THE CHEMISTRY INSIDE SPICES & HERBS: RESEARCH AND DEVELOPMENT

VOLUME 4

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The Chemistry Inside Spices & Herbs: Research and Development

(Volume 4)

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PREFACE

VOLUME-4 of the **book series "The Chemistry Inside Spices and Herbs: Research and Development**" is a nice collection of a total of eight chapters written by experts from India, Brazil, and Nigeria. Volume-4 has chapters full of scientific knowledge on the pharmacology of different herbs and spices, and different pharmaceutical roles of herbs and spices along with their chemistry have been excellently expounded by the experts. This volume of the book includes several pharmaceutically relevant topics such as the pharmacological potential of *Sphaeranthus indicus* Linn, Indian spices in the management of emerging viral infections, Coriander and its properties, *Copaifera* spp. Oils' pharmacological study, *Nardostachys jatamansi* and its pharmacognostic profile, edible bush onion (*Afrostyrax lepidophyllus)* as a source of essential food and medicinal constituents, chemistry, biochemistry and medicinal applications of different herbal essential oils and insights into the pharmacologically valuable plant proteases.

Chapter 1, written by Singh, illustrates the necessity for novel antivirals, which is further supported by the recent pandemic scenario. The effect of various Indian spices on the immune system, as well as how well they might be capable of fighting viral infections, is covered in detail in the second section.

Chapter 2, written by Zambelli, describes the chemical, functional and nutritional properties of Coriander.

In **Chapter 3**, Tiwari *et al.*, have compiled the traditional uses, chemical components and pharmacological properties of *Sphaeranthus indicus* Linn to provide a ready reference for scientists working on this plant species.

Chapter 4, written by Kumar *et al*., comprehensively describes the phytochemistry of Copaiba oleoresins, conventional uses, and pharmacological properties of various oils from *Copaifera* species.

Chapter 5, written by Gupta *et al*., comprehensively describes the pharmacognostic profile of *Nardostachys jatamansi*, a potent medicinal herb. In this chapter, they have described the various aspects of this medicinal plant in detail.

Chapter 6, written by OYETAYO *et al*., describes a medicinal herb, Bush Onion (*Afrostyrax lepidophyllus*), along with its nutritional and medicinal values.

In **Chapter 7**, Agrawal *et al.*, describe the various plant's essential oils, the chemistry of EO, extraction methods, essential oils in aromatherapy, as well as medicinal functional properties of different EOs like Lavender Oil, Clove oil, Eucalyptus oil, Peppermint oil, Lemongrass oil, and Cinnamon oil.

In **Chapter 8**, Roy *et al.*, have comprehensively discussed the various plant proteases, highlighting their pharmaceutical, industrial and biotechnological aspects as well as the structure, properties and catalytic mechanisms.

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CHAPTER 1

Role of Indian Spices in the Management of Emerging Viral Infections

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Abstract: The viral pandemic, with both emerging and re-emerging characteristics, has had a significant impact on human lives worldwide. This pandemic has resulted in substantial morbidity and mortality due to its rapid and widespread transmission among the general population. Unfortunately, the lack of effective antiviral treatments has further complicated the situation, making it challenging to control and manage the disease effectively. The ideal method for safeguarding against viral infections is to be immune. India's indigenous systems of medicine, with its rich array of phyto-therapies and natural remedies, have attracted the global community's interest. As a result, people all around the world are turning to and rekindling their interest in immune-boosting traditional remedies. Spices, with their significant therapeutic potential and excellent safety profiles, are currently being extensively studied as herbal drugs and immune-enhancing home remedies against infectious diseases. The first part of this chapter discusses the need for new antiviral drugs, especially in light of the recent pandemic. The second part reviews the extensive scientific evidence on the immune-boosting effects of many Indian spices, as well as their potential to fight viral infections. It also discusses their safety and toxicity profiles.

Keywords: Antiviral potential, Immune boosters, Safety profiles, Traditional remedies.

INTRODUCTION

From time immemorial, infectious diseases, particularly viral infections, have tormented humanity and civilization [1 - 4]. The virus's replication motifs and transmission modes are the prime roots of viral pandemics [5, 6]. However, substantial progress in the medical field against emerging viral infections has been made in the past few decades, particularly in the 1990s and 2000s. This progress has been driven by a number of factors, including advances in understanding the biology of viruses and their replication, the development of new technologies for

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drug discovery and vaccine development, and increased investment in global health research and development [7 - 10].

