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AN IN-DEPTH REVIEW ON THE MEDICINAL FLORA *ROSMARINUS OFFICINALIS* (LAMIACEAE)

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ABSTRACT

Rosmarinus officinalis (Rosemary) is a common household plant which belongs to the family Lamiaceae and is grown in many parts of the world. It is a woody, perennial herb with fragrant, evergreen, needle-like leaves and white, pink, purple or blue flowers. The two most commonly grown hardy Rosemaries are *Rosmarinus officinalis* 'Arp' and *R. officinalis* 'Madelene Hill' (syn. 'Hill Hardy'). The other cultivars of the plant are *R. officinalis* 'Albus', *R. officinalis* 'Bendenen Blue', *R. officinalis* 'Goodwin Creek', *R. officinalis* 'Herb Cottage', *R. officinalis* 'Logee's Light Blue', *R. officinalis* 'Miss Jessup's Upright', *R. officinalis* 'Russian River', *R. officinalis* 'Salem'. The chemical constituents include bitter principle, resin, tannic acid, volatile oils and flavonoids. The volatile oil consists of borneol, bornyl acetate, camphene, cineol, pinene and camphor. It is used for problems involved in central nervous system, cardio vascular system, genito urinary conditions, liver treatments, reproductive system and respiratory system. The volatile oil of the plant is used in oils and lotions for the treatment of various ailments like arthritis, gout, muscular pain, neuralgia, wound and rubbed into hair for stimulating the hair bulbs to renewed activity, to prevent premature baldness.

Key words: rosemary, Lamiaceae, borneol, culinary, hair growth

INTRODUCTION

Rosemary is a powerful herb belonging to the family Lamiaceae that originates from the Mediterranean region. It is derived from the Latin word *ros* (dew) and *marinus* (sea) which means 'dew of the sea' [All about... 2012]. It has been named the Herb of the Year in 2001 by the International Herb Association. Rosemary is regarded as the herb of faithfulness as Elizabethan sweethearts carried a twig of rosemary as its sign. Today market demand of the plant is growing, as it is used in several commercially available products. Rosemary is composed of pine-like leaves, which is the heart of all medicinal and other benefits that are derived from the use of its oil [Rosemary... 2012].

The synonyms of the plant include Garden Rosemary, Polar Plant, Compass-Weed and Compass Plant [http://www.globalherbalsupplies.com 2012]. It is known in several vernacular names like Alecrim, common rosemary, echter Rosmarin, encensier, garden rosemary, rosmariin, rosmarina, Rosmarin, rosmarini, rosmarino, rosemary, tresmarino [Bedevian 1994, Farnsworth 2005, Youngken 1950]. Rosemary is indigenous to South Europe and Asia but it is also cultivated

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in Mediterranean basin and India [WHO guidelines... 2007, Kokate et al. 2010].

Scientific classification
[Master data/monograph... 2007]
Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: magnoliophyta
Class: Magnoliopsida
Subclass: Asteridae
Order: Lamiales
Family: Lamiaceae
Genus: *Rosmarinus* L.
Species: *officinalis*
Binomial name: *Rosmarinus officinalis* L.

History

Rosemary has been named the Herb of the Year in 2001 by the International Herb Association. It was introduced to Britain by the Romans and is still particularly loved today by the Italians and the British, who use it frequently in their cooking. In ancient Greece and Rome rosemary was believed to strengthen the memory, which accounts for its being known as the herb of remembrance and fidelity. Rosemary was an essential part of the apothecary's repertoire during the Renaissance. Hippocrates, Galen, and Dioscorides prescribed rosemary for liver problems [Rosemary... 2012]. Rosemary is not a popular plant in India. It was introduced by the Europeans as a garden plant due to its pleasant fragrant scented leaves.

Varieties

There are more than 20 varieties of rosemary plant. The different types of rosemary are listed in Table 1.

Upright rosemary. It measure between six and eight feet in diameter and two feet or more in height.

Creeping rosemary. It covers eight or ten feet in diameter in a very short period of time. It can also trail down eight or ten feet. It falls all the way to the ground and is covered with pale blue flowers.

Pine scented rosemary. Pine scented rosemary is a soft sea green that grows to about three to four feet high by about four or more feet wide.

Arp rosemary. This plant grows where winter temperatures are frequently in the teens or less.

Madalene hill rosemary is a cold hardy Rosemary. It is rated to survive minus 15 degrees and is erect, growing to about three feet. Its flowers are light blue.

