

REVIEW

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Traditional, phytochemical, and biological aspects of *Rosa alba* L.: a systematic review

Anju Verma^{1*} , Rajni Srivastava¹ , Pankaj Kumar Sonar² and Ramprakash Yadav³

Abstract

Background: *Rosa alba* L. belongs to the family Rosaceae. This species is widely cultivated in Europe, Asia, North America, and Northwest Africa due to its fragrance, ornamental, and medicinal values. It is commonly known as white oil-bearing rose, white rose, white rose of York, backyard rose, and sufaid gulab.

Main text: *Rosa alba* L. has many biological properties like antioxidant, antimicrobial, antifungal, antifertility, teratogenic, memory enhancing, cytotoxic, and genotoxic activities. The essential oil of *Rosa alba* L. possesses good antimicrobial activity and consists of many chemical constituents like- citronellol, geraniol, nerol, linalool, citral, carvacrol, eugenol, etc.

Conclusion: This article briefly reviews the cultivation, traditional uses, phytochemistry, and biological activities of *Rosa alba* L. Many research papers have been published on the proposed plant and still, there is a very vast scope of research on it. Therefore, this review will be very fruitful for those scientists who are doing or plan to do research work on this plant. All the scientific findings written in this review are explored from Google web, Google Scholar, PubMed, ScienceDirect, Medicinal and Aromatic Plants Abstracts (MAPA), and SciFinder. To date, it is the first systematic review article of such kind, on this plant.

Keywords: Rosaceae, *Rosa alba* L., White rose of York, Backyard rose, Sufaid gulab, Citronellol, Geraniol

Background

Rosa alba L. is a perennial flower shrub of the genus *Rosa* and family Rosaceae comprises 95 genera and 3000 species across the world. This species easily hybridize from different parts of the world which have given rise to the many cultivars of garden roses. Moreover, 435 taxa, 308 species, 13 subspecies, 28 varieties, 17 forms, and 71 natural hybrids have been recognized in *Rosa*. This is one of the largest and most important aromatic and medicinal genera of this family, vital in folk medicine, pharmacological, and commercial value due to its essential oils and volatile products. Most of its species are native to Asia, Europe, North America, and Northwest Africa. While *Rosa alba* L. is found in the central-

west region in the state of Goiás, Brazil and some areas of Turkey, popularly known as white rose or yard rose or backyard rose or white rose of York or Sufaid gulab [1–5]. Various groups of compounds like flavonoids, anthraquinones, saponins, tannins, monoterpenes, triterpenes, sesquiterpenes, aldehydes, phenolic/alcoholic compounds, and minerals are reported in this species [6–10]. Symptoms of little leaf disease, i.e., yellowing and shortening of internodes, were observed in the *Rosa alba* L. due to the association of *Candidatus Phytoplasma asteris*-related strain which is firstly reported by Chaturvedi et al. in 2009 [11].

Main text

Plant description and taxonomy [1]

Kingdom:Plantae

Division:Magnoliophyta

Class:Magnoliopsida

Order:Rosales

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Family:Rosaceae

Genus:*Rosa*

Species:*Rosa alba* L.

Rosa alba L. or rosebush is a little-large tree or shrubs up to 1.8 m in height with perfect velvety white roses of pleasant smell, therefore attracting insect pollination. Its branches are wide apart, big, bent downwards, and have thorns. It can grow in cold and unsuitable soils. The leaves are simple, palmer shaped with reserved trichomes, reticulated ribs, and small side lances. The central rib is elevated and fishbone. Flowers are usually in the form of large clusters as a rosette with 3 or more flowers that bloom throughout the year. Then, 5–70 but generally 15–40 in numbers of pure white-colored petals form the corolla in an overlapping manner. Stigma is not apparent; therefore, the carpel is not developed. The androecium has short stamens with poorly formed anthers. Sepals are round and mostly seesaw toothed [1, 12]. University of Arid Agriculture, Rawalpindi, Pakistan (UAAR) reported the pollen morphology of the flower as the length of pollen 20 μ , breadth 10 μ , size 20 \times 10 μ , and shape of pollen is elliptical. UAAR has also reported the 95 % fertility of pollen [13].