The discovery of new treatment targets is not always followed by the formulation and authorization of new chemotherapeutics. Antivirals are not an exception when it comes to treating viral infections. Between 2017 and 2022, the FDA (Food and Drug Administration) granted approval to a mere seven new antiviral drugs, as highlighted in Table **1**. The emerging and re-emerging viral outbreaks, as shown in Fig. (**1**), have propelled the scientific community to develop effective and sophisticated remedies to address the escalating demands imposed by these deadly diseases [11, 12].

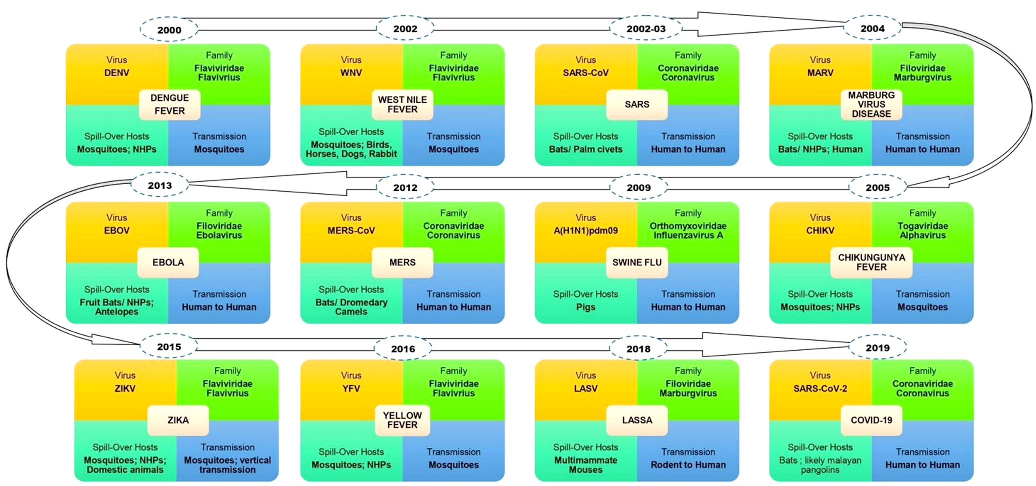

Fig. (1). Emerging and re-emerging viral diseases.

Table 1. New antivirals approved by the FDA during the last five years (https://www.fda.gov/drugs).

Drug (Common Name)	Month and Year of Approval	Mechanism of Action	Treatment
Remdesivir (*Veklury*)	December 2020	Inhibition of RNA-dependent RNA polymerase enzyme of SARS-CoV-2	Treatment of COVID-19
Molnupiravir (*Lagevrio*)	November 2021	Oral antiviral drug that works by introducing errors into the RNA of SARS-CoV-2, which prevents the virus from replicating.	Treatment of asymptomatic or mildly symptomatic COVID-19 in high-risk adults

(Table 1) cont.....

Drug (Common Name)	Month and Year of Approval	Mechanism of Action	Treatment
Paxlovid (*PF-07321332*)	December 2021	It is an oral antiviral drug that works by inhibiting the SARS-CoV-2 protease enzyme.	Managing the symptoms of mild-to-moderate COVID-19 in adults who are at high risk of severe disease
Evusheld (T*ixagevimab* and c*ilgavimab*)	October 2021	This treatment works by using antibodies to target and neutralize, the SARS-CoV-2 spike protein, crucial for its attachment to human cells.	For the prevention of COVID-19 in adults and adolescents 12 years of age and older who are at high risk of severe disease.
Telaprevir (*Invirase*)	January 2022	It is an oral antiviral drug that works by inhibiting the protease enzyme of the hepatitis C virus.	For the treatment of chronic hepatitis C in adults who are co-infected with HIV.

Viral Life Cycle and Possible Drug Interventions

As parasites, contagious microscopic viruses encroach on living cells incorporated with host DNA. The virus takes control of the cellular machinery, initiating the production of numerous virion particles. As the entire life cycle of the virus unfolds within the host cell, discovering an effective treatment becomes exceedingly challenging. Different strategies have been developed by the scientific community to combat viral infections, and the main antiviral approaches currently under consideration may be classified into two types:

(i) The approaches that directly target the viruses and

(ii) The indirect approach involves targeting viruses by modulating the immune system of the host through various strategies, aiming to enhance the innate immune response or reduce inflammation triggered by viral infections [13].

