THE CHEMISTRY INSIDE SPICES & HERBS: RESEARCH AND DEVELOPMENT

Editors:
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The Chemistry inside Spices & Herbs: Research and Development

(Volume 2)

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FOREWORD

The book titled "The Chemistry inside Spices and Herbs: Research and Developments (Volume: 2)" edited by: Dr. Pankaj Kumar Chaurasia and Dr. Shashi Lata Bharati has an excellent collection of 10 chapters written by the experts of their subjects from countries like India, UK, and Turkey. Each chapter of the volume, attractively written by the experts, is also full of research as well as academically momentous information. This book brilliantly deals with biologically valuable information on chemistry and biochemistry of spices and herbs along with in-depth scientific updates on natural drugs for the management of skin diseases, turmeric and curcumin for arthritis, curcumin in oral health, resveratrol in osteoarthritis, and piperine with wide range of therapeutic properties. It also includes the chemistry, biochemistry and pharmaceutical roles of various types of plants like Fenugreek *(Trigonella foenum-graecum* L.), Ashwagandha, Basil *(Ocimum basilicum* L.), turmeric (*Curcuma longa* Lin) and *Terminalia chebula.*

In the present time of pandemic and other problems, when the whole world is searching for various types of immunity boosters to fight this virus, volume-2 like volume-1 may also be helpful in this direction in order to provide in-depth information because there are also different types of spices, herbs and their constituents discussed in the book which are radiantly useful in the treatment of various human problems and enhancements of immunity. In my view, after giving a thorough look at the contents, this book may be very advantageous for academicians, researchers and scientists working in the field of spices, herbs, their related chemistry, natural medicinal therapy and so on. I am congratulating the editors of the book for creating such a useful, academically as well as a scientifically relevant book by compiling the comprehensive chapters contributed by the experts of various countries. I also strongly recommend this volume for UG and PG students of life sciences, natural chemistry, biochemistry, natural medicinal studies and scientists working in aforesaid areas.

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PREFACE

Plants are the boon of nature on the earth for us in many ways. They detoxify the environments and save the lives living on this earth. Out of several advantages of plants, their different parts and/or substances are known for their noteworthy medicinal values. Spices and herbs which are involved in our daily routine life are the treasure of good health. Spices, a routine part of the kitchen, as well as herbs of our garden, are full of medicinal virtues and benefits and can be significantly used for the treatment of various disorders and diseases of humans. Spices are actually fruits, seeds, barks, roots and other parts of the plants widely used for enhancing the taste, color and quality of the foods (https://en.wikipedia.org/wiki/Spice) and are the source of various valuable chemical constituents of pharmaceutical significances while herbs are leafy green or flowering parts of the various plants with savory or aromatic properties (https://en.wikipedia.org/wiki/Herb). They are the major source of Ayurveda and other traditional culture of treatments and also have a great potential in the modern time. Spices and culinary herbs and their various chemical constituents involved in the treatment of various problems, diseases and wounds have been beautifully covered in this book.

In the present time of the serious pandemic COVID 19 period, demands of pharmaceutically valuable spices and herbs have been surprisingly enhanced all over the world because they have a substantial and valuable position as nutraceutical which doubtlessly are due to their significant healthy, nutritious and immunity boosting properties. Actually, the main objective of the construction of this book was to collect the more significant valuable researches and information on spices and herbs, which are being widely used in our daily life either in the form of taste enhancing savory materials or quality improving materials or beautiful home decoration and so on. Collection of weighty researches on biologically active pharmaceutically interesting chemical compounds and their compositions and structure activity relationships of these compounds was the second most interesting objective of this book.

This book is full of scientific knowledge on spices, herbs, associated internal chemistry and wide biological performances. It includes biochemistry and biotechnology of spices and herbs, along with the in-depth approach to natural drugs in skin diseases, Fenugreek, Basil, *Terminalia chebula*, Curcumin, Resveratrol in osteoarthritis, Piperine, Turmeric and Curcumin in Arthritis, Natural Medicinal Therapy, and so on.

This book consists of total ten chapters and each chapter has been written by the various learned experts of their field. Learned experts come from various countries like India, UK, and Turkey. This unique collection of ten chapters may be highly beneficial for the students of graduate and post graduate level studying in the field of life sciences, biotechnology and biochemistry, plant sciences and for researchers and scientists working research in the field of spices, herbs, compounds with biological activity, natural treatment and natural pharmacology. The book is full of updated knowledge, information and recent researches, and without any doubt, it will be very much fruitful for the readers.

Chapter 1, titled “Drugs from Natural Sources in the Management of Skin Diseases” is written by Mandlik and Kulkarni and aims to provide detailed scientific information about the management of skin diseases by using drugs from natural sources.

Chapter 2, titled “Turmeric and Curcumin for Arthritis: Evidence for their therapeutic use” is written by Kudva et al. In this chapter, they compiled the validated observations and discussed their mode of action that confers their beneficial effects.

Chapter 3, titled "Curcumin, the principal compound of turmeric (*Curcuma longa* Lin) in oral health: a mini review", is written by Lasrado et al. This article looks into the chemoprotective and immunomodulant roles of curcumin in regards to the oral diseases and proposes the importance of naturally occurring phytochemicals in general health.

Chapter 4, titled "Resveratrol in osteoarthritis: a memoir", is written by Mathai et al. This memoir looks into the origin, structure and patho-mechanism of resveratrol on its action against osteoarthritis.

Chapter 5, titled "Piperine: An alkaloid from Piper species with a wide range of therapeutic properties", is written by Singh, S. The present chapter accounts for an overview of therapeutic properties of piperine, the bioactive constituent of pepper. It also focuses on methods used to extract piperine from pepper along with recent approaches for the enhancement of the bioavailability of piperine.

Chapter 6, titled "Fenugreek (*Trigonella foenum-graecum* L.): A Palatable Spice, An Active Herb, A Promising Functional Food and Even More", is written by Onder et al. They have comprehensively discussed the plants' phytochemical content and biological activity.

Chapter 7 titled "Clinical Aspects of Ashwagandha", concisely describes the various recent clinical aspects and researches on this medicinally valuable herb.

Chapter 8, titled "Phytoconstituents, Biological Properties and Health Benefits of Basil (*Ocimum basilicum* L.)", is written by Urvashi et al. This chapter has covered up-to-date information on pharmacological investigations of the herb and its health-related benefits.

Chapter 9, titled "Phytochemistry and Pharmacology of *Terminalia chebula*: an Update", is written by Agrawal and Kulkarni. They have given an update on the phytochemistry and pharmacology of T. *chebula*.

Chapter 10, titled "Role of Plants in Natural Medicinal Therapy", is written by Mulgund and Bhat. They have discussed the potential and significance of plants for natural pharmacological care.

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CHAPTER 1

Drugs from Natural Sources in the Management of Skin Diseases

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Abstract: The skin or dermis is the largest organ of the human body, having important functions, such as protection and thermoregulation. Skin-related diseases are an important public health concern. A variety of skin diseases like acne, eczema, psoriasis, dermatitis, and skin cancer affect a large group of people throughout the world. The innumerable etiological factors for skin diseases are bacteria, fungi, viruses, and protozoa infections, declining immunity, interaction with allergens, noxious substances, or infected skin of other person's and genetic factors.

Many synthetic drugs in various dosage forms are available in the market to treat these skin conditions, but they are associated with certain drawbacks. The usage of medicinal plants for the management of various diseases is as ancient as mankind. Treatment of different skin diseases with herbs and natural products is an economical and safe option. Many plants like *Aloe vera, Azadirachta indica, Curcuma longa, etc*., are reported to have significant effects on various skin problems. The present chapter aims to provide detailed scientific information about the management of skin diseases by using drugs from a natural source.

Keywords: *Acne vulgaris*, Atopic dermatitis, Bio active compounds, Herbal plants, Psoriasis, Skin, Skin cancer, Skin diseases, Skin pigmentation.

INTRODUCTION

Skin

The skin comprises three layers; the epidermis, dermis, and subcutaneous fat layer (hypodermis). These layers comprise various kinds of cellular level components bringing about various skin structures displaying diverse functions and different

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sorts of light proliferation. The outer layer is called the epidermis and is made out of five sublayers: the stratum corneum (inner layer), stratum granulosum, stratum spinosum, stratum basale, and stratum lucidum. The second layer of skin is the dermis, thicker and composed of collagen and elastic fibers. It also consists of papillary and reticular layers. The third layer is made up of fats [1].

Skin is the largest organ of the human body that covers a major part of the human body. It is continually exposed to dangerous compounds, physical and natural toxins. It gives essential protection against microorganisms, as it acts as a significant barrier between environmental conditions and the body. It is involved in thermoregulation, protection, and a strikingly decent boundary against microbial diseases [2]. Skin is populated by enormous microbes, the vast majority of that is innocuous and beneficial. Cooperative microorganisms possess extensive scope of specialties of the skin and give defence against attack by pathogenic microbes. The microbiota of the skin is linked to the skin site. There is, nonetheless, a harmony between the host and the microorganisms; interruptions in a critical position can bring about skin diseases or infections [3].

