SCIENCE OF SPICES & CULINARY HERBS

LATEST LABORATORY, PRE-CLINICAL, AND CLINICAL STUDIES

Editors:
Atta-ur-Rahman
M. Iqbal Choudhary
Sammer Yousuf

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Science of Spices and Culinary Herbs

Latest Laboratory, Pre-clinical, and Clinical Studies

(*Volume 4*)

Edited by

Atta-ur-Rahman, *FRS*
Kings College, University of Cambridge, Cambridge, UK

M. Iqbal Choudhary

&

Sammer Yousuf
H.E.J. Research Institute of Chemistry, International Center for Chemical and Biological Sciences, University of Karachi, Karachi, Pakistan

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Singapore
Email: subscriptions@benthamscience.net

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PREFACE

According the World Health Organization, the overwhelming majority of people, both in the developed and the developing world, rely on alternative and complementary medicines and botanicals for the prevention and treatment of diseases. The world market of botanicals already exceeds 100 billion USD with a CGAR of 21.7%, making it one of fastest growing industries globally. With the importance of herbal products in health and economy, the field is receiving much attention of the scientific community, particularly with respect to safety, efficacy, standardization and method development towards regulatory compliance. Culinary herbs and spices have several added advantages over other non-dietary herbs. Since they are nontoxic, palatable, and culturally acceptable, they therefore occupy a high place in the global business of botanicals. These fascinating herbs are now used in all kind of products, including nutraceuticals and health supplements. Personal care items, beverages, aromatherapy products, fragrances or cosmetics are other fields in which they are commonly found. The key objective of this book series entitled ***"Science of Spice & Culinary Herbs"*** is to provide a comprehensive account of the most recent scientific researches, carried out on the most common spices and dietary herbs. The first three volumes of the book series have received immense appreciation and overwhelming interest. The 4th volume of the series contains five comprehensive review articles, covering scientific studies on pharmacological, clinical and industrial uses of several common herbs and spices.

The review by Boskabady *et al* is focused on recent studies on molecular and cellular aspects of anti-inflammatory, antioxidant, and immunomodulatory effects of *Curcuma longa*, commonly known as turmeric. These studies firmly establish the therapeutic potential of this well-known spice against various diseases. Flax seeds (*Linum ustatissimum*) have attracted major scientific and general interest in recent years due to the omega-3-fatty acid content and fiber contents which make it an attractive health food. Chandra *et al* have contributed a review on pharmacological and clinical studies on flax seeds in the context of their lipid lowering, anti-oxidant, anti-obesity properties as well as their role in prevention of cancers, cardiovascular, cerebrovascular, and gastrointestinal diseases. Mohi-ud-din *et al* have reviewed the pharmacological, clinical and phytochemical studies carried out on the globally popular traditional spice *Nigella sativa* (black cumin) and its main phytoconstituent thymoquinone, demonstrating iys potential for the treatment of various diseases. The Article of Escobedo-Bonilla covers an interesting aspect of the usefulness of essential oils of Mexican oregano (*Lippia* species) as antimicrobial agents for aquaculture industry, thus avoiding the use of synthetic antibiotics and biocidal compounds. Last article in the volume is centered around the pharmacological properties and medicinal benefits of curry leaf (*Murraya koenigii*). The authors (Mir *et al*) has also provided details of various phytochemicals obtained from this flavoring herb used in South-Asian cuisines.

We wish to express our profound gratitude to all the authors for their excellent contributions. We would also like to thank the excellent team of Bentham Science Publishers, particularly Ms. Fariya Zulfiqar (Manager Publications) and Mr. Mahmood Alam (Editorial Director) for the timely completion and release of the 4th volume of this important book series. We sincerely hope that this volume, like the previous volumes of this book series will contribute to the better understanding of the immense health benefits of spices and culinary herbs, nature's gifts to humanity, and trigger further research and development in this important field.

Atta-ur-Rahman, *FRS*
Kings College
University of Cambridge
Cambridge
UK

M. Iqbal Choudhary & Sammer Yousuf
H.E.J. Research Institute of Chemistry
International Center for Chemical and Biological Sciences
University of Karachi
Karachi, Pakistan

List of Contributors

A. Memarzia	Department of Physiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
Abdul Jalil Shah	Pharmaceutical Chemistry Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India
Cesar Marcial Escobedo-Bonilla	Instituto Politécnico Nacional-CIIDIR Sinaloa. Blvd Juan de Dios Batiz Paredes 250, Colonia San Joachin, Guasave, Sinaloa, Post Code 81101, Mexico
Dinesh Kumar Yadav	SGT College of Pharmacy, SGT University, Gurugram-122 505, Haryana, India
M.H. Boskabady	Applied Biomedical Research Center, Mashhad University of Medical Sciences, Mashhad, Iran Department of Physiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
M.R. Khazdair	Cardiovascular Diseases Research Center, Birjand University of Medical Sciences, Birjand, Iran
Nazia Banday	Pharmacognosy Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India
Neetu Sachan	School of Pharmaceutical Sciences, IFTM University, Lodhipur Rajput, Delhi Road (NH-24), Moradabad (UP)-244, India
Phool Chandra	School of Pharmaceutical Sciences, IFTM University, Lodhipur Rajput, Delhi Road (NH-24), Moradabad (UP)-244, India
Prince Ahad Mir	Amritsar Pharmacy College, 12 KM stone Amritsar Jalandhar GT Road, Mandwala-143001, India
Rafia Jan	Department of Pharmacology & Toxicology, National Institute of Pharmaceutical Education & Research (NIPER), Mohali -160062, Punjab, India
Reyaz Hassan Mir	Pharmaceutical Chemistry Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India
Roohi Mohi-ud-din	Pharmacognosy Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India
S. Behrouz	Department of Physiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
Saba Sabreen	Pharmaceutical Chemistry Division, Department of Pharmaceutical Sciences, School of Applied Sciences and Technology University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India
Saeema Farooq	Pharmacognosy and Phytochemistry Division, Department of Pharmaceutical Sciences, School of Applied Sciences and Technology, University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India
Sanjay M. Jachak	Department of Natural Products, National Institute of Pharmaceutical Education & Research (NIPER), Mohali, Punjab-160062, India