Cultivation

The first white rose was cultivated by Greeks and Romans [1]. In the last century, *Rosa alba* L. had been cultivated in small areas of Europe, primarily the Rose Valley of Bulgaria [14, 15]. Plantings are located in the areas on the Ridge of Sredna Gora Mountain and presently in the region of sub-Balkan valleys. Due to the low quantity of essential oil in white roses, the lands used for its farming decreased noticeably throughout the last century [16]. Essential oil content in the petal has increased by 13% to 33% after the application of pulsed electric fields (PEF) with an energy input of 10 kJ/kg on fresh rose blossoms. The PEF effect on the petals was examined by scanning electron microscopy (SEM) and found the increment of yield. The chemical composition on the treatment of 10 kJ/kg was optimal in regards to the quality of the product [17]. The maximum oil content in the white rose of Bulgaria was found to be at 12 o'clock (0.216%) and the potential to synthesize a high percentage of terpene alcohols up to 43.97% [18].

Traditional use

Generally, the leaves, root, flowers, and fruits are useful parts of *Rosa alba* L. The leaves are considered as rubefacient, lactagogue, and also have insecticidal properties. The leaf juice is used as external application for the treatment of piles. A decoction of leaves and roots is useful in the treatment of diarrhea. Yellow oil of the root is reported for strong anthelmintic action [19]. *Rosa alba* L. is cultivated mainly for the production of aromatic

water while fruits are used in the production of food preparations and sold commercially. In Tunisia, aromatic water is made from *Rosa x alba* (Nesri) called Nesri water, which is commonly used as a flavoring agent in the preparation of jam, marmalade, cake, and drinks. Hydrodistillate product of the flowers is used to prevent cardiovascular diseases [9]. The hydrosol obtained from the flowers is used as an antioxidant supplement for the treatment of oxidative stress etiology [20]. All fragrance products obtained from the plant are used in aromatherapy, phytotherapy, perfumery, and cosmetics. *Rosa alba* L. is traditionally used as tea for the treatment of eye troubles, vaginal candidiasis, and laxative [1]. Rose oil is also used in the preparation of various skin creams/ointment as fragrance or perfuming agent [21].

Quality control studies

Swelling index

The swelling index is defined as the volume in milliliter which is produced up by the swelling of 1 g of plant material on the particular sets of conditions. It gives an idea about the mucilage content of the drug; therefore, it is useful in the evaluation of those crude drugs which contain mucilage [22]. The swelling (intumescent) index of the petal and leaf powder has been determined and their average values are reported in Table 1. Results revealed that the presence of significant amount of mucilage in the leaf. In the pharmaceutical industry, the plant mucilages are used as excipients like thickeners, binding agents, emulsion stabilizers, disintegrating agents, suspending agents, gelling agents, and film formers for the preparation of various dosage forms. Therapeutically, it is utilized as antidiabetic, antioxidant, anticancer, angiotensin-converting enzyme (ACE) inhibitor, wound healing agent, etc. [23].

Moisture and ash contents

Moisture and total ash contents of the petals and leaves of the *Rosa alba* L. is reported by Fabio da Silva et al., which is represented in Table 1.

Microscopic analysis

Microscopic details of the leaf and stem of *Rosa alba* L. have been reported by Fabio da Silva Santos et al. (2014). Palisade and lacunous parenchyma are observed in the cross-section of leaves. Palisade parenchyma was observed with two layers of cells occupying about one-third of the mesophyll while lacunous parenchyma occupying about two-thirds of the mesophyll. Both epidermises of the leaf are uniseriate with unicellular trichomes (hairs) and stomata. Thus the leaf is amphistomatic type. Druses (crystals) were found in the cross-section of the stem and observed intense brighten in

Table 1 Swelling index, moisture and total ash contents of the powder of petals and leaves of *Rosa alba* L.

Sample	Ash content (%)		Moisture content (%)		Swelling index	
	Petal	Leaf	Petal	Leaf	Petal	Leaf
<i>Rosa alba</i> L.	5.22	9.23	4.45	4.71	4.4	11.7

polarized light. According to Ferri et al. (2003), druse is the set of incomplete crystallized crystals around a common nucleus [24].