Skin Infections

These are brought about by different organisms, including bacteria, fungi, parasites, and protozoa. Skin diseases can occur in any size and area, either in the form of a spot or covering the whole-body surface, as well as entering the circulatory system. Many skin diseases are transmitted by means of individual to individual contact and cause sickness, mortality, and morbidity [4]. As indicated in a study by Patel and Patel concentrating on the North Gujarat district, a significant skin issue was tingling with redness, swelling, and inflammation, and most of the antihistaminic medications are utilised to battle the skin diseases [5]. A few people are at specific risk of skin infections. For instance, individuals with diabetes can have a poor blood supply, particularly in the hands and feet, and the increased sugar in their blood declines the capacity of the body to battle infections. The individuals who are older, infected by human immunodeficiency virus or other immunological issues, and who are experiencing chemotherapy or medicines with different medications that suppress the immune system are at high risk because of the weakened immune system. Skin that is harmed by sunburn, scratching, or other injury is more prone to infection. There are five unique sorts of skin diseases: atopic dermatitis, psoriasis, skin inflammation vulgaris, skin pigmentation, skin microbial contaminations, and skin cancer.

Throughout the years, the prevalence of skin infections has likewise expanded in many parts of the world because of their relationship with human immunodeficiency infection (HIV) and AIDS [6]. Over 8 percent of individuals

infected with HIV lead to skin maladies [7]. In many parts of the world, the high occurrence of skin diseases is not viewed as a noteworthy medical issue considering the low degree of seriousness and lethality. Skin diseases present a significant wellbeing concern since they are systematically diagnosed and hard to treat [8]. They significantly affect the quality of life. Skin diseases have been related to expanded pressure, tension, and gloom in individuals, and patients with serious cutaneous skin diseases have expanded suicidality analyses, particularly patients of the youth stage [6]. The human being can suffer from skin disease at any stage in life. Various medications are available in the market to treat these ailments. The motive behind this chapter is to present scientific information on the effects of medicinal plants and bioactive compounds in important skin diseases (Fig. **1** & Table **1**).

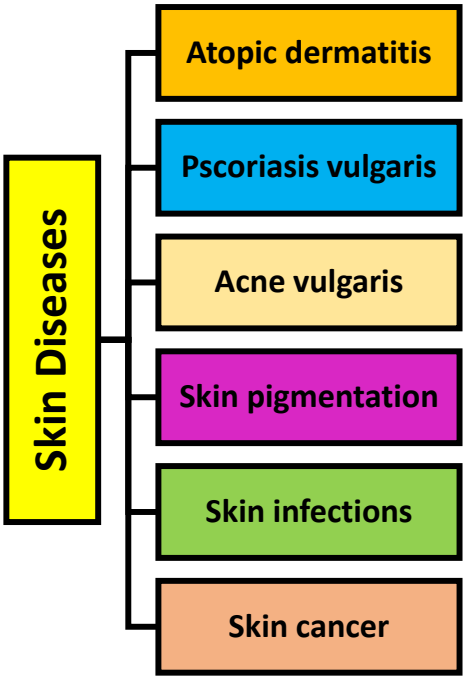

Fig. (1). Types of skin diseases.

CHAPTER 2

Turmeric and Curcumin for Arthritis: Evidence for Their Therapeutic Use

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Abstract: *Curcuma longa* L. frequently known as the Turmeric is a flowering plant belonging to the ginger family (Zingiberaceae). The rhizomes that grow below the ground are popularly used in cooking as a coloring and flavoring agent. Also, for ages, turmeric has been known for its medicinal properties, such as treatment of wounds, inflammatory conditions, arthritis, blood, gastric and hepatic disorders. The ethnopharmacology-based approach has shown that turmeric has a wide variety of bioactive polyphenols. Among them, curcumin, a yellow pigment predominantly found in the rhizome, has been extensively studied. Many preclinical and clinical studies have found that turmeric and its bioactive constituents possess multiple benefits in treating inflammatory conditions of the joints and arthritis. In this chapter, we compile the validated observations and discuss their mode of action that confers their beneficial effects.

Keywords: *Curcuma longa* L., Curcumin, Osteoarthritis, Rheumatoid arthritis, Turmeric.

INTRODUCTION

Arthritis is a multifaceted condition that causes inflammation and stiffness of diarthrodial (synovial) joints. There are over 100 different kinds of arthritis and

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related conditions known, of which rheumatoid arthritis (RA) and osteoarthritis (OA) are the two most frequently seen around the world (Fig. **1**) [1]. Arthritis is an inflammatory disease often accompanied by pain due to severe cartilage destruction, thus disrupts the joint function causing chronic disability, and loss of mobility affecting the patient's active lifestyle [1, 2]. According to CDC, in the United States, more than 20% of the population suffers from arthritis [3]. In India, reports suggest that about 15% population is known to be affected by arthritis [4]. It is notable to mention that RA and OA have a higher occurrence in these countries, thus imposing a potential public health challenge. At present, the use of non-steroidal anti-inflammatory drugs (NSAIDs) for OA and the use of analgesics and disease-modifying anti-rheumatic drug (DMARD) like methotrexate, for RA are the effective treatments available [1, 2]. But their prolonged use causes severe side effects such as hypertension, gastrointestinal bleeding, liver damage, renal and cardiac failure [1, 2]. Severe morbidity, suboptimal response to drugs, and apprehension towards surgery have persuaded RA patients to use unconventional treatments to improve their quality of life [1, 2].

Plant-based Treatment for Arthritis

For centuries, India has the distinction for using plants and its products to treat various ailments using indigenous medicinal systems, such as the Ayurveda, Siddha, Unani, yoga, and naturopathy. Apart from these systems, India also has many tribal (folk) medicines, which are indigenous and important to healthcare systems but are not organized into any category [6]. In recent times, many preclinical studies have validated therapeutic molecules extracted from plants, such as *Curcuma longa, Ocimum sanctum, Zingiber officinalis, Withania somnifera, Moringa oleifera, Carica papaya, and Boswellia serrate,* which help in ameliorating arthritis [7 - 14]. Amongst these, *Curcuma longa* Linn, commonly known as the 'Turmeric' is widely studied and has been shown to have beneficial effects in treating arthritis [5].

Turmeric (*Curcuma Longa* Linn) and Arthritis

Curcuma longa Linn is an herbaceous, perennial plant that belongs to the ginger family (Zingiberaceae). It is an indigenous plant of India and is today extensively cultivated in other tropical Asian countries, such as China, Srilanka, and Thailand [8]. The rhizome that grows below the ground is the most important part of this plant. In India, it is used in religious practices, along with culinary and various alternative systems of medicine. Turmeric has been extensively studied for its phytochemical components (Table **1**) and it is shown to contain diarylheptanoids that include curcuminoids, such as curcumin, demethoxycurcumin and bisdemethoxycurcumin (Fig. **2**) [15]. Amongst this, curcumin is the main

constituent that makes up 70-80% of the curcuminoids (Table **2**) [16]. Also, there are over 30 different types of essential oils present in turmeric, such as turmerone, zingiberene, atlantone, germacrone, α-phellandrene, and sesquiterpenes [17].