Pink rosemary has the thinnest leaves of all *Rosmarinus officinalis* plants. Flower is pale in colour and grows quickly to two feet.

White rosemary is visually different. This is a beautiful very erect plant with thich succulent leaves and white flowers that have just a spot of blue in the throat. The branches are reminiscent of candelabras and give the plant an open airy look and have white flowers.

Dancing waters rosemary. It is shorter, more mounding and has dark blue flowers.

Golden rain rosemary has weeping foliage. The golden hue of the plant turns darker green over summer and returns with cooler weather.

Blue boy rosemary is the smallest of all the Rosemary varieties. It has small leaves and little light blue pearls for flowers. This plant grows out to cover about 12 inches but rarely gets over six inches tall.

Spice islands rosemary has thick juicy looking leaves and very upright growth with a nice dark blue flower [Mountain... 2012].

CULTIVATION AND COLLECTION

It is cultivated in gardens and on slopes. Its cultivation is found successful on light calcarious soil. The propagation is by means of sowing the seeds or with slips. After flowering, the plants are cut about 10 cm above the ground and are steam distilled to isolate the volatile oil content in the plant [Kokate et al. 2010].

DESCRIPTION

Leaves are leathery, opposite, strongly recurved, fringed margins and with prominent midrib. Size of the leaf is 1.0-2.5 cm long and 4 cm width. The upper surface of the leaf is green coloured and the lowered surface is grey somewhat wooly due to numerous trichomes. The margins are entire and strongly revolute with obtuse apex, tapering and non petiolate base [European Pharmacopoeia 2007]. Typical labiates hairs contain the volatile oil, of which the BP specifies a minimum content of 1.2% calculated

Table 1. Types of rosemary (rosemary varieties, 2012)

Types	Flowers	Growth habit	Other	Uses
1	2	3	4	5
Rosemary, Arp (*Rosmarinus officinalis*)	pale blue, summer	upright	green-gray foliage	ornamental and culinary, popular bonsai subject
Rosemary, Benenden Blue (*Rosmarinus officinalis* 'Benenden Blue')	blue, midsummer	upright	dark green foliage, bred for deep blue flowers	ornamental and culinary
Rosemary, Blue Lady *(Rosmarinus officinalis* 'Blue Lady')	blue-violet, summer	twisted	very narrow leaves, very needle-like (popular bonsai subject)	ornamental and culinary
Rosemary, Blue Spires (*Rosmarinus officinalis* 'Blue Spires')	bright blue flowers on tall upright stems	creeper	specially developed for visual and olfactory appeal	very ornamental and yet still culinary
Rosemary, Collingwood Ingram (*Rosmarinus officinalis* 'Collingwood Ingram')	blue, summer	creeper	highly fragrant, bright green foliage	ornamental and culinary
Rosemary, Foresteri (*Rosmarinus officinalis* 'Foresteri')	blue, summer	upright	especially drought resistant	ornamental and culinary
Rosemary, Girardus (*Rosmarinus officinalis* 'Girardus')	blue, summer	upright	very dense foliage	culinary
Rosemary, Golden Rain (*Rosmarinus officinalis* 'Joyce de Baggio')	blue, summer	upright	variegated (yellow on foliage edges) increasing variegation with age	ornamental and culinary
rosemary, Gorizia (*Rosmarinus officinalis* 'Gorizia')	blue, summer	upright	densely packed branches of dark green needles, fragrant	ornamental and culinary
Rosemary, Hill Hardy (*Rosmarinus officinalis* 'Hill Hardy')	blue, summer	upright	needlelike foliage, fragrant	ornamental and culinary
Rosemary, Kenneth's Prostrate (*Rosmarinus officinalis* 'Kenneth's Prostrate')	blue, late summer and early fall	creeper	fast grower	ornamental and culinary
Rosemary, Lockwood de Forest (*Rosmarinus officinalis* var. angustifolius 'Lockwood de Forest')	lavender blue, summer	creeper	dark green foliage	ornamental and culinary
Rosemary, Logee's Blue (*Rosmarinus officinalis* 'Logee's Blue')	blue, summer	upright	bluish green foliage, smaller Ogee's	ornamental and culinary
Rosemary, Miss Jessup (*Rosmarinus officinalis* 'Miss Jessup')	blue	upright	bred especially for flowering	ornamental and culinary
Rosemary, Mrs. Howard's Creeping (*Rosmarinus officinalis* 'Mrs. Howard's Creeping')	small blue, mid to late summer	creeper	fast grower	ornamental and culinary

Table 1 – cont.