Taha Umair Wani Pharmaceutics Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India

Z. Ghlamnezhad Applied Biomedical Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
Department of Physiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

Zulfiqar Ali Bhat Pharmacognosy Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India

CHAPTER 1

Pharmacological Effects of *Curcuma longa*, Focused on Anti-inflammatory, Antioxidant and Immunomodulatory Effects

M.H. Boskabady[1,2,*], M.R. Khazdair[3], A. Memarzia[2], S. Behrouz[2] and **Z. Ghlamnezhad[1,2]**

[1] *Applied Biomedical Research Center, Mashhad University of Medical Sciences, Mashhad, Iran*

[2] *Department of Physiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran*

[3] *Cardiovascular Diseases Research Center, Birjand University of Medical Sciences, Birjand, Iran*

Abstract: *Curcuma longa* (*C. longa*) or turmeric is a plant with a long history of use in traditional medicine, especially for treatment of inflammatory conditions. Also, pharmacological effects such as antioxidant and anti-microbial properties were described for this plant. This chapter reports the latest knowledge on anti-inflammatory, antioxidant and immunomodulatory effects of *C. longa* based on a literature survey using various databases and appropriate keywords until the end of July 2020. Various studies showed anti-inflammatory effects of *C. longa*, including decreased total white blood cells (WBC), neutrophils and eosinophils, as well as its effects on serum levels of inflammatory mediators such as phospholipase A2 (PLA2) and total protein in different inflammatory conditions. The anti-toxin effects of *C. longa* were also reported in several studies. The plant extracts decreased malondialdehyde and nitric oxide levels but increased thiol, superoxide dismutase, and catalase levels in oxidative stress conditions. Treatment with *C. longa* improved the levels of IgE, pro-inflammatory cytokines including interleukin (IL)-4, transforming growth factor beta (TGF-β) and IL-17 as well as anti-inflammatory cytokines such as interferon gamma (IFN-γ) and forkhead box P3 ($FOXP_3$) and T helper cells 1 Th_1/Th_2 ratio in various conditions with disturbed immune balance. The reviewed papers showed anti-inflammatory, antioxidant and immunomodulatory effects of *C. longa,* indicating potential therapeutic property of the plant for treatment of inflammatory, oxidative and immune-dysregulation diseases.

Keywords: Anti-inflammatory effect, Antioxidant effect, *Curcuma longa*, Immunomodulatory effect, Inflammation, Oxidative stress.

[*] **Correspondence author M.H. Boskabady:** Applied Biomedical Research Center, Mashhad University of Medical Sciences, Mashhad, Post Code 9177948564, IR Iran; Tel: 0095 1388 0022 28, Fax: 0098 5138 828564;
E-mails: boskabadymh@mums.ac.ir and boskabady2@gmail.com

Atta-ur-Rahman, M. Iqbal Choudhary & Sammer Yousuf (Eds.)
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INTRODUCTION

Curcuma longa (C. longa) as a perennial herb, is a member of Zingiberaceae family distributed in the tropical region [1]. Turmeric is a golden spice derived from the rhizome of *C. longa* that has been used as a food ingredient for its color, flavor, and taste. Turmeric has been used in Ayurvedic and folk medicines for treatment of various diseases such as gastric, hepatic, gynecological, and infectious diseases for a long time [2].

Bioactive constituents of the plant include diarylheptanoids (curcuminoids), diarylpentanoids, phenylpropenes, vanillic acid and vanillin (as phenolic compounds), monoterpenes, sesquiterpenes, diterpenes and triterpenoids (as terpenes), linoleic acid, 8,11-octadecadienoic acid, methyl ester, oleic acid and stearic acid (as various fatty acids), β-sitosterol, stigmasterol and gitoxigenin (as steroids) and other minor compounds [3].

Several pharmacological effects were described for *C. longa* such as relaxant effects on various types of smooth muscle [4 - 7], anti-asthmatic [8], antioxidant [9 - 12], anti-inflammatory [13 - 15], and anti-cancer [16, 17] activities.

In this chapter, anti-inflammatory, antioxidant and immunomodulatory effects of C. *longa*, based on experimental and clinical studies, are shown.

METHODS

Studies regarding anti-inflammatory, antioxidant, and immunomodulatory effects of *C. longa* were retrieved from various databases such as Google Scholar, Scopus, PubMed, and Web of Science using appropriate keywords, such as *Curcuma longa*, turmeric, anti-inflammatory, antioxidant, and immunomodulatory. The data until the end of July 2020 was retrieved.

Anti-inflammatory Effects of *C. longa*

In various inflammatory conditions, macrophages, neutrophils and other inflammatory cells secrete considerable amount of different inflammatory mediators which cause tissue damage, resulting in various inflammatory disorders [18]. Therefore, natural products with anti-inflammatory properties could be considered potential candidates for treating inflammatory disorders. This topic has gained significant interest in recent years.

Three properties of turmeric are responsible for its anti-inflammatory effect. Firstly, turmeric decreases the production of histamine-induced inflammation. Secondly, the plant is able to increase and prolong the effect of cortisol which is a

natural anti-inflammatory hormone of the body secreted by adrenal glands. Thirdly, turmeric increases blood flow leading to the removal of toxins from the small joints in which cellular waste and inflammatory compounds are often trapped [19].