Phytochemical profile

Qualitative tests of the leaves and petals of *Rosa alba* L. have been performed for the detection of secondary metabolites [1]. Results of the tests showed positive test for flavonoid in the leaves and petals that are indicating the presence of a considerable amount of these compounds in this species while tests of phenolic compounds and anthraquinone showed positive in leaves only. According to Simões et al. (2007), phenolic compounds are generally constituents of volatile oils. It is believed that when preparing the alcoholic extract of the petals, their phenolic elements are destroyed that is why the result of phenolic compounds in the test comes negative. Saponins were also absent in both leaves and petals while tannins have been found in the petals only [6].

Chemical constituents and other characteristics

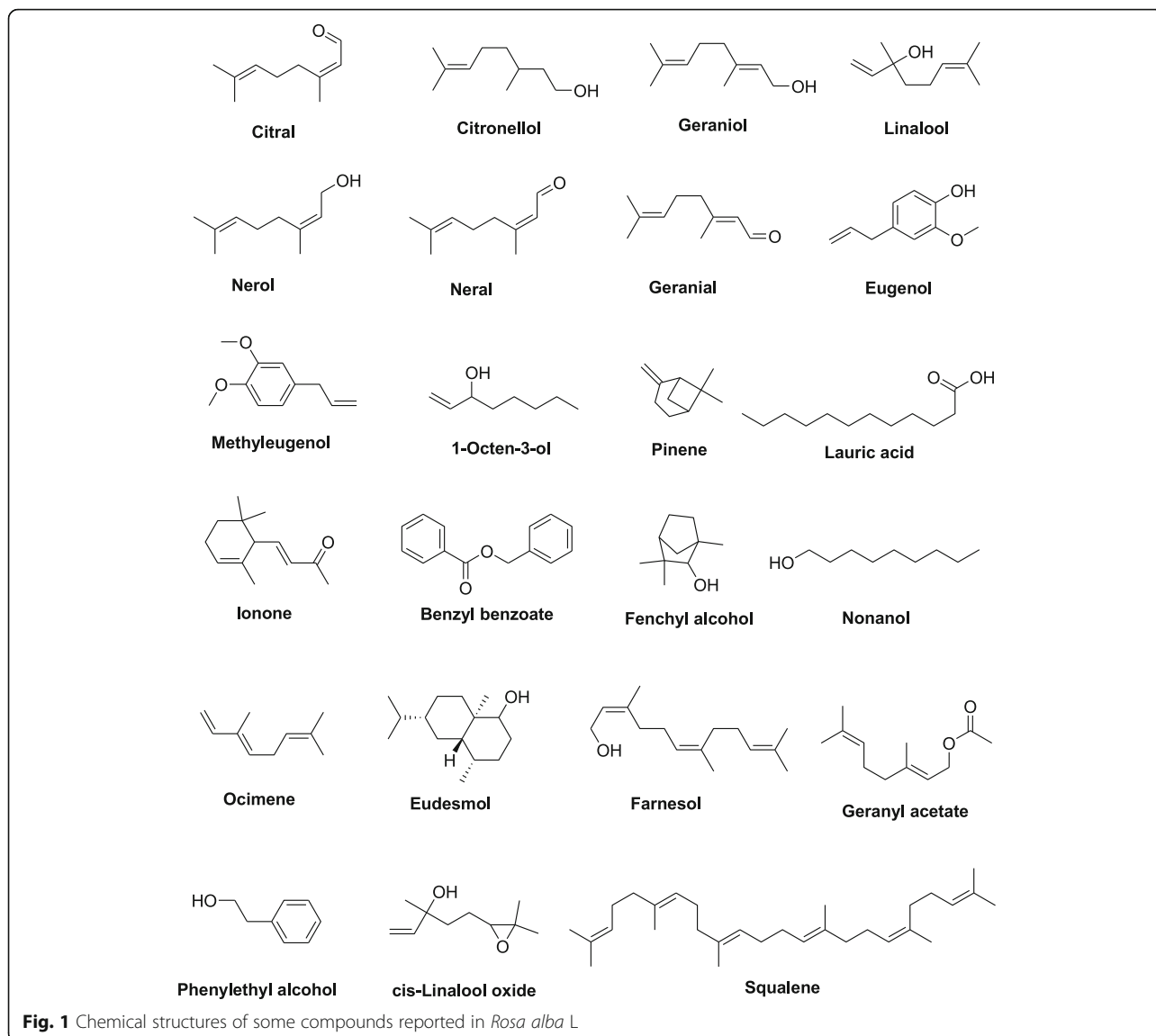
Various chemical constituents reported in the leaves, flowers, and fruits of *Rosa alba* L. are structurally represented in the Fig. 1. Out of them, the essential oil was found as chief constituent. The major components of the essential oil are geraniol, heneicosane, nonadecane, citronellol, linalool, β phenylethyl alcohol, nerol, neral, geranial, eugenol, methyleugenol, nonadecene, eicosane, and tricosane [7]. Mileva et al. also reported the quantitative information of citronellol, *n*-nonadecane, *n*-heneicosane, geraniol, nerol, citral, and eugenol in the essential oil, with the help of gas chromatography (GC) [8]. The abundance of some components like α , β -unsaturated aldehydes, and alcohols such as eugenol and linalool are reported in the leaves and 2-phenylethanol in flowers with well-documented biological properties. It is reported that the volatile oil obtained from leaves, applicable in the food industry, while oil obtained from flowers seems more appropriate in the cosmetic and perfume industries. The leaves, flowers, and fruits of the plant are rich sources of essential minerals. Therefore, leaves and flowers can be consumed as a salad and/or decoction, while fruits can be eaten fresh as a dessert or processed to jam. In another study, tannins, ellagitannins, and flavonoids were reported in petals while mucilage and anthraquinones in the leaves [10]. The