1	2	3	4	5
Rosemary, Pine-Scented (*Rosmarinus officinalis* 'Pine-Scented')	blue, summer	upright, feathery needle-leaves	grown as miniature Christmas tree, leaves have pine fragrance	ornamental and culinary
Rosemary, Rex (*Rosmarinus officinalis* 'Rex')	blue, summer	upright	dark green foliage	ornamental and culinary
Rosemary, Santa Barbara (*Rosmarinus officinalis* 'Santa Barbara')	blue, summer	upright	drought resistant	ornamental and culinary
Rosemary, Severn Sea (*Rosmarinus officinalis* 'Severn Sea')	violet-blue	upright	–	ornamental and culinary
Rosemary, Spanish (*Rosmarinus officinalis* 'Majorca')	pink, throughout summer	upright	very needlelike leaves (popular bonsai subject)	ornamental and culinary
Rosemary, Tuscan Blue (*Rosmarinus officinalis* 'Tuscan Blue')	blue, mid spring to late summer	upright	extremely fragrant, bred especially for dense flowering	ornamental and culinary
Rosemary, White-Flowered (*Rosmarinus officinalis* 'White-Flowered')	white	upright	extremely fragrant	ornamental and culinary

on the anhydrous drug. It has spiciform inflorescences of white or blue flowers, with the two stamens projecting far beyond the corolla [Youngken 1950, Bisset and Wichtl 1994, Bruneton 1995, Boulos 1983].

Description of the oil

Rosemary oil is colourless to pale yellow with characteristic flavour and camphoraceous taste. The specific gravity is 0.894-0.912, refractive index 1.464-1.476 and has an optical rotation of 5-10°. The oil is insoluble in water, soluble in 10 volumes of 80% of alcohol. The acid value is not more than 1.0 [Kokate et al. 2010].

MICROSCOPIC CHARACTERISTICS

Leaf is dorsiventral with upper epidermal cells polygonal in shape. It is slightly thickened walled and with occasional pits. Lower epidermal cells are sinuous and have numerous diacytic stomata on the lower surface only. Abundant uniseriate, multicellular, multi-branched covering trichomes are on the lower epidermis. Glandular trichomes are with a unicellular stalk and unicellular, bicellular or multicellular head which occurs on both epidermises and consists of spongy mesophyll [European Pharmacopoeia 2005].

Powdered plant material

The powder is greyish-green-yellowish-green. It has fragments of lower epidermis with straight to sinuous-walled cells and abundant diacytic stomata. The fragments of the upper epidermis with straight-walled cells, slightly thickened and pitted, and an underlying hypodermis composed of large, irregular cells with thickened and beaded anticlinal walls, fragments in sectional view showing the hypodermal cells extending across the lamina at intervals, separating the one or two-layered palisade into large, cresscent-shaped areas, numerous multicellular, extensively branched, covering trichomes of the lower epidermis and rare conical covering trichomes of the upper epidermis, glandular trichomes of 2 types, the majority with a short, unicellular stalk and a radiate head composed of 8 cells, others, less abundant, with a unicellular stalk and a spherical, unicellular or bicellular head are seen. Occasional cork fragments, fibres, vascular tissue and lignified parenchyma from the stems [British Herbal... 1996].

General identity tests

Macroscopic and microscopic examinations, thin-layer chromatography and high-performance liquid chromatography for phenolic acids are the general tests performed for the identification of these plants [Wagner and Bladt 2004, European Pharmacopoeia 2007, Ziakova and Brandsteterova 2003].

Purity tests include microbiological tests for specific microorganisms and microbial contamination limits are as described in the WHO guidelines for assessing quality of herbal medicines with reference to contaminants and residues [WHO guidelines... 2007].

STANDARDS

Foreign organic matter: not more than 5% of stem, and not more than 2.0% of other foreign matter [European Pharmacopoeia 2005].

Total ash: not more than 9.0% [European Pharmacopoeia 2005].

Acid-insoluble ash: not more than 1.5% [British Herbal... 1996].

Water-soluble extractive: not less than 15.0% [British Herbal... 1996].

Water content: not more than 10% [European Pharmacopoeia 2005].