Anti-inflammatory Effects of *C. longa,* Animal Studies

Potent anti-inflammatory effects were shown for the volatile oils of *C. longa* and curcumin in acute inflammation. Oral administration of *C. longa* in rats with Freund's adjuvant-induced arthritis significantly reduced inflammatory swelling compared to controls. In addition, curcumin inhibited neutrophil aggregation associated with inflammation in monkeys. Oral administration of curcumin was as effective as cortisone and phenylbutazone in cases of chronic inflammation [19]. *C. longa* ethanolic extract (250, 500 and 1000 mg/kg b.w) prevents edema in albino rats and its anti-inflammatory activity (at the dose of 1000mg/kg b.w) was comparable to aspirin. These findings indicate anti-inflammatory effects of *C. longa* and suggest its potential to prevent and treat inflammatory diseases such as edema [20]. Also, bone erosion was controlled by 60 mg/kg and osteophyte formation did not occur. The bone erosion in the ankle joints was also successfully prevented by *C. longa* at a dose of 110 mg/kg. Also, *C. longa* suppresses the production of pro-inflammatory cytokines especially IL-1 and TNF-α. The results showed that radiological changes in CIA rats were supressed in group treated with *C. longa*. Therefore, in diseases like arthritis, *C. longa* has a preventive effect by its anti-inflammatory properties [13].

In carrageenan-, dextran-, and formalin-induced inflammation in mice treated with turmeric oil dissolved in paraffin oil and given orally at different doses for 30 days, reduction of the paw thickness in carrageenan, dextran-induced acute inflammation, and formalin-induced chronic inflammation at dose of 1000 mg/kg b.w was shown when compared with the control group. These results demonstrated that turmeric oil reduced both acute and chronic inflammatory processes [21]. In both acute exudative (xylene-induced ear edema) and chronic proliferative (cotton pellet granuloma) inflammation models in male albino Swiss mice and albino Wistar rats, curcuminoids and oil-free aqueous extract (COFAE) of *C. longa* at doses of 45, 90, and 180 mg/kg, revealed a significant anti-inflammatory potential due to the presence of bioactive principles in the extract. The COFAE of *C. longa* significantly inhibited the wet and the dry weights of the pellets which correlated with transudative and proliferative (granuloma tissue) components of inflammation. COFAE also reduced the number of fibroblasts and the synthesis of collagen and mucopolysaccharides that are involved in the formation of granuloma tissue. Therefore, COFAE of *C. longa* demonstrates anti-inflammatory effects on acute and chronic inflammation [22].

CHAPTER 2

Ethnomedicinal Uses, Phytochemistry, Pharmacological Effects, Pre-clinical and Clinical Studies on Flaxseed: A Spice with Culinary Herb-based Formulations and its Constituents

Neetu Sachan[1], Dinesh Kumar Yadav[2] and **Phool Chandra[1,*]**

[1] *School of Pharmaceutical Sciences, IFTM University, Lodhipur Rajput, Delhi Road (NH-24), Moradabad (UP)-244 102, India*

[2] *SGT College of Pharmacy, SGT University, Gurugram- 122 505, Haryana, India*

Abstract: Flaxseed is an annual herb commonly known as linseed *Linum usitatissimum* Family: (Linaceae) comes from the flax plant. This is traditionally used in various diseases, such as asthma, cough, bronchitis, pleurisy, pneumonia, joint pain, renal colic, renal calculi, rheumatic swelling, preparation of paints and coatings, printing inks, soap, core oils, brake linings, and herbicide adjuvant. This is a rich source of various phytoconstituents, such as- omega-3 fatty acid, lignans, linolenic acid, α-lignin, secoisolariciresinol, di-glucoside, caffeic acid, p-coumaric acid, ferulic acid, high-quality proteins, fibre, phenolic acids, flavonoids, vitamins, various mineral, phenylpropanoids, and tannins. These mixes give bioactive incentive to the strength of animals and people through their mitigating activity, hostile to oxidative limit, lipid adjusting, antimicrobial properties, many types of cancer, diabetes, cardiovascular diseases, cerebrovascular stroke, antimalarial, anti-obesity, gastrointestinal health, brain development, hormonal status in menopausal women, atherosclerosis, arthritis, osteoporosis, antiestrogen, autoimmune and neurological disorders. As a functional food and nutraceutical fixing, it has been joined into heated nourishments, juices, milk, dairy items, biscuits, dry pasta items, macaroni, and meat items. Also, some clinical preliminaries have been indicated that flaxseed can have a significant role in diminishing bosom malignant growth risk, essentially in postmenopausal ladies. When used orally, ground flaxseed is likely safe and has been used in a variety of dosages and intervals in clinical trials. Flaxseed having lignin, which is possibly safe to use up to 12 weeks while raw and unripe flaxseed can be potentially toxic due to its potential for cyanogenic glycosides. Common adverse effects include gas, bloating, diarrhea, constipation, and it can increase the risk of bleeding. It should be avoided in pregnancy and lactation.

* **Corresponding author Phool Chandra**: School of Pharmaceutical Sciences, IFTM University, Lodhipur Rajput, Delhi Road (NH-24), Moradabad (UP)-244 102, India; Tel: +91 591 2360818; E-mail: chandraphool@gmail.com

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Keywords: Flaxseed, Lignin, Linaceae, Linseed, *Linum usitatissimum*, Omega-3 Fatty Acid.