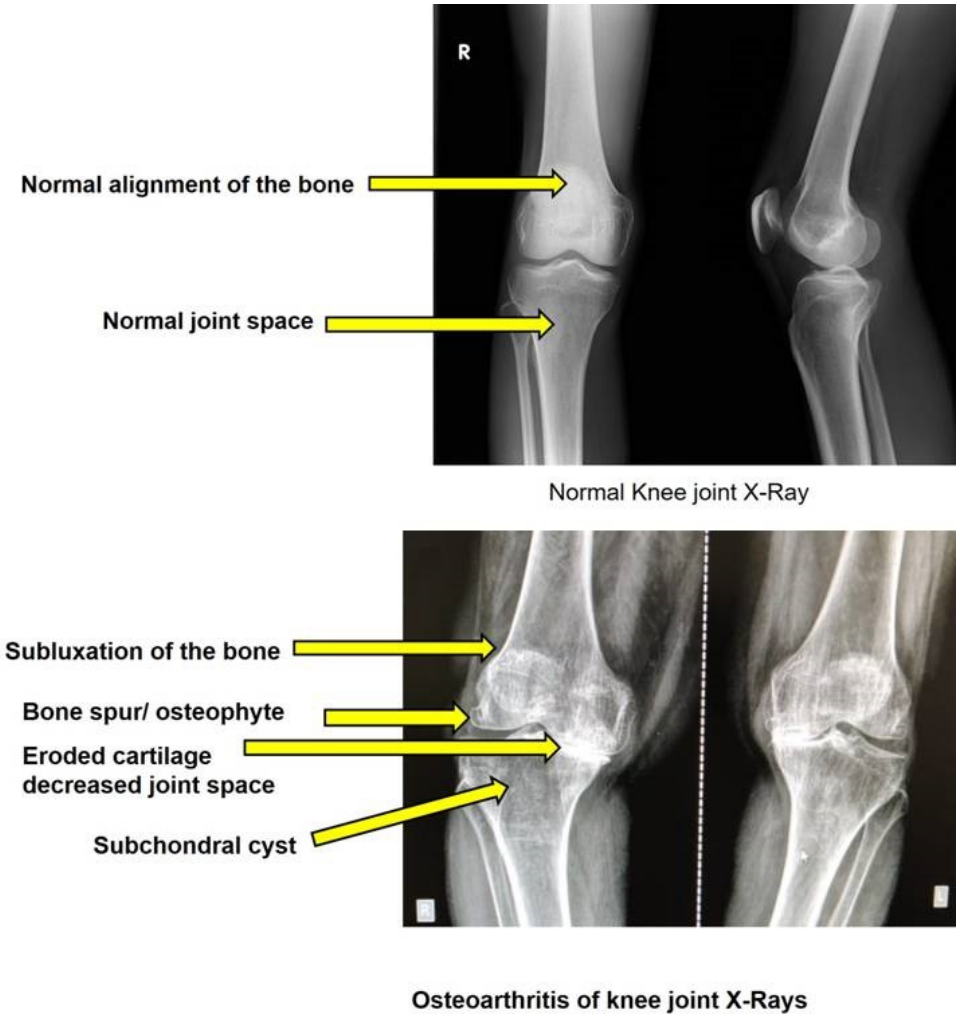

Fig. (1). Difference in the knee anatomy in osteoarthritis when compared to a normal knee.

CHAPTER 3

Curcumin, the Principal Compound of Turmeric (*Curcuma Longa* Lin) in Oral Health: A Mini-Review

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Abstract: Traditionally turmeric has been used as a spice and is part of regular diet in many parts of the world, and is employed as a medicinal herb in alternate systems of medicine. Recent studies on the beneficial roles of curcumin, the active ingredient and a potent phytochemical present in turmeric have shed light on the diverse roles it can play when used as an adjunct or as a therapeutic agent, along with its roles as a dietary flavoring agent. By virtue of its ingestion and ease of application as a topical agent intraorally, curcumin has been found to be useful while treating some of the common oral conditions, such as gingivitis, periodontitis, oral lichen planus, recurrent aphthous ulcerations, candidiasis and premalignant lesions, such as leukoplakia. This article looks into the chemoprotective and immunomodulant roles of curcumin in regards to oral diseases, and proposes the importance of naturally occurring phytochemicals in general health.

Keywords: Candidiasis, Gingivitis, Leukoplakia and cancer, Oral health, Oral lichen planus, Periodontitis, Premalignant lesions, Recurrent aphthous ulcerations.

INTRODUCTION

The oral cavity consisting of the oral vestibule and the oral cavity proper is an important organ of the body [1]. Primarily, it functions as the first part of the alimentary tract and is involved in the initiation of the digestive process [1]. It also serves as a secondary respiratory conduit, for speech and acts as a chemosensory organ [1]. Anatomically, the oral cavity lies from lips anteriorly to

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the oropharyx posteriorly and is separated from it by the circumvallate papillae, soft palate, and anterior tonsillar pillars, which make up its posterior boundary [1]. Oral health and general health are complementary to each other, and the mouth is considered a mirror of general health [1]. More than 100 systemic diseases and 500 medications have oral manifestations which are of importance in oral biology [2].

Seminal studies from around the world have now confirmed that curcuminoids (Fig. **1**), the principal phytochemical present in the rhizomes of turmeric [*Curcuma longa* Lin], is a promising agent with myriad pharmacological actions on various cells and tissues [3, 4]. The curcuminoids are a mixture of curcumin, chemically a diferuloylmethane [1,7-bis(4-hydroxy-3-methoxy-phenyl)-he-ta-1,6-diene-3,5-dione] mixed with its two derivatives, demethoxycurcumin [4-hydroxycinnamoyl-(4-hydroxy-3-methoxycinnamoyl) methane] and bis-demethoxycurcumin [bis-(4-hydroxy cinnamoyl) methane], and their ratio changes with the season and other abiotic factors [3,4]. Of the three, curcuminoidescurcumin is the principalnatural polyphenol found in the rhizome of *Curcuma longa* and other curcuma species [3, 4].

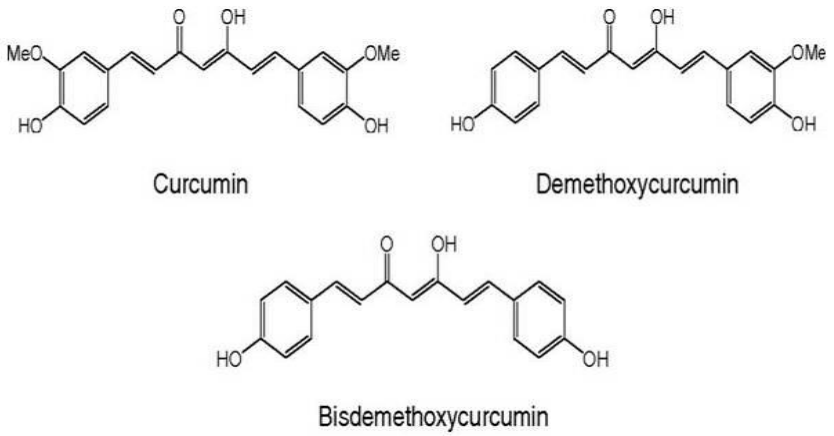

Fig. (1). Structure of curcuminoids.

Curcumin has been shown to be beneficial as an immunomodulator with neuro-protective, cardio-protective, hepato-protective, dermaprotective effects and has anticarcinogenic properties [3, 4]. At a cellular level, curcumin which is a pleiotropic molecule, is shown to mediate its effects by eliciting multiple mechanisms, the important being as a free radical scavenger, antioxidant and anti-

inflammatory agent [3]. Curcumin is also shown to increase the activities and levels of cellular antioxidants like glutathione (GSH), superoxide desmutase (SOD), catalases and have been shown to reduce lipid peroxides [3, 4].

Curcumin is known to down-regulate the activity of cyclooxygenase-2 (COX-2), lipoxygenase, and inducible nitric oxide synthase (iNOS) enzymes; inhibits the production of inflammatory cytokines, such as tumor necrosis factor-alpha (TNF-a), interleukin (IL) -1, -2, -6, -8, and -12, monocyte chemoattractant protein (MCP-1), migration inhibitory protein; and down-regulates signal transduction pathways like mitogen-activated (MAP), Janus kinases (JAK), extracellular signal–regulated kinases (ERKs) and nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB) which is a transcription factor [4]. Common oral and dental diseases ranging from infections to neoplastic condition affect the oral structures as discussed in the following sections and the usefulness of turmeric in preventing or mitigating these conditions have been addressed.

Curcumin and Gingivitis

Gingivitis is a non-destructive type of gum disease, induced by dental plaque and is the most common form of the gingival disease [5]. Clinically, gingivitis mostly presents as painful, soft, swollen bleeding gums and is associated with halitosis with receding gums [5]. Gingivitis is the result of the interaction of plaque bacteria and defense cells of the host [5], and research suggests that tissue injury is brought about by the inflammatory immune reaction [5]. From a biochemical perspective, numerous destructive enzymes are released by the polymorphonuclear leukocytes (PMNLs) with tissue destructive lymphokines and lymphotoxins produced by B or T lymphocytes enhancing the process [5]. Mechanistic studies have now confirmed that the interleukin-1 alpha (IL-1α) and Interleukin-1 beta (IL-1β) are known to increase the binding of PMNLs and monocytes/macrophages to the endothelial cells, which stimulate the production of prostaglandin E2 (PGE2) and release of lysosomal enzymes [6].

With regard to the protective effects of curcumin, Pulikkotil and coworkers studied the effects of curcumin on the levels in IL-1β and C-C Motif Chemokine Ligand 28 (CCL28) in the gingival crevicular fluid levels in an experimental system of study [7]. Subsequent studies carried out to understand the efficacy of curcumin mouthwash as an adjunct to oral prophylaxis (scaling and root planning) in the treatment of chronic gingivitis with chlorhexidine have also shown that curcumin was comparable to chlorhexidine as an anti-inflammatory mouthwash indicating its usefulness as an effective adjunct to mechanical periodontal therapy [8].

CHAPTER 4

Resveratrol in Osteoarthritis: A Memoir

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Abstract: Today, resveratrol is one of the highly investigated phytochemical in the world. Chemically, it is a stilbenoid present in high concentration in the grape skin and red wine. Structurally, it is a polyphenol and possesses two phenol rings linked by an ethylene bridge. Resveratrol, a phytoalexin, is produced by the plant as a defense mechanism against pathogens, including bacteria and fungi, and exposure to UV radiation and chemical substances. Numerous studies have shown that resveratrol possesses very high free-radical scavenging and antioxidant potential as a natural dietary ingredient. Resveratrol has also been reported to have anti-inflammatory and anti-apoptotic properties, and numerous preclinical studies have demonstrated it to possess great potential in preventing and/or slowing the breakdown of articular cartilage and extracellular matrix. Increased scientific attention has led to the validation of its biological activity and its ability to prevent or mitigate the process of osteoarthritis. This memoir looks into the origin, structure, and pathomechanism of resveratrol against osteoarthritis.