Pesticide residue: the recommended maximum limit of aldrin and dieldrin is not more than 0.05 mg/kg [European Pharmacopoeia 2005] and pesticide residues WHO guidelines 2007 and 1997.

CHEMICAL PROPERTIES

In plants the main active constituents are volatile oil which is constituted with camphene, camphor, cineol, borneol, resin, bitters matter, rosemary acid and flavonoids.

Chemical classification of active principles in rosemary plant

Flavonoids. 6-methoxygenkwanine, apigenine, diosmetine, diosmine, genkwanine, hispiduline, Luteoline, Sinensetine.

Di- and triterpenoids. Carnosolic acid, picrosalvine, rosmariquinone, oleanolic acid, ursolic acid (has anti-inflamation effect).

Active compounds in the ethereal oil

Monoterpenoids. alpha-pinene 12%, beta-pinene, camphene 22%, mycrene 1.5%, alpha-phellandrene, limonene 0.5-1%, alpha- and y-terpinene, paracymene 2%.

Sesquiterpinoids. beta-caryophyllene 3%.

Monoterpinoids. linalool 0.5-1% terpine-1ol-4, a-terpineol 1.5%, borneol 3-5%, isoborneol, cis-thuyanol-4, trans-thuyanol-4, p-cymene-8-ol.

Terpenic esters. bornyl-actate, a-phenchyl-actate.

Terpinic acid. 1,8-cineol 30%, caryophylline-oxide, humulene-epoxide I and II.

Non terpenic cetons. 3-hexanon, methyl-heptenon.

Monoterpenons. camphor 30%, verbenon, carvon 0.4%. The flowers contain about 1.0% of volatile oil, resin, ursolic acid and bitter principle. While leaves contain mainly 10-15% of borneol, 2.5,3% of bornyl acetate, camphor, eucalyptol, pinene, D-camphene, cineol and 45% of terpenes [Kokate et al. 2010].

Major chemical constituents of *Rosmarinus officinalis* volatile oil

The chief constituents of rosemary oil are: camphor (5-31%), 1,8-cineol (15-55%), pinene (9-26%), borneol (1.5-5.0%), camphene (2.5-12.0%), pinene (2.0--9.0%), limonene (1.5-5.0%), verbenone (2.2-11.1%), caryophyllene (1.8-5.1%) and myrcene (0.9-4.5%). The structures of 1,8-cineole, borneol and camphor are presented below [European Pharmacopoeia 2005, Salido et al. 2003, Domokos et al. 1997, Williams 2009].

Major chemical constituents present in *folium rosemarini*

To 2.5% of essential oil, the chief constituents of which are camphor (5-21%), 1,8-cineole (15-55%), pinene (9-26%), borneol (1.5-5.0%), 297 camphene (2.5-12.0%), pinene (2.0-9.0%) and limonene (1.5--5.0%). Phenolic compounds are represented by flavonoids with a methylated aglycone (e.g. genkwanin) and by phenolic acids (>3%), particularly by rosmarinic, chlororenic and caffeic acids. Also present are tricyclic diterpenes such as rossmaridiphenol, carnosol, carnosic acid and rosmanol, and diterpenes, including seco-hinokio (Fig. 1) [European Pharmacopoeia 2005, Salido et al. 2003, Bisset and Wichtl 1994, Bruneton 1995, Farnsworth 2005, Blumenthal 1998, Cantrell et al. 2005].