INTRODUCTION

Linseeds are the matured dried ripe seeds of *Linum usitatissimum*, belonging to the family: Linaceae. About 40% of the seed is produced and exported by Canada throughout the world. It is found in various nations, the US, Canter East, US, India, and Russia. Linseed is an annual herb that is normally available throughout Egypt. It has been cultivated worldwide for many numerous hundreds of years that its geological beginning is questionable. The business of flaxseed originates from Turkey, Argentina, India, Morocco, and other nations to Europe [1 - 3]. Flaxseed utilized in Chinese medication is delivered fundamentally in Internal Heilongjiang, Mongolia, Jilin areas, Liaoning, and [4] and its medication utilized in Indian is widely developed throughout India, generally in Bengal, Bihar, and the Unified territories [2, 5, 6]. It is one of the most seasoned developed plants around the world [3]. Burial chambers of Egypt are having fabric of flax. The Book of scriptures specifies in Departure that the devout Jewish clerics wore articles of clothing produced using flax [7]. Linseed is cultivated for the oil, and it has various medicinal characteristics due to the presence of their phytoconstituents. This is known for its significant medicinal plant worldwide. Plants consolidations into the eating regimen are especially alluring for explicit medical advantage. It is considered as protected nutraceuticals that give us minerals, proteins and peptides, lipids as omega-3 and omega 6 polyunsaturated fats, starches, lignans, and dietary filaments [8 - 12]. In recent years, the interest of plant protein utilized as useful food fixings in the food business ceaselessly step by step expanding because utilitarian properties, for example, gelation, emulsion, frothing limits, can add to the tactile qualities of different kinds of food items. Logical confirmations bolster the utilization of linseed for the high-quality content in omega-3, omega-6 rich oil, α-linolenic corrosive, lignans, amazing proteins and strands, blends which are organically unique in the balance of some constant disease, for example, numerous kinds of malignant growth, diabetes, cardiovascular illnesses and cerebrovascular stroke [13, 14].

Plants can be portrayed as a significant wellspring of medications, not just as disconnected dynamic standards to be administered in normalized measurement structure yet additionally as rough medications for the population [15, 16]. In the current situation, the interest for natural items is developing exponentially worldwide, and significant Pharmaceutical organizations are right now leading broad examinations on plant materials for their possible medicinal value [17, 18]. Developing interest, the market esteem, and the absence of nature of crude materials, which influences the security and viability, made the requirement for

normalization and basic assessment of the home-grown medications [19, 20]. This is important oilseed harvests for the present-day likewise as diet, feed, and fiber purposes. The Profile of Flaxseed is considered as following:

Biological Sources

The drug consists of the dried, ripe seed of *Linum usitatissimum* Linn. The oil can be obtained by cold expression and belonging to the Family: Linaceae [13].

Ethnomedicinal Uses

In the present scenario, the utilization of plants in various countries such as North America, Europe, and Asia, and medication of plant are following by Roman people. Significantly further to Egyptian and Greek. Pliny the Elder (ca. 23–79 C.E.) there is a report that 30 were cured by utilizing the seed of flaxseed. It can be used orally as a mild purgative and for local inflammation as topical poultice [21, 22]. It has been reported for constipation and dry tingling in the Chinese Pharmacopeia [23]. The Pharmacopeia of Ayurveda supports its topical use for boils as carbuncles and poultice. While its inside use as purgative and for shooting effects [6]. Poultices of a drug are uses in the treatment of abscesses, relief of pain, and inflammations in customary American medication [24]. Medication for veterinary used as emollient currently [25]. Normally flaxseed, entire or squashed with water used for purgative in Germany. It is additionally arranged in the form of an adhesive and slop in demulcent. It is applied as a hot clammy cataplasm, poultice or pack for the treatment of inflammation [3, 26]. In the United States, it is utilized similarly. However, American consumers are bound to accept seed as a part of a well-being food or nutraceutical item.

This is traditionally utilized in different diseases, for example, asthma, cough, bronchitis, pleurisy, pneumonia, joint pain, renal colic, renal calculi, rheumatic swelling, preparation of inks for painting, paints, core oils, cleanser, brake linings, and herbicides adjuvant and cleanser. Aside from this, the linseed is utilized in the treatment of gout and for as demulcent gouty and for the treatment for rheumatic swelling. The mucilaginous infusion is utilized inside as demulcent in cough and colds, and bronchial infection, inflammation of the urinary tract, gonorrhea, and dehydration. Oil of linseed has been utilized in different forms as a demulcent, diuretic, emollient, expectorant, and purgative properties and is used externally in lotion and liniments. As the linseed oil has a characteristic high 'iodine value' it is utilized for the most in the arrangement of Balm cleanser, Non-recoloring iodine salve flooring, varnishes, paints, clay, oils, shines, polymers, varnishes, oil materials, printing inks, tanning and enamelling leather, counterfeit elastic, following fabric and so forth. These are additionally arranged from Linseed oil. Restoratively, linseed oil is generally suggested for outside applications just;

CHAPTER 3

Nigella Sativa (Prophetic Medicine): The Miracle Herb

Roohi Mohi-ud-din[1,*], Reyaz Hassan Mir[2], Taha Umair Wani[3], Abdul Jalil Shah[2], Prince Ahad Mir[4], Nazia Banday[1], Rafia Jan[5], Asma Mohi-ud-din[6] and **Zulfiqar Ali Bhat[1,*]**

[1] *Pharmacognosy Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir 190006, Kashmir, India*

[2] *Pharmaceutical Chemistry Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir 190006, India*

[3] *Pharmaceutics Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir 190006, India*

[4] *Amritsar Pharmacy College, 12 KM stone Amritsar Jalandhar GT Road, Mandwala-143001, India*

[5] *Department of Pharmacology & Toxicology, National Institute of Pharmaceutical Education & Research (NIPER), Mohali, Punjab-160062, India*

[6] *Department of Food Science & Technology, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir 190006, India*

Abstract: *Nigella sativa* Linn. belongs to the family Ranunculaceae and is recognized as a prophetic medicine because of its mention in Prophetic Hadith, as a natural remedy for all diseases except death. It is known as Habat-ul-Barakah/Habat-ul-Sauda in Arabian countries and as Kalonji in India. As per Tibb-e-Nabwi (Prophetic Medicine), its daily consumption has been highly suggested. Considering its potential, ancient herbalists have termed it as 'the Herb from Heaven.' Ibni Sina, famous as Avicenna in the West, also referred to *N. sativa* as the seed "that stimulates the body's energy and helps recovery from fatigue" in his great book "The Canon of Medicine." Seeds and oil of *N. sativa* have a long history of folklore usage in various systems of medicines and food like Unani and Tibb, Ayurveda and Siddha. Numerous studies support that the seed of *N. sativa* and specifically its main active constituent, thymoquinone, has significant potential and possesses a broad range of biological activities like antihypertensive, diuretics, digestive, hepatoprotective, anti-cancer, appetite stimulant, anti-diarrheal, nephroprotective, neuroprotective, analgesics, anti-bacterial, and in treating skin disorders. In this chapter, we intend to present a comprehensive review of traditional and ethnomedicinal uses of Nigella seeds in different systems of traditional