The virus-directed methods require a thorough understanding of the virus's chemical nature, especially its interaction with the host cell. In the case of retroviruses, the exceedingly fast multiplication rate combined with the absence of exo-nuclease proofreading allows them to generate drug resistance mutations at an exceptionally fast rate. Viruses also exploit host machinery to not only replicate in host cells but also to escape the host immune system. The prospective targets in the viral life phases for the development of potential antivirals have been shown in Fig. (**2**).

CHAPTER 2

Chemical, Functional, and Nutritional Properties of Coriander (*Coriandrum Sativum*)

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Abstract: Coriander is a plant common to several countries. Its use is associated with traditional medicine due to its functional and therapeutic properties. However, more and more coriander has been used in various sectors, such as food, medicine, pharmaceuticals, and cosmetics. Given the importance of this plant, this chapter aims to present the main chemical, functional and nutritional characteristics in addition to the main applications of coriander. The different parts of coriander have several bioactive components, such as monoterpenes, alkanes, aldehydes, alcohols, pigments, flavonoids, phenolic compounds, and saturated and unsaturated fatty acids. Because of its composition, coriander has numerous functional and nutritional properties such as antioxidant, antimicrobial, antibiofilm, antidiabetic, anxiolytic, and antidepressant activity, among others. Applications range from studying the impact on microorganisms to improving animal diets and extract preparations. Therefore, it can be said that coriander is a plant with multiple applications, and its nutritional potential should be increasingly explored to promote health benefits.

Keywords: Antimicrobial, Essential oil, Fatty acid, Monoterpenes, Phenolic compound.

INTRODUCTION

Several plants have aroused the interest of researchers because of their phytotherapeutic, medicinal and functional properties. In this context, an example is coriander. Because of the emerging concept of functional foods, it plays a role not just in nourishing the energy needed for human daily activities, but in cultivating healthy habits from a diet rich in bioactive components.

Coriander (*Coriandrum sativum L.*) is classified as a member of the *Umbelliferae* or *Apiaceae* family [1]. It is popularly known as a kind of condiment used by different cultures in cooking and is considered an edible plant [2]. Its origins are from the Mediterranean coast of Europe and Central Asia. It is especially popular

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in Mexico, South America, and China. Coriander production has been increasing since 1994 due to increased consumer demand, especially in Asia, which is responsible for 71% of world production [3]. It is also grown naturally in North Africa [4].

In addition, there are reports of crops in Europe, especially in the Nordic countries (Finland, Denmark, Norway, and Sweden), Germany, Hungary, Belgium, and Poland [5]. The use of this plant has been recorded since before 1550 BC, being one of the oldest spice crops of humanity [6].

The top producers in 2022 were India ($47.2M), Russia ($29.0M), Italy ($27.9M), ($16.2M), ($13.4M), Iran ($10.8M), Ukraine ($5.9M) and Canada ($4.7M), according to a study [7].

Botanically, coriander is a slender, tender, glabrous, branched, annual plant and is considered a perennial herb that grows up to 50 cm in height. Its harvest period is between 2 to 3 months after sowing, and it is plucked by the roots [8].

This species has functional properties and nutraceutical and bioactive compounds of biotechnological interest [9]. In some cultures, coriander is planted with the aim of being a raw material for medicinal, culinary, and aromatic purposes. Its economic importance is valued due to its use as a flavoring agent in foods, cosmetics, and medicines [10]. Its leaves have an irritating and pungent aroma, and its seeds exude a sweet and spicy aroma [11]. The dried seeds are widely used as a spice in the Mediterranean region and India [12].

Dried fruits and leaves are used to provide aroma and flavor to food. Fruit is often used as a component of curry powder and is important in Indian cuisine. In turn, the leaves are often appreciated in Thai and Vietnamese cuisine [13]. In Brazil, especially in the northeast region, it is used as a seasoning in soups, broths, and beans. According to a study [14], the essential oils obtained from coriander fruits are used in food, alcohol, and cosmetic industries. Its leaves are rich in various food elements such as proteins, fats, fibers, vitamins, carbohydrates, water, vitamins C, calcium, phosphorus, iron, thiamine, riboflavin, and oxalic acid [15].