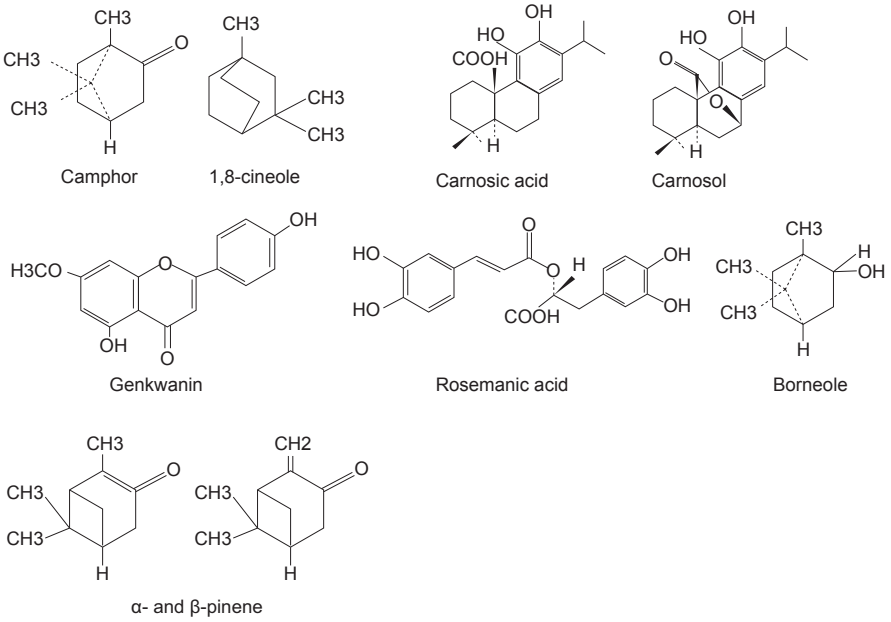

Fig. 1. Chemical structures of few a compounds present in *Rosmarinus officinalis*

Chemical assays

Gas chromatographic analysis for Spanish, Morocco and Tunisia rosemary volatile oil was performed to assess the content of chemical constituents in each. It was observed that Morocco and Tunisia rosemary contained same amount of chemical constituents while the Spanish one possessed a higher amount in comparison (Table 2).

Medicinal uses

It is used as carminative, rubifacient, stimulant and as flavouring agent for liniments, hair lotions, inhaler, soaps and cosmetics [Kokate et al. 2010]. Rosemary leaves have many traditional uses based on their antibacterial and spasmolytic actions. Used orally for the treatment of dyspeptic complaints [British Herbal... 1996], and in external applications for supportive management of rheumatic complaints and circulatory disorders [Blumenthal 1998]. *Aetheroleum Rosmarini* crude drug may enhance cognition. It is used as a cholagogue, diaphoretic, digestant, diuretic, esmmenagogue, laxative and tonic [Bedevian 1994, Farnsworth 2005] also used in the management of headache, menstrual disorders, nervous menstrual complaints, tiredness, defective memory, sprains and bruises [Hagers... 2003].

Table 2. Gas chromatographic analysis of Spanish, Morocco and Tunisia type rosemary oil (European Pharmacopoeia 2005)

Chemical constituents	Spanish rosemary oil, %	Morocco and Tunisia rosemary oil, %
α-pinene	18-26	9-14
β-pinene	2.0-6.0	4.0-9.0
camphene	8-12	2.5-6.0
myrcene	1.5-5.0	1.0-2.0
limonene	2.5-5.0	1.5-4.0
1,8-cineol	16.0-25.0	38.0-55.0
p-cymene	1.0-2.2	0.8-2.5
camphor	13.0-21.0	5.0-15.0
bornyl acetate	0.5-2.5	0.1-1.5
terpineol	1.0-3.5	1.0-2.6
borneol	2.0-4.5	1.5-5.0
verbenone	0.7-2.5	0.4

Brain and nervous system conditions. In general debility long-term nervous or physical illness, improves the memory, insomnia, mental fatigue, nervous anxiety and tension, nervous depression, nervous disorders, restorative effect on the nervous system, soothes the nerves, stimulates the brain and nervous system, tension headaches, and migraines.

Cardiovascular conditions. It improves circulation, raises blood pressure, and stimulates the weak heart subject to palpitation when consumed in small doses.

Gastrointestinal circulatory systems. In conditions of bad breath, and stomach upset. Promotes proper digestion, toning and calming effect on the digestion.

Genitourinary conditions. Dropsy.

Female conditions. Regulates the menstrual cycle.

Liver conditions. Promotes liver function, promotes the production of bile.

Reproductive system conditions. Stimulates the sexual organs.

Respiratory system. Colds, colic.

Other. Eases cramps, expels morbid matter from the system, failing eyesight, headache.

Externally. It is used to treat bites, stings.

In aromatherapy the essential oil is used as a decongestant, as an inhalant, for exhaustion, for headaches, to enhance memory and clear concentration.

The oil is used in oils/lotions for Arthritis, bruises, eczema, gout, muscular pain, neuralgeia, revitalizing paralysed limbs, rheumatism, rheumatoid arthritis, sciatica, scrofulous sores, wounds and rubbed into hair for stimulating the hair bulbs to renewed activity and to prevent preature baldness.