[*] **Corresponding authors Zulfiqar Ali Bhat and Roohi Mohi-ud-din:** Department of Pharmaceutical Sciences, School of Applied Science and Technology, University of Kashmir, Hazratbal, Srinagar, J & K-190006, India; Tel: 9419077701;
E-mails: zabhat@kashmiruniversity.ac.in and roohidin@kashmiruniversity.net

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medicines. Then, the present chapter is directed towards highlighting the beneficial contribution of researchers to explore the pharmacological actions with the therapeutic potential of this miraculous herb and its bioactive compounds in modern medicine as *in vitro*, *in vivo*, and clinical studies to reveal its potential for the treatment of various diseases.

Keywords: Black seeds, Habat-ul-Barakah, Islamic Traditional Medicine, *Nigella sativa*, Thymoquinone, *N. sativa* oil, Tibb-e-Nabwi, Pharmacological actions, Phytochemistry.

INTRODUCTION

Since ancient times natural sources are utilized for treating various ailments, and due to intensive research, various herbal products are prepared for the debilitating disease, which are potent in action with no or minimal side effects. The use of these herbal products has now surpassed the allopathic methods of treatment worldwide, and as per WHO, 80% of the global population relies on herbal products for primary health care needs [1 - 3]. In Unani, Chinese and Indian System of medicine, medicinal plants have been frequently used in traditional medicine, and most of them have been explored for treating various disorders like diabetes, hyperlipidemia [4], arthritis [5, 6], inflammation [7, 8], gastrointestinal diseases, headache and migraine, fertility, renal injury, obesity, respiratory diseases [9 - 11], neurological disorders [12, 13], liver disorders [14] and cancers [15]. Among various medicinal plants which have been thoroughly studied for therapeutic properties, mechanism of action, safety, and toxicity, black seed (*Nigella sativa*) is one of the popular plants in traditional medicines having a wide range of pharmacological activities.

TAXONOMY, BOTANICAL DESCRIPTION, AND DISTRIBUTION

Nigella sativa (*N. sativa*; NS), commonly called black seed, black cumin, kalonji, nigella, habat-ul-baraka, is an indigenous plant of northern Africa, southern Asia, and Europe [16]. *N. sativa* is an annual herbaceous spice commonly cultivated in the subtropical regions, Morocco, Turkey, Syria, northern Africa, India, and West Asia [17].

N. sativa belongs to the kingdom Plantae, division Tracheophyta and family Ranunculaceae. The complete taxonomy of *N. sativa* is depicted in Fig. (**1**).

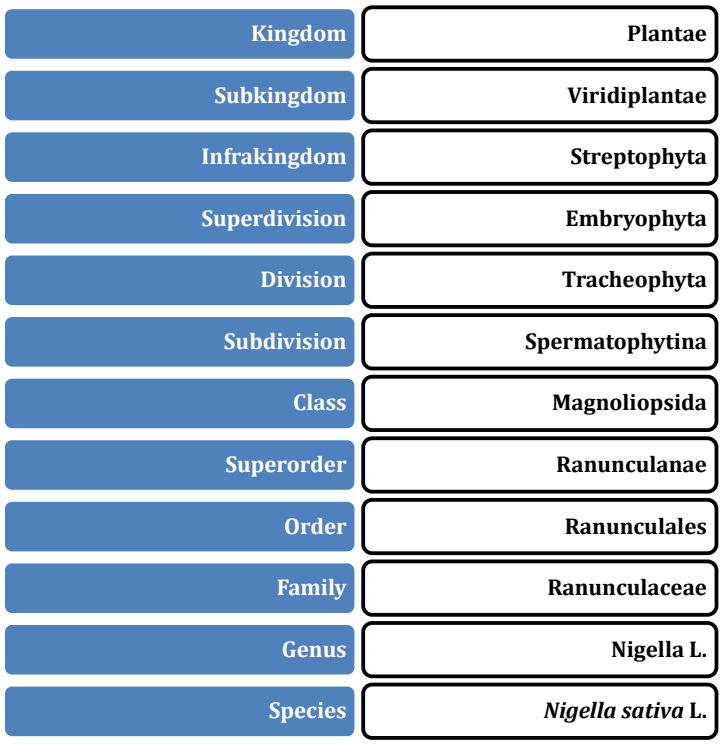

Fig. (1). Taxonomical classification of *Nigella sativa*.

The plant is used for culinary purposes in Asia and the Middle East. It is an erect plant with 30 to 60 cm in height. The plant possesses compound greyish green, feathery leaves with no marginal blades and consists of two or more small leaflets. The stem throughout consists of one leaf per node. The flower of the plant is light blue, possessing radial symmetry and consisting of five sepals, five petals, five carpels, a petaloid, and several stamens. The fruit of NS is a capsule with epicalyx and numerous nectaries. The capsules contain 0.15 to 0.3 cm long black trigonous seeds having fennel-like aroma [18]. Seeds that are black-coloured and slightly curved with three edges are enclosed within seed pods (Fig. **2**). The plant takes one year to mature. Whole black cumin seed can be characterized by a very dark colour and a thin, crescent shape with a pungent, bitter taste and smell. The cultivation period of NS is mostly between November and April, and germination lasts for about 10-15 days after sowing seeds. The flowering and fruiting times of the plant are generally from January to April [17, 19].