quantitative analysis of the volatile oils from leaf, flower, and fruits of *Rosa x alba* is represented in the Fig. 2 [9]. Georgieva et al. (2019) performed gas chromatography-mass spectrometric (GC-MS) analysis of hydrosol, which was produced by water-steam distillations of rose blossoms. They reported various monoterpene hydrocarbons, aliphatic hydrocarbons, oxygenated aliphatic hydrocarbons, oxygenated monoterpenes, oxygenated sesquiterpenes, triterpenes, and benzenoid compounds in that hydrosol. Out of them, trans-Geraniol and β -Citronellol were found 36.44% and 28.69% respectively. All the explored compounds and their quantities are represented in the Fig. 3. Geraniol, nerol, citronellol, and citral are the constituents of the essential oil, responsible for the antioxidants and antimicrobial effects. Pure geraniol and citronellol are better antimicrobial agents than rose hydrosol. In the plant, biogenesis of geraniol and citronellol occurs through the mevalonic acid pathway [20, 25]. Significant changes in the content and composition of essential oil of *Rosa alba* L. were observed when it was investigated at various stages of its flowers development. Flowers from the population of white rose were investigated in six phases. The optimum quantity and quality of the essential oil was not found same at one time, but there was a correlation between the two indicators. The maximum content of essential oil was observed in the phase IV at the time of semi-opened petals. Authors have examined the content of flavonoids (such as quercetin) in the flowers at the different phases of its development. They found that the basic content of flavonoids is 11 mg/g and reported that with the opening of the flowers, the content of flavonoids is increases and reaches up to the maximum amount (18 mg/g) when flowers are fully open [26].

Biological activities

Antioxidant activity

A comparative antioxidant effect of hydrosols, prepared from the flowers of *Rosa alba* L. and *Rosa demesana* Mill., was evaluated and showed good capacity to inhibit Fe^{2+} /ascorbic acid-induced lipid peroxidation in the egg liposomal model system. The antioxidant effect of hydrosol of *Rosa alba* L. was found higher than those of *Rosa damascena* Mill. at all tested concentrations. On the basis of above findings, it is concluded that *Rosa alba* L. could be used as supplementary material with antioxidants in oxidative stress condition [20]. Piotr