Research involving this plant focuses on the leaf, seed, or essential oil due to its attractive value in medicine and therapeutic potential; however, other parts of coriander may also have industrial potential.

Coriander is also highly valued for its functional and biological properties. Several studies have shown that parts of the plant may have antifungal, antiulcer, antimutagenic, anticancer, antiprotozoal, antidiabetic, anticonvulsant, antifertility, anxiolytic, diuretic, anthelmintic, sedation and hypnotic, hepatoprotective, and cholesterol-lowering potential. It also has appreciable amounts of vitamins A, B, E and K, in addition to micro and macroelements and essential oils [16 - 19].

Coriander leaves have good amounts of vitamin C, carotenoids, dietary fiber, and polyphenols, as well as various amounts of volatile components that give coriander its specific fragrance. In turn, the seeds have high antioxidant activity, and this is attributed to the high contents of tocopherols, phospholipids, and carotenoids [20].

Chemical Properties

Green coriander contains 84% moisture, reduced content of saturated fats and cholesterol and high level of thiamine, zinc and dietary fiber [21], in addition to natural pigments such as chlorophyll-a, which gives the characteristic color of coriander leaves [22].

Coriander seeds have up to 1% essential oil and are composed of oxygenated monoterpenes, monoterpene hydrocarbons, long-chain alcohols, and fatty acids [23, 24]. A research points out that the monoterpenes present in coriander are linalool, camphor, geraniol and limolene.

The different parts of this plant contain monoterpenes, limpnene, α-pinene, γ-terpinene, p-cymene, citronellol, borneol, camphor, coriandrin, cis-geraniol, dihydrocoriandrin, coriandronsA-E, flavonoids, and essential oils [25]. Significant amounts of 2-Carene, p-mentha-1,3,8-triene, β-terpinyl-acetate, eucalyptol, β-myrcene, β-ocimene, trans-linalool oxide, terpinolene, borneol, terpinene-4-ol, α-terpineol, lavandulyl and geranyl acetate were found in coriander seeds [26].

In turn, compounds like decanal, (Z)-2-decenal, Undecanal, Dodecanal, 2-dodecenal, 2-tridecenal and 2-undecenal were found in the aerial parts of coriander; however, these components were not detected in the seeds [27]. These components are classified as aldehydes and can be formed from the oxidation of alcohols in the plant, which have antibacterial activity [28].

Many volatile components were found in coriander, including alcohols, aldehydes, hydrocarbons, and esters, with the class of aldehydes having the highest amount (878 $\mu g.g^{-1}$) [29]. In turn, the presence of 46 aromatic components was detected in coriander essential oil, and the obtained coriander essential oil by the hydrodistillation method and gas chromatography analysis coupled with mass spectrometry identified 24 components, which were mostly aldehydes and alcohols [30].

CHAPTER 3

Phytochemical and Pharmacological Potential of *Sphaeranthus Indicus Linn*

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Abstract: *Sphaeranthus indicus Linn* (Asteraceae) is commonly known as Munditika, Mundi, Shravana, Bhikshu, Tapodhana, Mahashravani, Shravanahva, and Shravanashirshaka. It is generally found in wet places of the lowlands and also grows as a weed in rice fields. Herein, the traditional uses, chemical components and pharmacological properties are compiled to provide a ready reference for scientists working on this plant species. The whole plant and various morphological parts are extensively used in Indian medicine to treat a variety of diseases. The plant has astringent, stomachic, reviving, pectoral, demulcent, and calming properties. Various secondary metabolites, such as eudesmanolides, sesquiterpenoids, sesquiterpene lactones, sesquiterpene acids, flavone glycosides, flavonoid C-glycosides, isoflavone glycoside, sterols, sterol glycoside, alkaloids, peptide alkaloids, amino acids, and sugars have been found in the plant. Numerous monoterpene hydrocarbons, oxygenated monoterpenes, oxygenated sesquiterpenes, and sesquiterpene hydrocarbons were found in the essential oils from the plant. The entire plant and various morphological parts have been reported to have ovicidal, anthelmintic, antifeedant, antimicrobial, antiviral, macrofilaricidal, larvicidal, analgesic, antipyretic, hepatoprotective, antitussive, wound healing, bronchodilatory, mast cell stabilising, anxiolytic, neuroleptic, immunomodulatory, anti-diabetic, antihyperlipidemic, antioxidant, central nervous system depressant, anti-arthritic, nephroprotective, and anticonvulsant activities. Acute toxicity of extracts from different plant parts revealed the safety of the drug.