CHAPTER 4

Properties of Mexican Oregano (*Lippia* spp.) Essential Oils and their Use in Aquaculture

Cesar Marcial Escobedo-Bonilla[1,*]

[1] *Instituto Politécnico Nacional-CIIDIR Sinaloa. Blvd Juan de Dios Batiz Paredes 250, Colonia San Joachin, Guasave, Sinaloa, Post Code 81101, Mexico*

Abstract: Aquaculture is an important animal production industry and since its beginnings it has been threatened by the occurrence of infectious diseases of various etiologies. Of these, bacterial diseases are one of the most damaging both to fish and shellfish aquaculture. The use of antibiotics to control such infections poses a number of disadvantages such as low efficacy, antibiotic resistance and antibiotic residues in product, water and soil. One of the alternatives to antibiotic use is the application of plants with antimicrobial properties, and other pharmacological activities. Mexico has an ancient knowledge and use of medicinal plants, which are still used. Many plants of the family Verbenaceae, genus *Lippia* are commonly known as Mexican oregano. These seem to form a complex of closely related species, including *L. graveolens*, *L. berlandieri*, *L. alba* and other infraspecies which are located between the Chihuahua desert to southern Mexico and Central America. These species are usually used as spices to flavor food. Nonetheless, they also have different medicinal properties and have been traditionally used to treat a number of illnesses and ailments. One of their curative properties is antimicrobial, and therefore, many studies have been done in various species of the complex to elucidate their chemical composition and effect in various biological systems both in human and veterinary medicine. The study of Mexican oregano species in aquaculture is very recent, but it has uncovered a number of very useful pharmacological properties, including anesthetic, anti-stress and anxiolytic, antiparasite and antimicrobial. The present chapter presents a review on general aspects of aquaculture, its history, the main infectious agents affecting the industry and the current control measures used against diseases. It also focuses on the application of essential oils of some *Lippia* species regarded as Mexican oregano and their use as alternative natural products to antibiotics and other chemicals used in aquaculture.

Keywords: Anaesthetics, Antimicrobial activity, Aquaculture, Aquatic animal health, Carvacrol, Essential oils, Fish, Infectious diseases, *Lippia* spp. , Oregano, Oysters, Shrimp, Sisease control methods, Thymol.

[*] **Correspondence author Cesar Marcial Escobedo-Bonilla:** Instituto Politécnico Nacional-CIIDIR Sinaloa. Blvd Juan de Dios Batiz Paredes 250, Colonia San Joachin, Guasave, Sinaloa, Post Code 81101, Mexico; Tel: +52 5729-6000 x 87637; E-mail: cesar_escobedomx@yahoo.com

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INTRODUCTION

Aquaculture probably is the most recent animal production industry. This activity has improved aquatic production of fish and shellfish through the culture of other aquatic organisms such as rotifers, copepods, brine shrimp and microalgae, which are used as live food for larval stages of fish and shellfish [1, 2]. It also has boosted the culture of aquatic plants, seaweeds and microalgae for human consumption and industrial uses [2, 3]. This industry has shown steady growth in the last four decades, making it one of the most productive activities. At present, aquaculture contributes almost half (46.8%) of the overall volume of certain fish and shellfish species [1]. Despite this impressive growth and development, aquaculture has been threatened since its beginnings by a number of factors, of which infectious diseases are probably one of the most damaging [4 - 6].

Strategies to control or reduce the impact of infectious diseases have been implemented throughout the different culture systems and farmed species. Such strategies include the domestication of stocks and development of specific pathogen-free (SPF) or specific pathogen-resistant (SPR) animal stocks; pathogen exclusion using sieves and other devices that prevent the entry of vectors/carriers of pathogens; using chemical and/or physical means to disinfect the water, soil and tools in the hatcheries and farms [5, 7]. Antibiotics are commonly used in hatcheries and grow-out ponds to tackle infectious diseases caused by bacteria. They are routinely used in various activities such as maintaining water quality; transportation and manipulation of animals at different stages, added to feed formulations as growth promotors, to enhance reproduction, treat diseases and general health management [5, 8].

Although the application of such strategies has shown good results against some infectious diseases, their associated effects can also cause damage to the environment, increasing the risk to human health due to the exposure of aquaculture workers to the residues of chemicals used in feeding, treating or preventing diseases. Substances such as antibiotics, hormones and disinfectants may remain as residues in water, soil and the surfaces of the facilities. Also, it is possible that some pathogens become resistant to antibiotics used in human medicine, with the risk that consumers could become exposed to either those resistant pathogens and/or to antibiotic or chemical residues in the aquaculture products [5, 9].

The fight against infectious diseases caused by bacteria, fungi and viruses has brought up a series of associated risks and side-effects to the environment, microbial and human communities by using chemical disinfectants and antibiotics [10]. Natural products derived from plants and seaweeds with active compounds

that have a number of biological properties, including antimicrobial activity, could effectively be used to prevent or treat infectious diseases caused by bacteria, fungi and even viruses in aquaculture [11, 12]. Many of these alternative natural substances may reduce the negative impact of infectious diseases caused by microorganisms. Also, they could decrease the associated side-effects caused by the chemical products commonly used to tackle infectious diseases.

Among the various plants and herbs used to treat several diseases in humans, the Mexican oregano may have different properties and uses in aquaculture. The Mexican oregano is a collective group of up to 40 different species spanning along the country, belonging to four families: Verbenaceae, Lamiaceae, Asteraceae and Fabaceae [13 - 15]. Of these, two genera are the most commercially relevant: *Poliomintha* (Lamiaceae) and *Lippia* (Verbenaceae) [13, 14]. The Mexican oregano of the genus *Lippia* seems to be comprised of a complex of closely related species, including *L. graveolens, L. berlandieri* and other infraspecies which are located between the Chihuahua desert to southern Mexico and Central America [14, 16]. The present chapter presents a review on general aspects of aquaculture, its history, the main infectious agents affecting the industry and the current control measures used against diseases. It also focuses on the application of essential oils of some *Lippia* species regarded as Mexican oregano and their use as alternative natural products to antibiotics and other chemicals used in aquaculture.