Keywords: Osteoarthritis, Phytoalexin, Resveratrol.

INTRODUCTION

Osteoarthritis (OA), a disease of the middle-aged and elderly, is the most prevalent joint disease [1]. In the recent past, the prevalence of the disease has increased and reached in countries where there is a considerable proportion of the aged population. The morbidity associated with OA is high and has a high socioeconomic impact on the individual. Advances in medical science have

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increased life expectancy, thereby increasing the prevalence of the disease in general [2]. With reports indicating that around 20–40 million suffer worldwide from this disability, OA is a crucial public health issue due to its increasing incidence in both developed and developing countries [3, 4].

Clinically, the symptoms of OA are debilitating, which hamper activities of daily living [3]. From an anatomical perspective, OA sequentially involves inflammation of the synovial membrane, erosion of articular cartilage, and resorption of the underlying subchondral bone (Fig. **1**). In effect, it is the degradation of the cartilaginous extracellular matrix that leads to the destruction of the articular cartilage (Fig. **1**). The apoptosis of chondrocytes causes an imbalance between anabolism and catabolism attributed to the degeneration of articular cartilage. As OA primarily affects the articular cartilage and subchondral bone of synovial joints, it progresses in a gradual manner affecting joints responsible for the mobility of the individual [4].

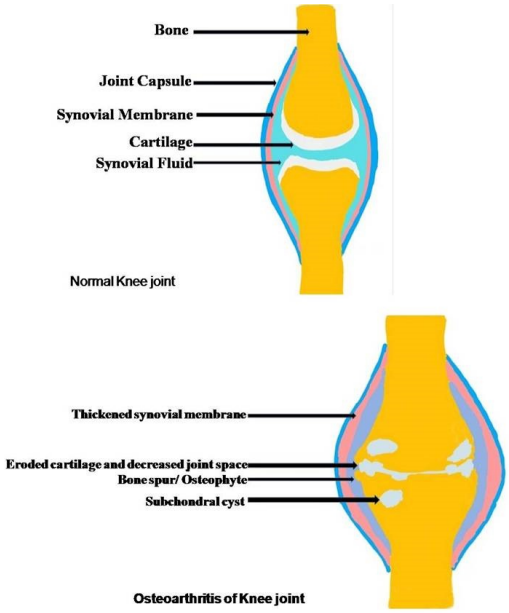

Fig. (1). Difference in the kneee anatomy in osteoarthritis when compared to a normal knee.

From a therapeutic perspective, there is no definitive cure for OA. Current medical treatment strategies are focused on pain control and symptomatic relief rather than disease modification. Usually, non-steroidal anti-inflammatory drugs (NSAIDs) are the first-line analgesic used. However, their use is limited due to frequent side effects ranging from nausea, vomiting, gastritis, peptic ulcer to allergic reactions, including rash, wheezing, and hepatic and renal toxicity [3].

Alternates to oral anti-inflammatory drugs include topical application of the same NSAIDs or intraarticular injection of corticosteroids or hyaluronic acid into the affected joint [4]. Other medications, such as glucosamine, chondroitin (basic components forming the cartilage) supplementation, and collagen substitutes, can also be used [3].

When these options fail, or the disease progress is too advanced, relief is aimed at removing the cartilaginous or bony debris affecting the functioning of the affected joint. Osteotomies around the knee are surgical options to address the mechanical malalignment. Total knee replacement, which refers to the replacement of articular surfaces of both tibia and femur, is suggested in case of the severe and advanced stage of OA, which, although effective, may be painful in the immediate postoperative period. Despite these modes of treatment, the efficacy of treatment is still limited [3].

The non-surgical or conservative management of osteoarthritis includes physical therapy, aerobic exercises, muscle strengthening, weight reduction, walking aids, knee braces, footwear, and insoles. Occasionally, acupuncture has also been tried. These options are subjective as results vary from person to person. Understandably, numerous studies and research focusing on the use of herbal medicines or natural molecules present in food exhibiting anti-inflammatory properties are carried out in anticipation of a safe drug [4]. The increasing demand for safe and effective alternative drugs for the treatment of OA can be addressed by promising nutraceutical products [5]. There are many potent natural agents helpful in reducing the destruction of cartilage in OA, such as turmeric, green tea, and resveratrol, to name a few [5]. With respect to this, resveratrol (Fig. **2**) has been found to reduce and prevent the breakdown of articular cartilage and extracellular matrix in preclinical studies and will be addressed here in the following sections [5, 8].

CHAPTER 5

Piperine: An Alkaloid from Piper Species with a Wide Range of Therapeutic Properties

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Abstract: Based on the usefulness and importance among the spices, black pepper (*Piper nigrum* L.) is commonly referred to as "The King of Spices". It is valued for its flavor, aroma, nutritional, and medicinal uses. The value of pepper is owed to its pungency and flavor, which is attributed to the presence of a naturally occurring alkaloid known as piperine. The amount of piperine varies in plants belonging to the Piperaceae family; it constitutes 2% to 7.4% of both black pepper and white pepper. It has been confirmed from the scientific studies that piperine has many bioactive effects, such as antimicrobial action, as well as many physiological effects that can contribute to general human health, including immunomodulatory, hepatoprotective, antioxidant, antitumor, and many other activities. Clinical studies demonstrated remarkable antioxidant, antitumor, and drug availability-enhancing characteristics of this compound, together with immunomodulatory potential. All these properties showed the therapeutic potentials of piperine and the need to incorporate this compound into general health-enhancing medical formulations, as well as into those that would be used as adjunctive therapy in order to enhance the bioavailability of various therapeutic drugs. The present chapter accounts for an overview of the therapeutic properties of piperine, the bioactive constituent of pepper. It also focuses on methods used to extract piperine from pepper along with recent approaches for the enhancement of the bioavailability of piperine.

Keywords: Alkaloid, Antioxidant, Bioavailability, Immunomodulatory, Piperine.

INTRODUCTION

Spices are natural food additives that contribute enormously to the taste of our foods. They have been used to enliven our foods since ancient time. Spices possess medicinal as well as nutritional properties. They have been effectively used as one of the most important constituents in the medical field worldwide. They have a beneficial influence on lipid metabolism efficacy as anti-diabetics. They have ability to stimulate digestion and have antioxidant and anti-inflam-

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matory (*i.e*., reduce painful swelling caused by tissue injury) potential [1]. Keeping in mind the potency of spices for medicinal and nutritional uses, black pepper was selected and reviewed for its nutritional and medicinal value. In addition to their sensory properties, the herbs and spices in our diet are rich sources of different phytochemicals with putative beneficial effects, *e.g*., antioxidative, anti-inflammatory, chemopreventive, antimutagenic, immune-modulatory properties [2]. Due to their potent biological activities and low or non-existent side effects, some of these phytochemicals are being investigated in preclinical and clinical trials as a new approach to treat diseases [3] or as lead compounds in the design of innovative drugs [4]. Moreover, there is evidence that some phytochemicals can enhance the bioefficacy of drugs like antimicrobials, antihypertensives, anticancer drugs, and improve the bioavailability of some nutraceuticals [5]. Due to their natural origin, ease of access, cost-effectiveness, and satisfactory safety profiles, these kinds of nutraceuticals have attracted the attention of scientists, consumers, and commercial enterprises [6]. Among the spices, pepper has occupied a supreme and unique position due to its characteristic pungency and flavor. Black pepper, rightly nicknamed the King of Spices, is the most important and extensively consumed spice worldwide. It is the only spice that is invariably served at dining tables and is an inevitable ingredient of many prepared foods. Black pepper has been used for many purposes in the past, continues to be so currently, and is expected to remain so in the future.

In ancient Chinese and Indian medicine, black pepper was used as a natural medicinal agent for the treatment and alleviation of pain, chills, rheumatism, influenza, muscular pains, chills, and fevers. In tea form, black pepper was also credited for relieving migraine headaches, strep throat, poor digestion, and even coma [7]. It was also used for enhancing the circulation of blood, increasing the flow of saliva, and stimulating appetite [8]. Recent investigations have shown that piperine has chemopreventive and antioxidant activities. It also has immunomodulatory, anticarcinogenic, stimulatory, hepatoprotective, anti-inflammatory [9], antimicrobial [10], and antiulcer activities [11]. Piperine also has biotransformative effects and can enhance the bioavailability of different drugs such as rifampicin, sulfadiazine, tetracycline, and phenytoin by increasing their absorption, by slowing down the metabolism of the drug, or by a combination of the two [12]. Piperine shows a protective effect against radiation, and so it can be applied to cancer patients before radiotherapy [13]. It has also been reported that piperine remarkably increases pancreatic lipase activity and stimulates pancreatic amylase, trypsin, and chymotrypsin [14]. Some of the traditional uses of pepper and recent studies on the therapeutic effects of pepper/piperine are summarized in Table **1** [15].