Other uses. the oil is used as perfume in ointments, shampoos and soaps. The flowers are laid in clothes and cupboards to destroy moths. The leaves are crushed into meats, fish, potato salads, etc. to prevent food poisoning.

Experimental pharmacology

The plant is scientifically proved to possess anti-inflammatory activity [Lo 2002], antioxidant activity [Del Bano et al. 2003], antihepatotoxic activity [Fahim et al. 1999], antinephrotoxic activity [Makino et al. 2002], antimicrobial activity [Mangena and Muyima 1999], antitrypanosomal activity [Abe et al. 2002], antitumour activity [Singletary and Nelshoppen 1991], antiulcer activity [Dias et al. 2000], diuretic effects [Haloui et al. 2007], antispasmodic effects [Lis-Balchin 1996], osteoclastic effects [Muhlbauer et al. 2003], enzyme induction [Debersac et al. 2001], estrogenic effects [Zhu et al. 1998], immune stimulant activity [Hur et al. 2004], carcinogenesis, mutagenesis, impairment of fertility [Alkofahi et al. 1997].

Toxicology

The embryotoxic effects of d-camphor were investigated in rats and rabbits after intragastric administration for the treatment of hypotonic circulatory dysregulations [Leuschner 1997].

Clinical pharmacology

A clinical study to assess the olfactory impact of the essential oils of lavender (*Lavandula angustifolia*) and rosemary (*Rosmarinus officinalis*) on cognitive performance and mood in healthy volunteers was performed [Sanders et al. 2002, Diego et al. 1998].

REPORTED RESEARCH INVESTIGATIONS OF ROSEMARY

Singletary and Nelshoppen [1991]. "Inhibition of 7,12-dimethylbenz[c]anthracene (DMBA)-induced mammary tumorigenesis and of in vivo formation of mammary DMBA-DNA adducts by rosemary extract". Rosemary extract induces mammary tumerogenesis and in vivo formation of mammary dimethyl benz anthracene DNA adducts.

Al-Hader et al. [1994]. Hyperglycemic and insulin release inhibitory effects of *Rosmarinus officinalis*. The same treatment also resulted in a 30% ($P < 0.002$) decrease in serum insulin level, in comparison with that of control rabbits at the 30 min interval. In alloxan diabetic rabbits, *R. officinalis* volatile oil increased fasting plasma glucose levels by 17% ($P < 0.05$) above those of untreated animals 6 h after its administration.

Krause et al. [1999] studied the "Bioavailability of the antioxidative *Rosmarinus officinalis* compound carnosic acid in eggs". Using this method carnosic acid could be detected in 20 ng/g of egg yolk. Results showed that carnosic acid is bioavailable in egg yolk but not in albumen.

Yen et al. [1999] worked on the "Measurement of antioxidative activity in metal ion-induced lipid peroxidation systems". The antioxidant activity of

α-tocopherol is less than that of rosemary extracts in the iron ion-induced peroxidation systems.

Samman et al. [2000] reported that "Green tea or rosemary extract added to foods reduces nonheme-iron absorption". The presence of the phenolic-rich extracts resulted in decreased non heme-iron absorption.

Dias et al. [2000] reported that an ethanol (70%) extract was evaluated for antiulcerogenic activity *in--vivo*. Intragastric administration of 100.0 mg/kg body weight per day to 1.0 g/kg body weight per day of the extract decreased the ulcerative lesion index produced by ethanol and reserpine in rats. No antisecretory activity was observed in the pyloric ligation model.

Haloui et al. [2000] studied the effects of aqueous extracts of the crude drug on the treatment of kidney function and diuresis in rats were determined. Daily intragastric administration of the aqueous extracts of the leaves, at a dose of 10 ml/kg body weight of an 8% or 16% extract in distilled water for 1 week, significantly enhanced diuresis in rats compared to the control group from the fifth day of treatment ($p < 0.001$). No change was observed in plasma electrolytes and urea in any group, except for a decrease in sodium and chloride concentration in the group treated with the 16% extract of the crude drug. A decrease in creatinine clearance was observed after treatment with a daily dose of 8% extract.

Jaswir et al. [2000] studied "The synergistic effects of rosemary, sage, and citric acid on fatty acid retention of palm olein during deep-fat frying". A combination of 0.076% oleoresin rosemary extract, 0.066% sage extract, and 0.037% citric acid produced the optimal retention of the essential fatty acid.