AQUACULTURE

Aquaculture is the activity of raising species of fish, shellfish and other aquatic animals, algae and aquatic plants through technological intervention in some or all their life cycle stages [1, 17]. The cultured species often are commercially important as a high quality protein food source, but many other species can be raised for ornamental purposes [18]. Aquaculture can be done in pens, ponds or farms located inland or within their respective marine, brackish and/or freshwater environments [1, 17].

The history of aquaculture is ancient. It is known that China is the cradle of aquaculture by culturing common carp as far as 4000 years ago. Also, records exist on the description of a fish pond in China in the 5th century B.C [17, 19 - 21]. Attempts of intensive fish culture were recorded in the middle kingdom in Egypt, and efforts for culturing shellfish and oysters in the Roman Empire have been reported [17, 22]. The Japanese, Romans and Greeks were probably the first oyster farmers. In Japan, oysters were cultured in intertidal zones 2000 years ago. Aristotle in Greece and Pliny in Rome give accounts of oyster cultivation around 100 BC [17].

CHAPTER 5

Curry Leaf: An insight into its Pharmacological Activities, Medicinal Profile, and Phytochemistry

Reyaz Hassan Mir[1,*], Nazia Banday[2], Roohi Mohi ud din[2], Saba Sabreen[1], Rafia Jan[3], Abdul Jalil Shah[1], Taha Umair Wani[4], Saeema Farooq[2], Sanjay M. Jachak[5] and **Mubashir Hussain Masoodi[1,*]**

[1] *Pharmaceutical Chemistry Division, Department of Pharmaceutical Sciences, School of Applied Sciences and Technology University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir 190006, India*

[2] *Pharmacognosy and Phytochemistry Division, Department of Pharmaceutical Sciences, School of Applied Sciences and Technology, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir 190006, India*

[3] *Department of Pharmacology & Toxicology, National Institute of Pharmaceutical Education & Research (NIPER), Mohali, Punjab-160062, India*

[4] *Pharmaceutics Division, Department of Pharmaceutical Sciences, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir 190006, India*

[5] *Department of Natural Products, National Institute of Pharmaceutical Education & Research (NIPER), Mohali, Punjab-160062, India*

Abstract: Throughout human history, medicinal plants are used in traditional medicine systems and are considered a potential source of healthy life. Curry leaf belongs to the family Rutaceae obtained from *Murraya koenigii*, which has been used widely as a spice, flavouring agent, and as herbal medicine since ancient times in the ayurvedic medicine system. Curry leaf is native to India and Sri Lanka. It is known for its flavour in cooking apart from various health benefits, including antidiabetic, anti-tumour, anti-inflammatory, and neuroprotection. Various carbazole alkaloids have been isolated from curry leaves, including mahanimbine, koenine, murrayacine, murrayazoline, koenimbine, murrayazolidine, murrayazoline, murrayacine, girinimbine, and mukoeic acid. Several studies on pharmacological activities of curry leaf *in vitro, in vivo*, and clinical trials confirm the application of curry leaf in traditional medicine and introduce some new medicinal aspects. The current review provides insight into phytochemical constituents, ethnobotany, and numerous pharmacological properties of crude extracts, fractions, and isolated compounds of curry leaf, leading to the development of effective drug candidates to address various ailments. Moreover, a comparison of the reported activities of a curry leaf in traditional medicine will be made with the modern medicine

[*] **Corresponding authors Mubashir Hussain Masoodi and Reyaz Hassan Mir:** Pharmaceutical Chemistry Division, Department of Pharmaceutical Sciences, School of Applied Sciences and Technology University of Kashmir, Hazratbal, Srinagar-190006, Kashmir, India;
E-mails: mubashir@kashmiruniversity.ac.in and reyazhassan249@gmail.com

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activities to show the potentiality of this precious herb in managing different disease conditions.

Keywords: Antioxidant, Bioavailability, Biological activity, *Murraya koenigii*, Phytoconstituents, Traditional medicine.

INTRODUCTION

At present, a large population among developing countries rely mostly on medicinal plant-based products for economic benefits, skincare, health care, and cultural development. From ancient times in traditional medicine systems, medicinal plants have been used extensively in countries like India, China, Germany, and Thailand. Many herbal extracts and isolated compounds have been used by practitioners as an alternative system of medicine for diseases like cancer, arthritis [1 - 3], diabetes, and for resolving the issues related to inflammation [4 - 7], neuroprotective, and hepatoprotective [8 - 11]. As per WHO reports, more than 80% of the world population depends on traditional medicine. The role of plants in human life has increased due to the advancements in the nutritional and medicinal disciplines. Several phytochemicals have been isolated from spices, herbs, and plants responsible for their medicinal properties [12 - 15].

Murraya koenigii (MK) is an ancient medicinal herb of the Rutaceae family, indigenous to India and China [16, 17]. It is commonly called curry leaves in Hindi. It is mostly widespread in the tropical and sub-tropical regions of the world [18]. Globally, there are 14 species of Murraya present, out of which only two are present in India, *viz*., *Murraya paniculata* (Jack) and *Murraya koenigii* (Spreng). The latter species is more significant owing to wide-spectrum homoeopathic properties.

The leaves of *M. koenigii* have a somewhat unpleasant taste, strong smell, and weak-acidic nature. They have been used in the treatment of pain, helminthiasis, and as an appetizer in Indian cuisine [19]. The roots possess a strong laxative property. The bark is used to treat poisonous insect bites. The leaves have also been used to treat dysentery, piles, bruises, oedema, itching and inflammation [20 - 23]. The volatile oil of the leaves holds anti-oxidant, anti-hepatotoxic [24 - 26], anti-fungal, anti-microbial [27], anti-inflammatory and anti-nephrotoxic properties [28].Various chemical components of the plant responsible for its therapeutic actions include carbazole alkaloids [29], flavonoids [20], terpenoids [30], carbohydrates [31], phenolics, vitamins, carotenoids [32], essential oil [16].