Keywords: Phytochemistry, Pharmacological activity, *Sphaeranthus indicus*.

INTRODUCTION

Herbal medicine is the oldest kind of healthcare ever used by humans. Herbs have been used by all societies throughout history. Nowadays, herbal medicine is becoming more popular in both developed and developing countries. As improvements in clinical research, analysis, and quality control show how beneficial herbal medicine is in the treatment and prevention of disease, it is

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becoming ever more popular. Because they have fewer side effects, are much more easily accessible, are less expensive, *etc*., herbal medicines are replacing synthetic ones to a greater extent frequently. Numerous drugs have entered the market as a result of research on ethnopharmacology and conventional therapies. Ayurveda, one of the Indian systems of medicine, employs a number of medicinal plants in the treatment of various disease conditions. The effectiveness of Ayurvedic medicine requires the establishment and validation of evidence. One of these medicinal plants that has been investigated for its phytopharmacological significance is *Sphaeranthus indicus* Linn.

Fig. (1). *Sphaeranthus indicus* **A)** Fresh whole plant of *S. indicus*, **B)** Fresh flower of *S. indicus*, **C)** Dried flower of *S. indicus*, **D)** Dried leaves of *S. indicus*.

The Hindi name of *S. indicus* is Gorakhmundi. It is a tall, multi-branched, fragrant plant that may grow up to 50 feet in the hills and is frequently found in India's plains (Fig. **1**). The various morphological parts of the plant have been utilized in different forms against an array of health conditions. The plant is also rich in a variety of secondary metabolites having pharmacological significance. The information related to traditional uses, phytochemical investigation and pharmacological studies on*S. indicus*was collected from different scientific databases such as Scopus, Pubmed, and Google Scholar and compiled here as a ready reference for future researchers to explore the plant from different angles.

PHYTOCHEMISTRY AND BIOACTIVE COMPOUNDS OF *SPHAERANTHUS INDICUS*

The alkaloid sphaeranthus with chemical formula $C_{13}H_{19}NO_5$ and melting point 166-168 °C has been isolated from chloroform extract of the entire *S. indicus* plant [1]. Additionally, they collected the volatile oil from *S. indicus* fresh flower by steam distillation and established its physicochemical constants. From the entire plant of *S. indicus*, three novel eudesmanoids (Fig. **2**), 11,13-dihydro-3,7 -dihydroxy-4,5-epoxy-6, 7-eudesmanolide (**A**), 11,13-dihydro-7 -acetoxy-3-hydroxy-6 (**B**) and 7 eudesm-4-enolide and 3-keto-β-eudesmol (**C**) have been isolated from the whole plant of *S. indicus* [2].

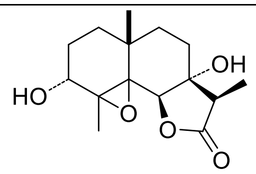	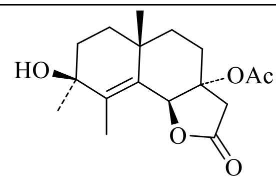	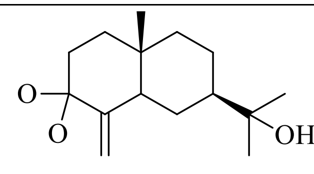
A	**B**	**C**

Fig. (2). Novel eudesmanoids in *S. indicus.*

An immune-stimulating novel sesquiterpene glycoside called sphaeranthanolide has been isolated from the flowers of *S. indicus* and the structure was determined by using 2D-NMR and other spectroscopic methods (Fig. **3**) [3]. Three novel eudesmanolides, 11-,13-dihydro-3-,7-dihydroxyfrullanolide, 11,13-dihydro-7,13-dihydroxyfrullanolide and 11-,13-dihydro-7-hydroxy-13-methoxyfrullanolide have been identified in the flowers of *S. indicus* [4]. A flavonoid C-glycoside called 5-hydroxy-7-methoxy-6-C-glycosylflavone has been isolated from the aerial parts of *S. indicus,* and spectroscopic techniques were employed to determine its structure [5]. From the entire *S. indicus* plant, the well-known 7-hydroxyeudesmanoiide, two sesquiterpenoids (cryptomeridiol and 4-epicryptomeridiol), and 7a-hydroxyeudesmanolides have been identified, and structures of the novel compounds were determined by X-ray crystallography [6].