Galobart et al. [2001] reported the "Effect of dietary supplementation with rosemary extract and *α*-tocopheryl acetate on lipid oxidation in eggs enriched with *ω*3-fatty acids". The antioxidant effect of dietary supplementation with 500 or 1,000 mg/kg of a commercial rosemary extract vs. 200 mg/kg of *α*-tocopheryl acetate (*α*-TA) on the lipid oxidative stability of *ω*3-fatty acid (FA) – enriched eggs was compared.

Sotelo-Félix et al. [2001] worked on the evaluation of the effectiveness of *Rosmarinus officinalis* (Lamiaceae) in the alleviation of carbon tetrachloride-induced acute hepatotoxicity in the rat). Histological evaluation showed that *Rosmarinus officinalis* partially prevented CCl4-induced inflammation, necrosis and vacuolation.

Park et al. [2001] reported the "Neuroprotective effect of rosmarinus officinalis extract on human dopaminergic cell line, SH-SY_5Y". *R. officinalis* might potentially serve as an agent for prevention of several human neurodegenerative diseases caused by oxidative stress and apoptosis.

Sacchetti et al. [2004] worked on the "Comparative evaluation of 11 essential oils of different origin as functional antioxidants, antiradicals and antimicrobials in foods". Antioxidant and radical-scavenging properties were tested by means of 1,1-diphenyl-2--picrylhydrazyl (DPPH) assay, b-carotene bleaching test and luminol-photochemiluminescence (PCL) assay.

Cavero et al. [2005] reported the "*In vitro* antioxidant analysis of supercritical fluid extracts from rosemary (*Rosmarinus officinalis* L.)". Using forward stepwise multiple linear regression, carnosic acid, methyl carnosate and carnosol were the compounds selected to predict the mentioned activity, with a value of 0.95 for the coefficient of determination.

Aziza Kamal et al. [2008] reported "Rosemary (*Rosmarinus officinalis*) – a study of the composition, antioxidant and antimicrobial activities of extracts obtained with supercritical carbon dioxide". Rosemary leaf extracts were obtained by supercritical fluid extraction (SFE) and Soxhlet extraction. Their chemical compositions were evaluated by GC-MS. Antioxidant, antibacterial and antifungal activities of the extracts were confirmed.

Kissi et al. [2009] reported "The evaluation of antioxidant potential of *Veronica officinalis and Rosmarinus officinalis* extracts by monitoring malondialdehide and gluthione levels in rats". The reduced and total glutathione were quantified from rat plasma, after derivatization with o-phtalaldehyde, using a HPLC method with fluorescence detection.

Gutierrez et al. [2009] studied the "Oxidative stress modulation by *Rosmarinus officinalis* in CCl_4-induced liver cirrhosis". The effect produced by a methanolic extract of *Rosmarinus officinalis* on CCl_4-induced liver cirrhosis in rats was investigated using both prevention and reversion models.

Malo et al. [2010] discussed the "Anti-oxidant supplementation improves boar sperm characteristics and

fertility after cryopreservation: Comparison between cysteine and rosemary (*Rosmarinus officinalis*): (1) the effective concentration of cysteine in freezing extender was 10 mM; (2) the addition of exogenous rosemary or cysteine to the freezing extender positively affected post-thawed viability and acrosome integrity. Only rosemary supplementation improved total motility at 3 h and progressive motility at any time.

Horvathova et al. [2010] discussed the "Administration of rosemary essential oil enhances resistance of rat hepatocytes against DNA-damaging oxidative agents". Administration to rats of rosemary oil, exhibiting free radical-scavenging activity measured by DPPH assay.

Ibarra et al. [2010] studied the "Importance of extract standardization and *in vitro/ex vivo* assay selection for the evaluation of antioxidant activity of botanicals: A case study on three *Rosmarinus officinalis* L. extracts". The carnosic acid extract was better than the rosmarinic acid extract in inhibiting the oxidation of LDL *ex vivo*.

Abu-Al-Basal [2010] worked on the "Healing potential of *Rosmarinus officinalis* L. on full-thickness excision cutaneous wounds in alloxan-induced-diabetic BALB/C mice". The essential oil of *Rosmarinus officinalis* was the most active in healing diabetic wounds and provided a scientific evidence for the traditional use of this herb in wound treatment.

Derwich et al. [2011] explored the "Aromatic and medicinal plants of Morocco: Chemical composition of essential oils of *Rosmarinus officinalis*" determined by hydro-distillation, analysed by GC/MS and GC-FID.