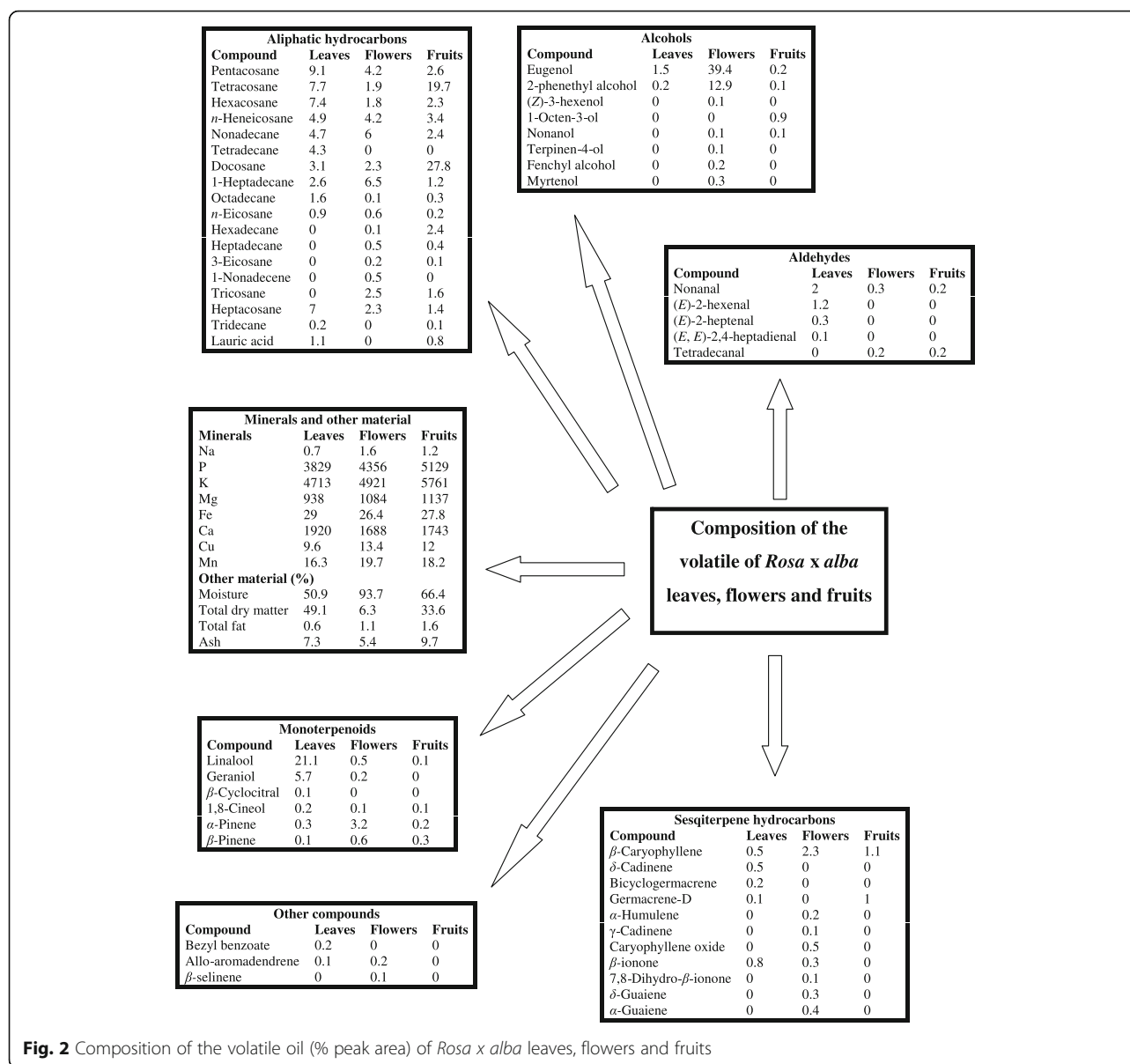


Brzezinski and Lorenzo Martini (2019) have reported in their letter to the editor that the antiradical capacity of *Rosa alba* L. is 72 $\mu\text{g/ml}$ at the concentrations of 100 $\mu\text{g/ml}$. They have also written in their letter about the usefulness of rose in the treatment of severe rosacea (rosacea is a long-term skin condition that typically affects the face characterized by redness, pimples, swelling, small and superficial dilated blood vessels often the nose, cheeks, forehead, and chin). The principle of DPPH (2, 2-diphenyl-1-picrylhydrazyl) assay is based on hydrogen atom transfer reaction and substrate polarity. Therefore, the presence of hydroxyl group in the geraniol, nerol, and citronellol may be an option for the hydrogen donation and/or superoxide scavenging activity [7]. Rubero and Barata (1999) have demonstrated that the free radical scavenging activity is the cumulative effect