Table 1. Therapeutic properties of Piperine.

Therapeutic Effects of Piperine	
• Piperine inhibits ascorbate-Fe++-induced lipid peroxidation • Piperine protected against oxidative stress induced carcinogenesis • Protection against diabetes induced oxidative stress • Inhibition/quenching of super oxides and hydroxyl radicals by piperine • Piperine protects Cu^{++}-induced lipid per-oxidation • Decreased mitochondrial lipid peroxidation • Dietary black pepper/piperine reduces high fat diet induced oxidative stress • Inhibition of aryl hydroxylation • Decreased UDP-glucuronic acid concentration • Inhibition of O-de ethylase activities in pulmonary microsomes • Inhibition of UDP-glucose dehydrogenase and UDP- glucuronyl transferase • Increased bioavailability of vaccine and sparteine • Enhanced systemic availability of propranolol and theo-phylline • Increased serum concentration • Delayed elimination of anti-epileptic drugs • Enhanced bioavailability of β-lactam antibiotics	• Increased plasma levels and delayed excretion of epigallo-catechin-3-gallate • Stimulation of digestive enzymes of Pancreas by dietary piperine • Increased orocecal transit time • Black pepper increased gastric acid secretion • Piperine modulated the membrane dynamics and permeation characteristics, • Reducing mutational events • Tumour inhibitory activity • Anti-metastatic activity of piperine on lung metastasis • Chemopreventive effect • Growth stimulatory activity • Anti-thyroid activity • Piperine inhibited mitochondrial oxidative phosphorylation • Piperine exerted protection against t-butyl hydroperoxide • Piperine promoted cytotoxicity induced by benzo(α)pyrene • Piperine potentiated hepatotoxicity of carbon tetrachloride in rats

Despite the excellent therapeutic properties of piperine, it is slightly soluble in water (40 mg/L at 18 °C [16]. The low solubility of piperine in water and its poor dissolution is the rate-controlling step in the absorption process of piperine. The pharmaceutical activities of piperine are limited due to its low water solubility and because the use of it at high concentrations can be toxic for the central nervous and reproductive systems [17]. Attempts have been made to develop new formulations to improve the bioavailability of piperine. The use of modern nanotechnology for nanoparticle formulations of piperine and its encapsulation in lipid matrixes are the most recent advancements to overcome its low solubility in water.

This chapter accounts for the widespread therapeutic properties of piperine, the bioactive compound of pepper, along with documentation of its extraction techniques, recent approaches for utilizing its bio-enhancing ability in various fields of medical sciences.

CHAPTER 6

Fenugreek (*Trigonella foenum-graecum* L.): A Palatable Spice, An Active Herb, A Promising Functional Food, and Even More

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Abstract: Since ancient times, *Trigonella foenum-graecum* (fenugreek), a plant from the legume family (Fabaceae), is one of the most popular spices worldwide. Medicinal benefits and properties of this plant have been recognized. Fenugreek has a long history as a remedy for diabetes mellitus with a known effective anti-diabetic plant. The studies indicated that *T. foenum-graecum* has several important biological activities, such as potent immunomodulation-associated anticancer and anti-inflammatory effects. Besides the healing properties, it is stated as a functional food for promoting well-being and a tasty spice often used in the kitchens and the industrial fields. However, to the best of our knowledge, no research has been done so far concerning this plant as a comprehensive literature search. In this chapter, we discuss how fenugreek may be beneficial in clinical and prophylactic health and what further research is necessary to understand whether regular consumption can contribute to healthy living generally.

Keywords: Fabaceae, Fenugreek, Herbs, Leguminosae, Phytochemistry, Spice, *Trigonella*, *Trigonella foenum-graecum*, Usages.

INTRODUCTION

Many herbs and spices, particularly in the cultures of Asia, Africa, Europe, and America, have been well-known for their traditional, therapeutic applications, and flavoring properties, which have been used since ancient times [1-3]. Spices contribute to flavor, taste, and color in foods, while the consumption of spices provides many

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human health benefits [4]. The effects of herbs and spices used as foods are an area of research interest [5]. The different parts of the plants are used as spices [1], and their culinary usages and health benefits are commonly due to their phytochemicals [6-8]. Phytochemicals play a positive role in prevention of specific diseases, such as cardiovascular, pulmonary, neurological, and autoimmune diseases, diabetes and cancer [9]. Many herbs and spices contain several antioxidant components, especially their phenolic compounds that have potent, anti-inflammatory, antimutagenic, and anticancer activities [10 - 12].

Trigonella foenum-graecum L. is considered as one of the oldest medicinal plants originated in central Asia ~4000 BC and is known as fenugreek, an annual plant at 10-50 cm height that belongs to the Fabaceae (Leguminosae) family [13, 14], native to India, China, and North Africa [15]. Fenugreek (Latin name is *Trigonella*) means "little triangle" for its yellowish-white triangular flowers [16, 17]. The plant name comes from the Greek word "trigonou" meaning triangle, because of the triangular shape of its leaflets, and the means of "foenum-graecum" is "Greek hay" or "Greek grass" because of its prevalent use in ancient Greece [18]. The plant is called by many names in diferent languages such as Methi, Sagmethi, Kasurimethi, (Indian, Urdu, Punjabi, and Marathi), Hulba, Hhulbah, Hhuelba (Arabic), Moshoseitaro (Greek), Uluva, Halba (Malaya), Shoot (Hebrew), Dari, Shanbelieh (Persian), Trigonelle, Senegrain, Foingree, Fenugrec (French), Gemeiner, Hornklee, Bockshorklee (German), Fienogreco, Erbamedica (Italian), Fenugreek, Hayseed (English), Pazhitnik (Russian), Alholva (Spanish), Koroha (Japanese) and K'u-Tou (Chinese) [13, 18, 19]. It has been used by humans for a wide range of medicinal purposes for more than 2500 years. Seeds are most widely used as spices due to their strong flavor and aroma [20, 21]. Furthermore, the leaves of this plant are used as vegetables in nutrition [19]. It is widely grown all over the world and cultivated in Asian, African and Mediterranean countries, such as south of France, Spain, Morocco, Turkey, Iran, North Africa, India, Pakistan, Afghanistan, Nepal, Egypt, Argentina, and China [16, 22, 23], because the seeds have medicinal benefits [24]. According to Flora Iranica, more than 32 species of this plant are registered in the central regions of Iran [25]. Even fenugreek is one the most popular crops of legumes for Ethiopian farmers in Africa [26]. India is the largest producer of fenugreek and its main consumer for culinary and medicinal purposes in the global market [19].

Phytochemical analysis of fenugreek seed extract detected the presence of flavonoids, terpenoids, phenols, proteins, saponins, tannins, alkaloids, polysaccharides, and steroids [27, 28]. The plant and its seed have been utilized for hypoglycemic, hypocholesterolemic, appetite stimulation, edema and exhibited gastroprotective, chemopreventive, antioxidant, antifertility, anti-inflammatory, immunomodulatory, and antipyretics effects [27, 29 - 34]. The

biological effects of fenugreek have primarily been attributed to their active constituents such as galactomannan, 4-hydroxy isoleucine, and steroidal saponins (diosgenin) [35].

Fenugreek is acceptable as food legumes. Anciently, the plant was used as a food and as a medicinal agent in India, Greece, and Egypt; especially, the description and benefits of fenugreek had been reported in the Ebers Papyrus (one of the oldest maintained medicinal documents) earlier in 1500 BC in Egypt [36]. Recently, fenugreek has been most common product in the food industry and the pharmaceutical field. However, fenugreek may also exhibit allergic reactions, similar to other plants belonging to the Leguminosae family. Although the exact factor is not apparent, it has been shown that curry and pastes containing fenugreek caused two cases of anaphylaxis in children [37]. Moreover, there are mild side effects of fenugreek [38, 39]. Also, among the natural galactagogues for breastfeeding women, *T. foenum-graecum* is included as an herbal food supplement. Still, safety and efficacy data are lacking [40]. In toxicological studies, fenugreek has been evaluated the risks to human health, eventually defined as "Unrestricted Trust" as standard seed extract of the plant used in many food supplements [41]. For instance, the safety and mutagenicity of standard fenugreek seed extract rich which is in saponin have been investigated, and the highest dose at which the side effect of the product was not observed was at 1000 mg/g, weight/day [42]. However, the toxicological properties of fenugreek were discussed in all details in a literature [43].

The mucilage composition of the fenugreek seeds consisting of mainly a galactomannan-like polysaccharide structure has an excellent emulsification capacity, which allows it to be applied in the food, cosmetic, and/or pharmaceutical industries for its strong thickening properties [44]. The seeds of the fenugreek as a functional food are widely used in the preparation of spices, pickles, curry powder, dietary supplements, and comparatively large amounts in making soups and pancakes [19, 45 - 48].

The beneficial effects of the herbs and spices scientifically has been approved and is the most challenging part of a research assignment. Hence, this chapter provides a comprehensive approach for fenugreek, including traditional usages, main bioactive components, pharmacologic and therapeutic potential with methodological developments, and future prospects.