Muñoza et al. [2011] reported the "Rapid HPTLC--based method for quality control: simultaneous chemical analysis and antioxidant activity determination in herbal, nutraceutical and functional foods". 44 samples of *Calendula officinalis*, 18 samples of *Thymus vulgaris* and 12 samples of *Rosmarinus officinalis*, based on the combination of HPTLC with a diode array detector (DAD) and post chromatographic DPPH radical derivatization.

Tavafi and Ahmadvand [2011] worked on the "Effect of rosmarinic acid on inhibition of gentamicin induced nephrotoxicity in rats". RA alleviates GS nephrotoxicity via antioxidant activity, increase of renal GSH content and increase of renal antioxidant enzymes activity.

Noqueira de Melo et al. [2011] worked on "*Rosmarinus officinalis* L. essential oil inhibits *in vivo* and *in vitro* leukocyte migration". The effects of REO on leukocyte migration highlight an important mechanism of the anti-inflammatory action of rosemary.

Derwich et al. [2011] reported the "*In vitro* antibacterial activity and GC/MS analysis of the essential oil extract of leaves of *Rosmarinus officinalis* grown in Morocco". Their chemical composition was determined by hydro-distillation and analysed by GC/MS and GC-FID.

Boix et al. [2011] studied on the "Glandular trichomes of *Rosmarinus officinalis* L.: Anatomical and phytochemical analyses of leaf volatiles". It demonstrated the importance of leaves as a center of volatile production in peltate and capitate trichomes, as well as the nature of volatile composition, which is involved in species survival.

Coran et al. [2012] reported the "Crucial aspects of high performance thin layer chromatography quantitative validation. The case of determination of rosmarinic acid in different matrices". HPTLC Li-Chrospher silica gel 60 F254s, 20 cm × 10 cm, plates with toluene:ethyl formate:formic acid (6:4:1, v/v) as the mobile phase were used.

Tai et al. [2012] worked on "Antiproliferation effect of Rosemary (*Rosmarinus officinalis*) on human ovarian cancer cells *in vitro*". It induced apoptosis by modifying the expression of multiple genes regulating apoptosis, and holds potential as an adjunct to cancer chemotherapy.

Murata et al. [2012] "Promotion of hair growth by *Rosmarinus officinalis* leaf extract". Topical administration of *Rosmarinus officinalis* leaf extract (RO-ext, 2 mg/day/mouse) improved hair regrowth in C57BL/6NCrSlc mice that experienced hair regrowth interruption induced by testosterone treatment. The inhibition of testosterone 5α-reductase is well recognized as one of the most effective strategies for the treatment of androgenic alopecia.

ADVERSE REACTIONS AND CONTRA INDICATIONS OF ROSEMARY OIL

1. Inhalation can occasionally cause irritation and very rarely laryngospasm [Blumenthal 1998].

2. External use may worsen bronchospasm. Rarely hypersensitivity reactions of the skin may occur.

3. Photoaggravated allergic contact dermatitis and cheilitis have been reported. *Aetheroleum Rosmarini* [Armisen et al. 2003, Fernandez 1997, Guin 2001].

4. *Aetheroleum Rosmarini* is contraindicated in cases of hypersensitivity or allergy to the plant material [Blumenthal et al. 2000].

5. It should not be used in patients suffering from bronchial asthma or bronchitis or on damaged skin, such as in cases of burns, lesions or skin rashes.

PRECAUTIONS

Drug interactions

Cineole, the main constituent of the oil is known to induce liver metabolic enzymes in animals. Therefore, the oil may interact with other prescription medications. The crude drug is anti-mutagenic in rats treated with cyclophosphamide and is reported to be carcinogenic, mutagenic and produce impairment of fertility. It is reported show teratogenic effects and non-teratogenic effects in pregnancy. Due to the lack of safety data, the use of the crude drug during breastfeeding and children under the age of 12 is not recommended [Fahim et al. 1999, gits4u.com 2012].

CONCLUSION

Rosemary is an exotic evergreen shrub with multiple medicinal and cosmetic properties. It is popular herb which serves as flavoring agent and spice. Although it is well renowned for all these potencies, the oil of the plant is adhered with lot of side effects and hence lacks safety data. Therefore the use rosemary in pediatrics, as well as pregnant women should be always dealt with utmost care.

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