of essential oil's ingredients (nerol, eugenol, geranol) due to their polar bonded hydrogen atoms [27].

Antimicrobial activity

Antimicrobial effect of essential oil obtained from *Rosa alba* L. was evaluated against Gram-positive bacterial strains, belonging to genera *Staphylococcus* and *Bacillus*; Gram-negative bacterial strains, belonging to genera *Escherichia*, *Pseudomonas*, *Salmonella*, and *Citrobacter*; and some yeasts, belonging to genera *Candida*. Results of the study revealed that the Gram-positive bacteria were found to be more sensitive than Gram-negative bacteria, especially *Pseudomonas* spp. were found to be more resistant to the essential oil and pure components. The pure citronellol, geraniol, and nerol have demonstrated higher antimicrobial activity than the isolated

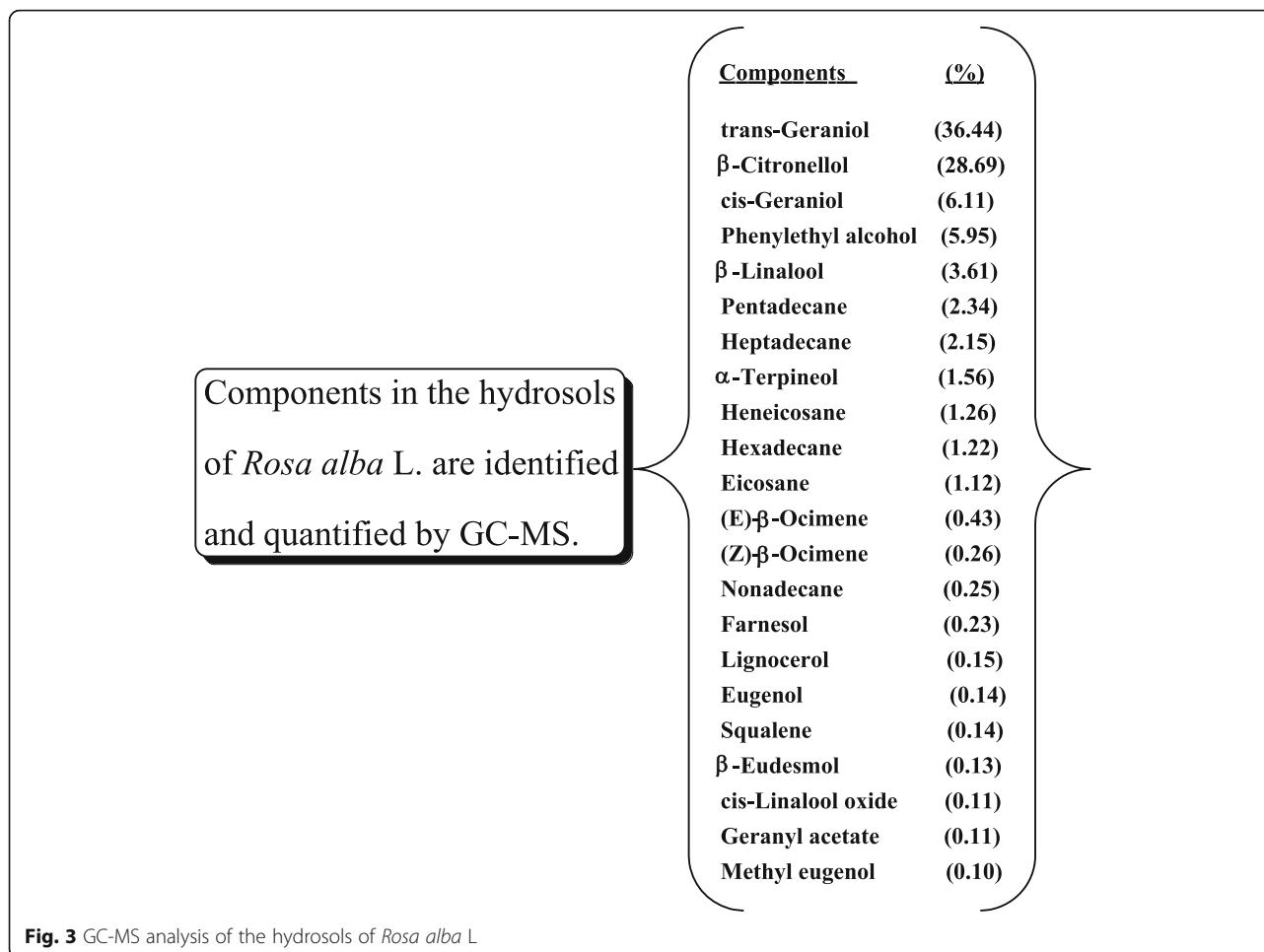


one [7]. *Rosa alba* L. also showed significant antimicrobial effect against *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans* [28]. In another study, six essential oils of the *Rosa* genus and their ingredients were evaluated for their antifungal activity against *Aspergillus flavus* and *Aspergillus niger*. Findings of the study showed larger resistance of *Aspergillus niger* against rose oil in contrast to *Aspergillus flavus*. Antifungal activity of the essential oil is mainly due to the presence of its geraniol, nerol, and citronellol. Some more antimicrobial screening studies revealed that the rose oil found to be less effective against Gram-positive *Enterococcus faecalis* as compare to *Streptococcus mutans* and most effective against Gram-negative *Aggregatibacter actinomycetemcomitans* [8]. The lipophilic character of

monoterpenes present in essential oils may be responsible for antimicrobial effect by disrupting the permeability of microbial cytoplasmic membrane for protons and bigger ions [16, 29, 30].

Antifertility and teratogenic activity