TRADITIONAL USAGES

Trigonella foenum-graecum L., commonly called fenugreek in many countries [22], one of the oldest herbs, has been considered traditional herbal medicine in Asian, African, and Mediterranean countries for many years [49, 50]. It is used in

CHAPTER 7

Clinical Aspects of Ashwagandha

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Abstract: In the present pandemic, demands for natural herbs and spices have been surprisingly enhanced, and the reason behind enhancements in the demands of these spices and herbs are genuine because they have super immunity boosting capability, and they strengthen the human body against various diseases and pathogenic microbes. In this direction, *Withania somnifera,* also popularly known as 'Ashwagandha,' is one of the popular herbs known for its different medicinal values and various biological functions. This Ayurvedic herb is known for its potential anti-inflammatory properties, fatigue reduction, stress reduction, anticancer properties, and it is also helpful for diabetic patients, arthritis pain, and others. Due to lack of research and scientific evidence, there is no concrete information on the direct medicinal importance and use of this plant, but it has a historical pharmaceutical role in Ayurveda as traditional Indian medicine, and its medicinal impacts have now been proved *via* various pieces of research. This chapter concisely describes the various recent clinical aspects and pieces of research on this medicinally valuable herb.

Keywords: Ashwagandha, Anti-diabetic, Anti-inflammatory, Anticancer, Ayurveda, Herbs, Medicinal properties, Stress, *Withania somnifera*.

INTRODUCTION

In the present time, when a lot of research is going on to discover medicines with lesser harmful effects, more effectiveness, lesser side effects, and stable efficien-

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cies, natural herbs may play a significant role. There are several medicinal herbs known from ancient times for their effective role in the treatment of various human diseases and problems. Herbal medications with suitable knowledge, proper doses, and effective monitoring may give effective relief from diseases and human problems. Different plants like *Allium sativum, Aloe vera, Azadirachta indica, Bellis perennis, Capsicum annuum, Carica papaya, Citrus limon, Nigella sativa, Citrus trifoliata, Curcuma longa, Jasminum officinale, Ocimum tenuiflorum, Papavar somniferum, Rosa majalis, Triticum aestivum, Vaccinium spp, Withania somnifera,* and so on (https://en.wikipedia.org/wiki/List_of_plants_used_in_herbalism) [1] are full of medicinal properties having a role as either medicinal supplements or medicinal components.

Ashwagandha is a common name of the plant, *Withania somnifera,* from the Solanaceae family. It is also known as Indian ginseng or winter cherry. In Latin, the meaning of somnifera is 'sleep inducing' [2], while the meaning of 'ashwa' in Sanskrit is 'horse' and the meaning of 'gandha' is 'smell.' Its root has horse-like odor [3]. This is a short perennial shrub growing 35–75 cm tall with dull green, elliptic leaves and small, green, bell-shaped flowers (https://en.wikipedia.org/wiki/Withania_somnifera) [4]. The root of this plant is generally used in Ayurveda as traditional medicine in India (https://en.wikipedia.org/wiki/Withania_somnifera) [4, 5]. There are not many clinical pieces of evidence for its medicinal use, but in Ayurveda, it is used as a supplement for improving health benefits. When utilising it as a supplement, it is necessary to have the correct knowledge. There is a lot of research that support the pharmaceutical applicability of *W. somnifera* but still, there is a requirement for more deep research in this field. In this chapter, only some important recent works on *W. somnifera* have been explained for disclosing the medicinal applicability of this gift from the nature.

Recent Research Updates

W. somnifera has a variety of medical benefits in humans, including helping in the development of a healthy brain, having an anti-inflammatory effect, making the heart healthier, lowering cholesterol levels, improving fertility, reducing stress, lowering sugar levels, making the body healthier and so on. Different types of important medicinal functions of Ashwagandha are known (https://www.healthline.com/nutrition/12-proven-ashwagandha-benefits#12) [6]. There are various pieces of research on this medicinal herb that show its relevance to human health. Here, the authors have discussed some important pieces of recent research on *W. somnifera*.

Pérez-Gómez *et al*. (2020) [7] worked on the study entitled "Effects of Ashwagandha (*Withania somnifera*) on VO_{2max}: A Systematic Review and Meta-Analysis." During their work, they concluded that its supplementation might improve maximum oxygen consumption (VO_2max) in athletes and non-athletes [7]. Balkrishna *et al*. (2020) [8] have worked on "Withanone from *Withania somnifera* may inhibit Novel Coronavirus (COVID-19) Entry by disrupting Interactions between Viral S-Protein Receptor Binding Domain and Host ACE2 Receptor" and based on their study, they concluded that this herb may be helpful in controlling the infection of COVID-19 [8]. Ng *et al*. (2020) presented a systematic review on the clinical use of *W. somnifera* (Ashwagandha) to ameliorate cognitive dysfunction [9].

Khanchandani *et al*. (2019) [10] reviewed different antibacterial and antifungal activities of this herb. They concluded that Ashwagandha is known for its various types of medicinal applications along with its antibacterial and antimicrobial applications. They showed how many studies have been conducted on extracts and purified compounds from various parts of this herb in order to determine its antimicrobial activities, as well as the significant potential in this field for identifying antimicrobial agents from this herb [10]. Lopresti *et al*. (2019) [11] conducted a study to determine the effectiveness of the extract of Ashwagandha in stress relief and pharmacological activity. Their study shows that its stress-relieving effects may occur *via* its moderating effect on the hypothalamus-pituitary-adrenal axis [11].

Azgomi *et al*. (2018) [12] described the effects of *W. somnifera* on the reproductive system through their systematic review. They designed this review in 2016. The results suggested that this plant was found to be effective in improving the quality of the reproductive system. It has been found that its extract enhances the quality of semen, probably due to the enhancement of enzymatic activity in seminal plasma and lowering of oxidative stress and thus, it was found to be beneficial in decreasing infertility. They concluded that spermatogenesis and sperm-related indices in males were found to be enhanced by its use and were also helpful in enhancing sexual behavior in females [12]. There is another review article written by Sengupta *et al*. (2018) on Ashwagandha [13]. Oral intake of different herbs may be effective in the treatment of infertility. It has been previously studied that Ashwagandha has an effective role in this direction. When this plant's root extract was taken orally, it was effective in improving the sperm count and motility, inhibiting the lipid peroxidation, and regulating the reproductive hormone levels. In their article, they have discussed the effective role of medicinal herbs in the infertility study of males. They included this herb in their detailed human and animal research and analyses. They also described the proposed direct oxidative mechanism involving the mitigation of oxidative stress

CHAPTER 8

Phytoconstituents, Biological Properties, and Health Benefits of Basil (*Ocimum basilicum* L.)

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Abstract: Herbs have been an important part of Indian food since the times of Romans and are effectively used as a possible alternative for medicinal treatments. Basil (*Ocimum basilicum*) is one of such annual herbs cultivated for several millennia for its ornamental and therapeutic importance in Ayurveda and traditional Chinese medicine. This chapter distinguishes sweet basil *O. basilicum* from other species of genus *Ocimum,* providing a place of origin and botanical distribution along with historical significance. The culinary, cosmetic, and traditional medicinal uses of sweet basil are described, followed by the chemical composition of the different parts of the plant used. Different types of chemical constituents found in the plant include terpenoids, alkaloids, flavonoids, tannins, saponin glycosides, and ascorbic acid. Major compounds which have been observed to be present in higher amounts in essential oils or extracts from different parts of the plant include rosmarinic acid, linalool, eugenol, 1, 8-cineone, methyl eugenol, and anthocyanins. These compounds have been found mainly responsible for various bioactive properties such as antioxidant, anticancer, antimicrobial, antidiabetic, analgesic, anti-inflammatory, hepatoprotective, insecticidal activities, *etc*. This chapter has covered up-to-date information on pharmacological investigations of the herb and its health-related benefits.

Keywords: Sweet Basil, phytochemicals, pharmacological studies, rosmarinic acid, linalool.

INTRODUCTION

Since time immemorial, there has been evidence of the applications of aromatic plants in food, cosmetics, perfumery, and pharmaceutical industries. Ethnobotanical studies have revealed a relationship between culture and the traditional use of plants [1]. In the past few decades, interest has been triggered for the use of these plants primarily for medicinal purposes for preventing diseases. Almost 10,000 different herbs/spices having medicinal properties have been discovered so far, and about 4500 have already been tested for pharmaceut-

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ical applications [2]. The efficiency is mainly attributed to the chemical constituents present in these plants. In recent years, a number of advancements have been made in the field of medicines using herbs and spices. More than 2/3rd of the world population is dependent on these medicinally important plants to be used as pharmaceutical drugs because of acceptance and adaptation of these herbs along with little or no side effects to humans [3]. All these advantages promoted the scientific communities to look at medicinal plants as an alternative to their synthetic counterparts for the treatment of deadly diseases.

