qualities and rheological and sensorial properties [60]. The incorporation of herbs and spices or their extracts to different dairy products adds variety and excitement besides raising their nutritional qualities. For that, the dairy industry should find out more innovative ways to enhance the functionality of dairy products and afford it extra value [61]. Sumac was successfully incorporated into dairy industry in the evidence of many studies. A study was examined on pasteurized milk fortified with ethanol extracts of 5 medicinal plants: sumac, tamarind, rosemary, roselle and lemon. All plants worked as natural preservatives and extended the shelf-life of pasteurized milk; however, sumac extract exhibited the greatest microbial activity among all examined plants [15]. In a research, sumac extract was incorporated to ultra-filtrated soft cheese, the results reflected that the incorporation of 0.4% of the extract improves the cheese texture, increases its storage life and was admitted by the sensorial panelists [62]. Goat milk yogurt was also fortified with sumac, yogurt with sumac generates a product with notable increase in antioxidants and phenolic content compared with unfortified yogurt [63]. The antimicrobial effect of aqueous sumac extract and *Lactobacillus* against *E-coli* and *Salmonella* present on Bane traditional cheese was studied. The result shows that the synergistic effect of the sumac extract and *Lactobacillus* induces inhibition zone diameter 2 times larger than the growth inhibition zone of *Lactobacillus* alone [64]. Moreover, antioxidative and anti-spoilage power of sumac fruit extract was noticed during the fortification of cheddar cheese, however, less than 3% of sumac extract was recommended for flavor acceptance [65]. During another research, authors noted that crushed spices were better than whole spices while incorporating different spices into Ras's cheese to decrease its microbial load [66]. As an additional interesting finding about the leaves of sumac, a study declared the antioxidant activity, phenolic content and bio accessibility of phenolic compounds in goat milk yogurt supplemented with sumac leaf powder in vitro digestion. The authors find that sumac leaf powder was successfully utilized to increase antioxidant activity and total phenolic content, producing fortified yogurt with enhanced nutritional and functional properties [67]. Bring to an end, sumac succeeded to put its mark in dairy industry by ameliorating dairy products functionality and qualities.

5.4 *Application of sumac in meat*

Although meat products are nutrient and protein dense food, however, they are highly perishable since they are highly prone to oxidation process and spoilage bacteria [68]. If meat products were exposed to oxidation or microbial growth during manufacturing and storage, the nutritional value would be affected, the sensorial acceptability would be altered, the storage life would be shortened and toxic compounds would be generated [68-69] Since Polyphenols can act as antioxidant and antimicrobial agents in meat and meat products, thus they can inhibit oxidative processes and bacterial spoilage [68]. Sumac is a polyphenol-rich spice as stated before, so, its functionality in meat and meat products as a natural additive would be promising. A study exhibited that sumac fruit extract worked as a natural preservative when added to beef patties. The protein and lipid oxidation in the treated meat was minimized and the product storage period was prolonged [70]. In another research, beef burgers were fortified with sumac extract where the results showed

that sumac was effective against all Gram positive and Gram-negative bacteria tested, yeasts and molds, to be utilized as a great natural preservative in processed meat industry [71]. Sumac fruit extract extends the storage life of ground beef during refrigeration, but 3% of sumac extract was recommended for the consumer overall acceptability for the cooked beef meatballs [65]. In a research, three spices: cinnamon, clove and sumac were incorporated into ready to eat (RTE) doner kebab to study their antimicrobial activity. All spices belayed strong antimicrobial effect. Sumac extract along with heat treatment was effective against *Bacillus cereus* and *Clostridium perfringens*. The treated doner kebab shows increase in spices and salt concentrations and decrease in pH. Authors conclude that those spice extracts including sumac, can conserve safe and good quality of RTE doner kebab [72]. Also, the microbial growth in ground beef meat fortified with sumac and rosemary water extracts was investigated during refrigerated storage. The antimicrobial activity of sumac was greater than that of rosemary, and the greatest effect of both spices was detected on *Staphylococcus aureus*, for that, authors declared that sumac is a good natural preservative in ground beef meat [73]. In another research, ground sheep meat was supplemented with sumac and barberry water extracts to assess the microbial profile during refrigerated storage. Sumac extract showed to be more effective than barberry extract in inhibiting microbial growth and in controlling chemical changes in the supplemented meat. The application of both extracts to ground sheep meat not only enhanced its sensorial properties but also prolonged its storage life [74]. Moreover, a study showed that Sumac was effective as a natural meat tenderizer [75]. Due to the previous several studies, Sumac was used in the meat industry to boost the meat quality and shelf-life; in addition, it brings out dishes with distinctive flavors.