Leaf powder of *Rosa alba* L. has mixed with an equal quantity of gum-acacia and double distilled water for preparing the dose of 175 mg/kg. This dose was administered in albino rats orally once a day for 10 days in post-mating period for the evaluation of its antifertility effects. Results of the study depicted the fertility control levels up to 19%. Marked malformations have been observed in newborns in cases where the pregnancy was not terminated [31].



Cytotoxic and genotoxic activity

Jovtchev et al. have evaluated the cytotoxic and genotoxic activity of *Rosa alba* L. through classical cytogenetic methods and comet assay. They used 1-methyl-3-nitro-1-nitrosoguanidine as a standard mutagen. The essential oil was found to be inactive up to 1000 mg/ml on root tip meristem cells isolated from *Hordeum vulgare* [32]. Generally, essential oils and their components are safe in low concentrations while several researchers have reported that the higher dose (500 mg/ml) of geraniol (citral A) and geraniol are responsible for cytotoxic and genotoxic effects in human cells [33, 34]. Geraniol inhibits prostate cancer growth by targeting cell cycle and apoptosis pathways [35].

Memory-enhancing activity

The memory-enhancing activity of the aqueous extract of *Rosa alba* L. was evaluated on three-month-old male Swiss albino mice. Elevated plus-maze and passive-avoidance apparatus served as the exteroceptive behavioral models and diazepam-induced amnesia served as the interoceptive behavioral model in the study. Mice were treated with 100, 200 mg/kg p.o. doses of *Rosa*

alba L. and 200 mg/kg i.p. dose of piracetam as a standard nootropic agent. The results of the study showed that *Rosa alba* L. enhanced learning and memory in animals, as announced by transfer-latency and improved step-down latency. On the other hand, *Rosa alba* L. significantly reversed diazepam-induced amnesia. The plant has also improved memory power by inhibiting the enzyme cholinesterase. The nootropic activity of *Rosa alba* L. extracts may be due to the improvement of memory in the absence of cognitive deficits [36, 37].