Some of the synonyms used are Curry leaves (English), Pindosine (Burmese), Folhas de caril (Portuguese), Karrry bald (Danish), Kerriebladeren (Dutch), Curry

blatter (German), Feuilles de Cari (French), Daunkari (Indonesian), Fogli de Cari (Italian), Hojas de curry (Spanish), Listya karri (Russian), Bevusoppu (Tulu), Kari-Patta (Hindi), Mahanimb (Sanskrit).

BOTANY, TAXONOMY AND DISTRIBUTION

Murraya koenigii is an aromatic, semi-evergreen tree, about 13 - 31 feet tall, with robust, willowy, dark green to brown coloured stem having about 16 cm diameter [33, 34]. The bark of the tree has longitudinal striations and is grey coloured. The leaves are compact and about 15 - 30 cm in length, 11 - 25 leaflets are present alternately, margins of the leaf have scalloped edges, petioles are 2 – 3 mm in length. The flowers are small, white-coloured with a pleasant fragrance, funnel-shaped, and bisexual. The ripe fruits are purplish-black in colour, having a spheroidal shape with a rough surface, and being 25 mm in length, and 3 mm diameter. The fruit has mostly two seeds, is green in colour, being 1.1 cm in length and diameter 0.8 cm [35].

Murraya koenigii originally belongs to southern and eastern parts of Sri Lanka, China, India, and Pakistan. It is commonly grown in South-East Asia and certain parts of Australia and the USA [36]. In India, the plant grows widely up to the altitude of 1500 – 1655 m [37]. Globally, there are 14 species of Murraya present, out of which only two are present in India *viz*., *Murraya paniculata* (Jack) and *Murraya koenigii* (Spreng) [38, 39].

ETHNOBOTANICAL AND ETHNOMEDICINAL KNOWLEDGE

Curry leaves are found to be the essential element of Indian cuisine as it helps to stimulate the appetite and improve digestion. Based on ethnobotanical and ethnomedicinal knowledge, MK has been used widely in the traditional system of medicines in East Asia [40]. It was used in the treatment of diabetes and dysentery and also found to act as a stomachic, stimulant, purgative and antipyretic [41]. Different parts of this plant, *viz*., roots, bark, and leaves, possess carminative, stomachic and tonic properties, with leaves being used in curing vomiting and dysentery [42]. Leaves of the plant can be externally applied for the treatment of eruptions and ecchymosis [43]. The roots and leaves of the plant are used to treat fever, pain, helminthiasis, piles, itching, inflammation, leukoderma and emesis [44].

The fruit of *M. koenigii* has been used as an astringent, the juice extracted from the roots has been used to treat the kidney pain and the leaves after crushing into a paste can be applied on external skin surfaces to treat burns, eruptions and to cure the poisonous bites of insects and animals [42]. The twigs of the plant can be used to clean the teeth, to prevent tooth decay and swelling of gums [45]. In Ayurveda,

SUBJECT INDEX

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ATTA-UR-RAHMAN, *FRS*

Prof. Atta-ur-Rahman, Ph.D. in Organic Chemistry from Cambridge University (1968) has 1,232 international publications (45 international patents and 341 books). He received the following awards: Fellow Royal Society (FRS) London (2006), UNESCO Science Prize (1999), Honorary Life Fellow Kings College, Cambridge University (2007), Academician (Foreign Member) Chinese Academy of Sciences (2015), Highest Civil Award for Foreigners of China (Friendship Award, 2014), High Civil Award Austria ("Grosse Goldene Ehrenzeischen am Bande") (2007), Foreign Fellow Chinese Chemical Society (2013), Sc.D. Cambridge University (UK) (1987), TWAS (Italy) Prize (2009). He was the President of Network of Academies of Sciences of Islamic Countries (NASIC), Vice President TWAS (Italy), Foreign Fellow Korean Academy of Science & Technology, President Pakistan Academy of Sciences (2003-2006) and (2011 – 2014). He was the Federal Minister for Science and Technology of Pakistan (2000 – 2002), Federal Minister of Education (2002) and Chairman Higher Education Commission/Federal Minister (2002-2008), Coordinator General of COMSTECH (OIC Ministerial Committee) (1996-2012), and the Editor-in-Chief of Current Medicinal Chemistry.

M. IQBAL CHOUDHARY

Dr. M. Iqbal Choudhary is a Distinguished National Professor of Organic/Bioorganic Chemistry and Director at the International Center for Chemical and Biological Sciences (H. E. J. Research Institute of Chemistry and Dr. Panjwani Center for Molecular Medicine and Drug Research) and Coordinator General of COMSTECH (OIC Ministerial Committee). He is among the most prominent scientists of Pakistan, recognized for his original contributions in the fields of natural products and bioorganic chemistry. He has written and edited 27 books, most of which have been published in USA and Europe. He is also the author of over 1000 research papers and chapters in top international science journals of the West as well as 27 US patents (H-index: 70 & Citations: 29,500). He is the Volume Editor of many international book series and journals. He has served as a visiting faculty in many prestigious universities of the world including Cornell University (New York), Purdue University (Indiana), Pennsylvania State University (Pennsylvania), Scripps Institution of Oceanography (San Diego, California), The University of Rhode Island (Rhode Island), and other top Universities.

SAMMER YOUSUF

Dr. Sammer Yousuf, Associate Professor at the H. E. J. Research Institute of Chemistry, International Center for Chemical and Biological Sciences, University of Karachi, is the author of over 200 research papers in top international journals, and five chapters of books, with total citations exceeding 2300 (H-Index 26). She is the pioneer of crystal engineering in Pakistan, and established the first crystal engineering laboratory at the ICCBS. Based on her contributions in the field of structural and medicinal chemistry, she received prestigious TWAS Regional Prize for Young Scientist in 2011, elected as the TWAS Young affiliate in 2013 and a member of the prestigious Pakistan Academy of Sciences in 2017.