Amongst the different plants known for therapeutic value, basil occupies an important place because of its therapeutic potential. Basil, a member of the Lamiaceae family (the fourth largest family/ mint family), is considered a commercially important herb used worldwide. The name basil is derived from the Greek word "Basileus", meaning "Royal or King". It is usually mentioned as King of the Herbs. It belongs to the genus *Ocimum*, which is considered a genus with great morphological, chemical profile, and genotype variation. It comprises about 150 different species distributed and cultivated around the world [4]. Due to its wide distribution, it has got several names such as basil, sweet basil, common basil, lemon basil, French basil, Réunion basil (England), albahaca, albahaca de jardines (Spain), basilic commun (France), Bassilico (Italy), alfavaca, mangericao (Portugal), Basilienkraut/ Basilikum (Germany), kemangi, selasi hitam, selasi jantan (Malaysia), *etc*. Different species of this genus are commonly referred to as basil *viz.Ocimum basilicum* L., *O. americanum* L., *O. gratissimum* L., *O. tenuiflorum* L. and *O. sanctum*are cultivated for its flavour and medicinal purposes. It is difficult to identify between species because of the polymorphic character, cross-pollination as well as identical chemical composition of these varieties. Along with the above species, there are many varieties, as well as several related species or hybrids, which are also called basil. Among all these, *Ocimum* spp., *O. basilicum* L., commonly known as sweet, common, or genovese basil, is the most important in medicinal and commercial points of view. The name *O. basilicum* is thought to have derived from the Greek: okimon, smell and basilikon, royal [5]. In India, sweet basil has got vernacular names such as *Bawari bawai*, *Babui tulsi*, *Barbar*, *Babui Tuls*i, *Tulsi* in Hindi, *Berbery* in Sanskrit, *Nasabo or Sabja* in Gujarati, *Niazbo* in Punjabi, *Jangli Tulsi* in Urdu. In Arabic countries, it is named *Hebak or Rihan,* whereas, in Persia and Unan, it is named *Tohrakhurasani* and *Okimon* [6].

Place of Origin (Habitat) and Distribution

Sweet basil (*O. basilicum* L.) has been cultivated for more than 5,000 years as an ornamental and field crop. It is native to India, from where it eventually migrated to other tropical and hotter regions of the world [7]. It is widely distributed in

Asia (India, Pakistan, Burma, Iran, Indonesia, and Thailand), Africa (Morocco, Egypt), South America, Europe (France, Greece, and Hungary), and the Mediterranean region [8]. In India, it is primarily grown in Assam, West Bengal, Bihar, Uttar Pradesh, Madhya Pradesh, Maharashtra, and Jammu.

Historical Background

The use of basil has been mentioned in the earlier Greek literature as an important medicinal plant. Several interesting facts are related to the historical significance of the herb in different societies of the world [9].

- Ancient Egyptians used basil herb for embalming and preserving the mummies. This might be the reason for Greece people consider it as a glorious herb.
- French also considered it as a royal herb and used it to wish good luck.
- Europeans found it unlucky to dream about it.
- In Jewish culture, it is believed to enhance strength during fasting, while the Portuguese gifted basil as a symbol of love.
- Italian ladies wear the herb in their hair, and the youth considered it a symbol of love and put a twig of it above the ear while dating.
- In India, Hindus bury a basil leaf with their deceased because it is thought to be a passport to heaven [10].
- In the 1600s, the English used it to repel unwanted pests, such as flies as well as evil spirits.
- Africans believed that the herb protected them from scorpion's poison [11].

Botanical Description and Taxonomical Classification

O. basilicum is a medium-sized, erect, annual, or sometimes perennial herb with a strong scent. The mature herb grows to a height of 0.6-0.9 m (1-2 feet). The stems and branches are usually green or purple in colour. The leaves are simple, opposite, entire, glabrous, lanceolate, lanceolate-ovate, or oblong having many oil glands for the secretion of volatile oil. They are toothed often, 3-5 cm long, and petiole is slender and 1.3-2.5 cm long. Glandular as well as non-glandular hairs are found on both sides of the leaves of the herb. The flowers are 8-12 mm long, having verticillaster inflorescence. Flowers are labiate (like lips) and grow in cluster-like circles of 6-10 flowers. The colour of the petals can be white, pink, or purplish. Calyx 5-lobed, upper lobe expanded into a lid or cap over others, often bilabiate. The pedicel is short and almost sessile. The ovary is superior, and the fruit is 4-partite. Seeds are black in color and oval in shape. The taxonomical hierarchy of *O. basilicum* is as follows:

CHAPTER 9

Phytochemistry and Pharmacology of *Terminalia chebula*: An Update

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Abstract: Various plants and shrubs with enormous medicinal values are easily found in India. These are mostly used in routine home remedies and the treatment of various diseases or ailments. Since the ancient era, medicinal plants are being used in various traditional systems of medicine to treat minor to major diseases or disorders.

Considering their valuable contribution at various levels of treatment, these medicinal plants have gained importance and emerged as one of the most cost-effective remedies in the current health care system. Ayurveda, an ancient system of Indian medicine, has mentioned several important medicinal plants; out of all these, *Terminalia chebula* has owned its importance because of its phytoconstituents and potent action on enormous diseases. It is also an important part of *Triphala* churna, which is one of the important formulations in the Ayurvedic system of medicine. The current review focuses on the phytochemistry and pharmacological effects of *Terminalia chebula*. The literature search was performed using various datasets like EBSCO, PubMed, Scopus, ProQuest, and selected websites, such as the World Health Organization (WHO) and the National Institutes of Health (NIH).

Terminalia chebula shows the presence of tannins like ellagic acid, gallic acid, ethyl gallate, chebulinic acid, tannic acid, chebulin, arjungenin, arjunglucoside I, terflavin A, punicalagin, and luteolin, which is mainly responsible for showing their pharmacological effects. The various parts of the plant have been reported for the treatment of various ailments. It has laxative, antiseptic, antidiabetic, and hepatoprotective properties. It is also used in the treatment of upper respiratory tract infections and bronchitis. Half ripe fruits are used as purgative and ripe fruit as tonic, astringent, antipyretic, expectorant, dyspepsia, diarrhoea, allergic eruptions, biliousness, cough, and leprosy. The dry powder form of fruit is used for emesis, hoarseness of voice, and worm infestation, as an anthelmintic, asthma, useful in hepatitis, eye diseases, and piles. Kernels of *Terminalia chebula* have been reported as anodyne.

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Kernel oil has been reported for its purgative action. Gum of the bark is a painkiller and laxative.

In conclusion, *Terminalia chebula* contains important phytochemicals like tannins, gallic acid, and ellagic acid. These indicate that the plant and its different parts have a wide range of pharmacological effects. This book chapter provides detailed information on the recent studies for pharmacological activities of *T. chebula* and its active components.

Keywords: Ayurvedic medicine, Ellagic acid, Gallic acid, Phytoconstituents, *Terminalia chebula*.

INTRODUCTION

Ayurveda is one of the oldest systems of medicine in health care. It is called *'Science of life'*, as this ancient Indian system is mainly focused on human beings and their illness [1]. India has an age-old heritage of traditional herbal medicine and is one of the richest countries in the world, having variety of plants with medicinal properties [2]. *Terminalia chebula* [3] (Combretaceae) is also known as *'king'* of Mongolian and Tibetan medicines, considering its effectiveness as a potent drug by apothecaries [4], and always a drug of choice in the materia medica because of its active phytoconstituents having extraordinary power of treating ailments with a wide spectrum of biological activities [5]. *T. chebula* is a member of the family Combretaceae, found in Nepal, the Indian subcontinent, Bangladesh, Sri-Lanka, and South East Asia. It is a flowering evergreen tree, having different names such as in English, it is known as the black myrobalan; in Sanskrit and Bengali, it is known as Haritaki; in Hindi, it is called Harad; in Telugu, it is known as Karkchettu; in Tamil, the popular name is Kadukkaya, and in Gujarati and Marathi, it is called by Harada. *T. chebula* is a plant with anti-diabetic [6 - 9] and hepatoprotective effects [10, 11].