Stress-induced skin-barrier disruption

Essential oil of *Rosa alba* L. has been evaluated against two major stress-induced effects like activation of the hypothalamo–pituitary–adrenocortical (HPA) axis and skin-barrier disruption in the rats and humans. It is stated that the inhalational treatment of rose oil significantly controlled the plasma corticosterone and the number of c-Fos-positive cells in the hypothalamic paraventricular nucleus. Rose oil also maintains the skin-barrier disruption in both rats and humans. It also increases the salivary concentration of cortisol in humans

by controlling the elevation of transepidermal water loss [38]. Pharmacology underlying the suppressive effects of rose essential oil on the HPA axis and TEWL (transepidermal water loss) is not known but two possibilities are there. The first one is that the absorbed perfume component of rose essential oil via membrane of the nose or lungs triggers a certain reaction in the brain and/or skin, with consequent reductions of stress-induced HPA activation and skin-barrier disruption. The second possibility is that upon inhalation of oil, the olfactory nerves may be activated which directs to inhibition of the activities of stress-related forebrain regions, such as hypothalamic paraventricular nucleus (PVN) [39].

Bradykinin and substance P antagonist

Breton et al. (2000 and 2003) obtained United States Patents for inventions of novel substance P and bradykinin antagonist compositions comprising at least one extract of at least one plant of the rosaceae family. *Rosa alba* L. was also one of the plants in their composition as substance P and bradykinin antagonists. These inventions also narrate to the administration of *Rosa alba* L. extract as the active species or agent for treating disorders associated with an excessive synthesis and/or release of substance P and bradykinin [40, 41].

Conclusion

Rosa alba L. belongs to the family Rosaceae. Leaves, root, flowers, and fruits are useful parts of this ornamental plant with a variety of traditional values, as a tea for the treatment of eye troubles, vaginal candidiasis, and as laxative. It is used in the production of aromatic water, food preparations, as a flavoring agent for drinks, production of jam, marmalade, and cake. All fragrance products obtained from this plant are used in aromatherapy, phytotherapy, perfumery, and cosmetics. This holds a variety of biological activities like-antioxidant, antimicrobial, antifertility, teratogenic, cytotoxic, genotoxic, memory-enhancing, antistress, bradykinin, and substance P antagonist activities. Various chemical components are identified/isolated from different parts of the plant like essential oil, alcohols, aldehydes, monoterpene hydrocarbons, sesquiterpene, minerals, etc. This plant is not too much explored in pharmacological aspects yet the authors have made their full effort to compile the entire pharmacology published earlier on this plant. The plant contains a wide range of natural antioxidants like flavonoids, terpenoids, phenolic compounds, etc. which can neutralize the free radicals and thus prevent the development of many chronic diseases/disorders related with oxidative stress and reactive oxygen species (ROS) like neurodegenerative disorders, cancer, cardiovascular disease, diabetes, hepatic disorders, and diseases associated with aging. Though, phytochemical studies of the plant have been done

enough. Herbal formulation and development part of the plant must also be explored in the future. Biological standardization of the isolated compounds and their synthesis in the laboratory should also be explored as potential drug candidates.

Abbreviations

UAAR: University of Arid Agriculture, Rawalpindi, Pakistan; PEF: Pulsed electric fields; SEM: Scanning electron microscopy; GC: Gas chromatography; GC-MS: Gas chromatography-mass spectrometry; DPPH: 2, 2-Diphenyl-1-picrylhydrazyl; HPA: Hypothalamo-pituitary-drenocortical; ROS: Reactive oxygen species; PVN: Paraventricular nucleus; MAPA: Medicinal and Aromatic Plants Abstracts; ACE: Angiotensin-converting enzyme; p.o.: Per oral; i.p.: Intraperitoneal; TEWL: Transepidermal water loss

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Authors' contributions

All authors have studied and permitted the final manuscript for communication. AV created the idea, conducted the literature searches and wrote the manuscript. RS worked together with the correction and regulation of text and references. PKS equally contributed as AV, in the data analysis and organizing the manuscript in the proper format. RY collaborated with the correction, updating, and regulation of references. The authors read and approved the final manuscript.

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