6. Future perspectives

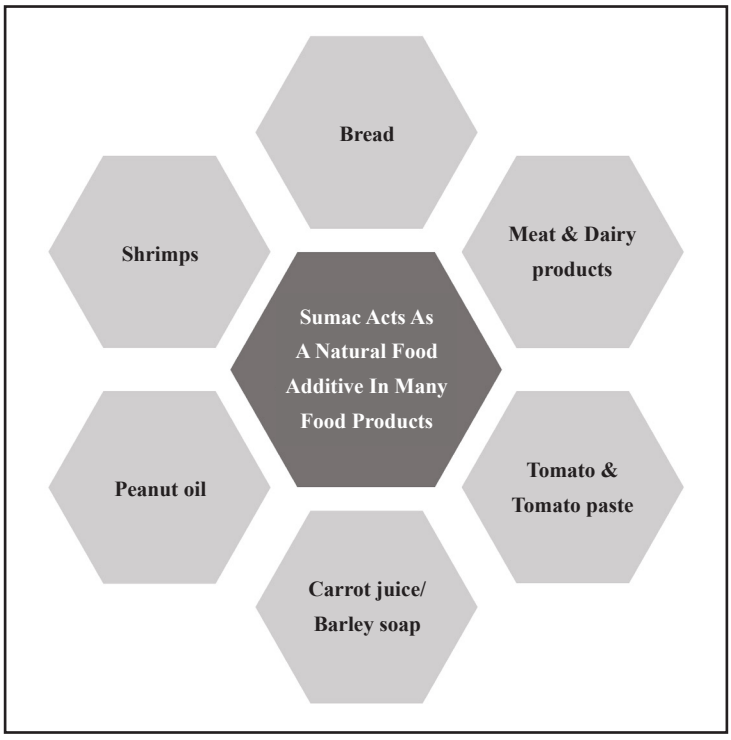

Figure 3. Incorporation of sumac in food industry (Scheme done by the authors of the manuscript)

Worldwide, mayonnaise is one of the most favored and desired sauces, with its high potential as a food product for examinations and attempts. Mayonnaise is composed of oil, water and emulsifier to produce an important emulsion [76], which consists of 3 different components: oil as the organic material, vinegar as the aqueous solution and egg

yolk as a combiner for oil and vinegar [46]. Traditional mayonnaise contains 65% to 80% of fat to be considered a high fat product [77]. Alike all high fat food products, mayonnaise is extremely perishable and liable to deterioration and lipid oxidation which liberates free radicals that contribute to the alteration of sensory and nutritional quality and generate a rancid odor [78]. Commonly, synthetic antioxidants are utilized in food industry to depress lipid oxidation, however, they might induce many health risks [50]. Moreover, there is a rising call from food safety organizations to substitute chemical ingredients by natural ones [46]. Since sumac was successfully utilized as a natural food additive in various food products, the incorporation of sumac into mayonnaise would be of great interest. To our knowledge, there is no research that examine the influence of sumac on mayonnaise products, thus, a suitable study is needed to clarify the effect of sumac on the texture and sensory attributes of supplemented mayonnaise, in addition to its effect on mayonnaise quality, nutritional profile and storage life.

Finally, based on several studies stated above, sumac is used as a medicinal plant for its effective role against various health issues. Besides, it acts as a natural food additive and its usage is effective in food industry (Figure 3).

7. Conclusions

Sumac is a nutritious spice that adds a distinctive taste to many traditional dishes. In addition, it proved to be a powerful medicine to many health issues due to its various health benefits. Moreover, it is considered a versatile ingredient applied in food industry that enhances the quality of many food items. Sumac was successfully utilized as a natural food additive and boosts the quality of many foodstuffs such as bread, meat, dairy products, tomato paste, barley soap, peanut oil and shrimps. Adding sumac to mayonnaise is considered an innovative step in food industry and might positively change the quality of mayonnaise products in terms of its quality and storage life, but a suitable study must be constructed in this domain. For that sumac could be considered a functional food product which when incorporated in food industry it meets the consumer demand for "natural label" food items.

Authors' contributions

Fatima El Ghizzawi, Maha Krayem and Sami El khatib: Conceptualization. Fatima El Ghizzawi, Maha Krayem: Writing-Original draft preparation equally. Maha Krayem: Supervision. All the authors: Writing, Reviewing and Editing. The first and last authors have contributed equally in the manuscript. All the authors have reviewed the manuscript.

Conflict of interest

The authors declare no competing financial interest.

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