The plant is native to India and Southeast Asia. This plant has several pharmacological properties like anti-bacterial [12, 13], antioxidant [3, 14, 15, 16, 17], maltase inhibitory activity [18], anti-allergic, antifungal, wound healing, anti-cancer, anti HIV, and anti-mutagenic [3]. Several chemical compounds such as tannins, polyphenols and triterpenoids, were isolated from *T. chebula* [19]. It is effective in the inhibition of cutaneous photo damage [20], lymphocyte proliferation and macrophage phagocyte response [21], caries [22, 23], aging [24, 25], hemorrhoid [26], and pain [27]. It has antivirulent activity [28], renoprotective effects [29], antitussive efficacy [30], antianaphylaxis action [31], apasmogenic activity [32], efflux-pump inhibitory activity [33], and purgative action [34, 17]. It shows inhibition of *M. tuberculosis* DNA Gyrase [35], HIV-1

RT inhibitory effects [36], free radical scavenging activity [37, 17], antifibrotic effects [38], management of Alzheimer's disease (AD) [39, 37], anti-Lipoxygenase activity [40], antiviral activity [41, 42], and adaptogenic property [43]. The phytoconstituents have been shown to have anti-inflammatory [44] and antioxidant activity [45]. It has shown a hepatoprotective effect in the liver of mice [10, 11]. In addition to the above, *T. chebula* extract was reported with free radical scavenging and inhibition of lipid peroxidation activity. Some treatments, not mentioned in modern phytotherapy but reported in traditional medicine are psychiatric issues, psychological problems, and fever [46]. It has also been reported to have wound healing properties [47, 48]. Kesharwani and co-researchers have reported that *T. chebula* extract contains phytoconstituents such as chebulinic acid and chebulagic acid. The report showed that it has significant antiviral activity [49]. The plant has antiplasmodial activity [50], reactive oxygen species scavenging properties [51], antimutagenic activity [52], free radical scavenging activity [53], whitening activity [54], intestinal and hepatic detoxifying effect [55], anti-arthritic activity [56], and potentiates the effect of tetracycline [57]. *Terminalia chebula* has also shown analgesic activity [58], Hepatitis C virus inhibitory activity [59], antidiarrhoeal property [60], anti-amyloidogenic effect [61], anti-necroptotic action [62], anti-apoptotic action [62], and NFκB inhibitory activity [63]. Chebulagic acid, an important constituent of plant has been reported to inhibit the proliferation of retinoblastoma cells [63]. Phytochemicals from the plant have been reported for cytotoxic activity [64], COX–LOX dual inhibitory activity [65], and anti-ulcer activity [66].

METHODS

The scientific information is obtained from the literature that is already published in reputed journals, with the main focus on traditional or medicinal uses, botany, phytochemistry, analysis of the active phytoconstituents, and pharmacological activities of *Terminalia chebula.* The data was collected from various databases such as PubMed, Science Direct, EMBASE, SciFinder, Scopus, Google Scholar, and ethnobotanical textbooks. The data published in the English language was considered in the study.

BOTANY, MICROSCOPY, AND POWDER CHARACTERISTICS OF *TERMINALIA CHEBULA*

Botanical Description, Distribution

Terminalia chebula is a large or moderate size tree found throughout all the States of India. It is mainly found in the light rain forest or deciduous forest up to 1500 m elevation. The plant has about 50 to 80 feet in height and a round crown-like

CHAPTER 10

Role of Plants in Natural Medicinal Therapy

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Abstract: Herbs and spices have been used as a source of medicine for the treatment of different diseases for thousands of years. Numerous pieces of evidence are available for the use of plants as a medicine in the treatment of diseases in the Indian, Egyptian, Chinese, Greek, and Roman systems of medicine. Biological diversity, such as herbs, spices, microbes, and other natural resources, has been explored, extracted, and screened globally throughout recent years. Phytochemicals are naturally available bioactive compounds that are derived from different plant parts and are primarily responsible for biological activities. Recent findings suggest that majority of phytochemicals have valuable therapeutic activities, such as anti-microbial, anti-diabetic, anti-bacterial, anti-arthritic, anti-malarial, *et al*. The chemical information coupled with traditional knowledge and supported by other biological activities will add additional value for the development of effective herbal drugs.

Keywords: Herbal medicine, Medicinal plants, Medicinal value, Phytochemicals, Pharmacognosy.

INTRODUCTION

Plants have been used as a source of medicine from prehistoric periods all around the world. Fossil records showed that herbal plants were used as medicine as early as 60,000 years ago. Neanderthal man's graves in and around Europe are one of the greatest pieces of evidence of this historical relationship. The information with respect to the medicinal benefits of plants with other therapies has been preserved in several documentations in Babylonia, Egypt, China, Greece, and Rome. Previous works of Theophrastus (370-287 B.C.), Aristotle (384-322 B.C.), Hippocrates (460-370 B.C.), and Dioscorides (50-100 A.D) provide evidence that Greeks and Romans were familiar with many of today's plant drugs. The "Ebers Papyrus," the best known Egyptian pharmaceutical record documented over 700 drugs, represents the history of Egyptian medicine (1500 BC). The Greek physician Dioscorides (100 A.D.) described more than 600 medicinal plants in

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"De Materia Medica." Erh-ya (300 B.C), Svu-ching (1000B.C) and Ben-tsao (1250A.D) are the early herbal documentations available in China, describing more than 600 medicinal plants [1]. In India, herbal remedies and health care preparations are also described in ancient texts like 'Charka Samhita' (100-800 B.C), 'Sushruta Samhita' (800-700 B.C), 'Rigveda' (1400-1800 B.C), and 'Atharva-veda' (4500-2500 B.C). Ayurveda is the basic source of Vedic knowledge for understanding the medicinal properties of plants (1000 BC) [2]. In addition to Ayurveda, Siddha and Unani are other traditional systems of medicine that provide additional information on plant-based drugs used in India. 'Unani' system of medicine originated in Greece and was introduced to India by Arabs and Persians after the discovery of the sea route to India. 'Sidda' system of medicine originated during the 10^{th} to 15^{th} century in southern parts of India and is similar to the Ayurveda system of medicine [3]. The allopathic system of medicine originated in Europe and became dominant in India with the establishment of the British Empire.

Bioactivity of Herbal Medicine

Human life and culture are directly and indirectly influenced by the surrounding environment. Humans depend upon the surrounding environment for their livelihood, healthcare, and sustenance and also for basic needs (food, fibres, shelter, clothing, and gum). Besides providing basic necessities, plants also fulfill their medicinal requirements. Along with plants, humans have started using animal products and other bio-resources available in nature for the preparation of medicine. As a result, different traditional medicine systems have evolved based on environmental conditions and social and cultural background with respect to the ethnic groups of different countries. This herbal healing art was transmitted orally from one generation to another generation. Herbal healing art is a kind of treatment with plants and herbs. Normally, the whole plant is considered to be more effective than the different parts of the plant because the plant's part has slow remedial properties due to the low concentration of different types of chemicals present in it [4, 5].

Herbal medicine has proven its efficacy, but the mode of action of herbal medicines and related products from nature is even more complex than systematic clarification of a single bioactive factor. This is due to mixtures of different constituents which are used in the formulations. Identification and isolation of such active principals and studying their mode of action is a challenging task. Herbal remedies are complex mixtures of many herbs which may sometimes produce a synergistic effect with each other, resulting in the increased therapeutic potential of remedy. For the identification of biologically active compounds responsible for medicinal property alone and in a mixture, there is a crucial

requirement for quality control. Correct identification and quality assessment are important to ensure the quality of herbal medicine, which contributes to its safety and efficacy. The therapeutic action of herbal formulation depends on the phytoconstituents of plants. The phytochemical investigation of the medicinally important plants should be carried out, as this would be beneficial in the standardization and dose determination of herbal drugs. Thus, pharmacognosy is found as an important tool to study medicinal plants for their identification, validation, and standardization [6, 7].

Biological diversity prospecting is the exploration, extraction, and screening of biological diversity and indigenous knowledge for commercially valuable genetic and biochemical resources. In the early stages, bioprospecting focused mostly on plants from the forest ecosystem. But in recent years, various other forms of biodiversity such as insects, algae, and microorganisms have been explored with considerable success [8]. This activity involves the use of advanced technologies to develop new pharmaceuticals, agrochemicals, cosmetics, and other bi-products from biological diversity [9]. With the help of advanced technology and sophisticated techniques and equipment, it has become an effective way to conduct research on the metabolic response of the living system, genetic manipulation, and new drug invention through bioprospecting. Various bio-molecules have been isolated and tested for their pharmacological activities [10].

Pharmacognosy is the study of crude drug actives derived from natural sources, mainly from plants which may further lead to the development of a new drug. The word pharmacognosy is derived from the Greek word *pharmakon*-drug and *gnosis*- knowledge. The term pharmocognosy was first time used by the Austrian physician Schmidt in 1811. A "crude drug" means a dried unprepared natural material of plant, animal, or mineral origin, which is used for medicine. Phytochemicals ('Phyto' meaning plant) are active metabolites of plants such as sugar, amino acids, protein, chlorophyll, alkaloids, flavonoids, steroids, tannins, *et al*. More than 4000 phytochemicals have been obtained, cataloged, and classified by protective function, and physical and chemical characteristics, of which 150 phytochemicals have been studied in detail [11]. The latest outcome suggests that the majority of phytochemicals have favorable activities like anti-microbial, anti-malarial, anti-diabetic, anti-arthritic, and anti-cancerous, *et al*. The medicinal, biological, and pharmaceutical values of phytoconstituents have helped in the utilization and exploration of plant resources in recent years. The chemical information of plants, together with traditional knowledge and supported by other biological activities, will add additional value for the development of effective herbal drugs [12].

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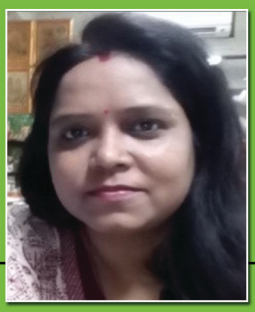

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