CHAPTER 4

The Chemistry and Pharmacological Study of *Copaifera* spp. Oils

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Abstract: Since ancient times, *Copaifera* tree oleoresin has been widely utilised for conventional medicine, and it is currently a well-liked remedy for a variety of illnesses. The vast majority of the chemical makeup that makes up copaiba resins is frequently composed of sesquiterpene hydrocarbons such as germacrene D, copaene, caryophyllene, elemene and humulene. Kaurenoic acid, alepterolic acid, copalic acid and polyalthic acid are a few of the physiologically useful diterpene compounds present in oleoresin. Due to its many pharmacological qualities and extensive usage, oleoresin is one of the most significant regenerative natural remedies and folk medicines. In addition to being used as a contraceptive, oil or plant bark decoction is also used to treat inflammation, bronchitis, syphilis, and cough. Wound healing is improved when oil is administered topically to the skin. During massages, it is administered to the head to manage convulsions, pain, and paralysis. It is also suggested to apply oil-soaked cotton to tumours, ulcers, or hives. Dog bites and other infected wounds are treated with the bark's decoction, which is also used to treat rheumatism. The oil is utilised to create a patch that is mechanically applied to wounds and some ulcers to treat them. Caryophyllene has exhibited its activity in a number of pharmacological models, including cannabinoid receptors, making it one of the most significant phytoconstituents in copaiba oils at the present time. The goal of this chapter is to look into the phytochemistry of copaiba oleoresins, conventional uses, and the pharmacological properties of various oils from *Copaifera* species.

Keywords: β-caryophyllene, Bark decoction, Bronchitis, Convulsions, Diterpene acids, Inflammation, Sesquiterpenes, Oleoresin, Paralysis, Tumours.

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INTRODUCTION

According to the taxonomical classification of the genus *Copaifera*, it belongs to the subfamily *Caesalpinoideae* and family Fabaceae. The copaiba trees make up the bulk of the *Copaifera* genus' tree species [1]. The allusions to the indigenous terms copava and copahu, which refer to a plant's secretions and the oil found within it, respectively, are most likely to be applicable to the origin of basic and common copaba [2].

In 1638, Marcgraf and Piso used the term "Copaiba" to describe the genus for the first time without identifying the particular species. Some scientists mentioned the plant species *Copaiva officinalis* in their work Enumeratio Systematica Plantarum in 1760. In his subsequent investigations, Species Plantarum, which was printed in 1764, Carl von Linnaeus accomplished a more comprehensive examination of the plant and specifically named it *Copaifera officinalis* (Jacq.) L as a particular type [3]. There are around 70 *Copaifera* species, with South and Central America possessing the largest abundance. In addition, a total of four species may be found in the African continent, and one subspecies can be found in Borneo, an island in the Pacific. Brazil has the most *Copaifera* biodiversity, with 26 species and 8 variations [4].

In light of the various botanical synonyms associated with certain species, more thorough, environmentally friendly, taxonomical, genomic, metabolomic, and genetic studies on the genus are necessary, as well as a revaluation of the species classification [5]. The botanical features of the leaves, such as the presence or lack of notches on the leaflets, the amount and shape of the leaflets, and floral attributes, such as the lengths of the petals and anthers and the condition of the stamens, are the primary distinguishing features among various *Copaifera* species [6]. To basically outline these plants, they can be recognised botanically through their petiolate and terminal leaves. These trees can live for a maximum of 400 years, grow slowly, exhibit shrubby or arboreal inclinations, reach heights of up to 40 m, and have peak diameters of up to 4 m [7].

Intercellular glandular lines are arranged in zones of peripheral axial parenchyma across their cylindrical shafts. The parenchyma cells of the tube's parenchyma produce a substance called the secretory layers' lumen and develop schizogenously. The species' leaves are alternating, pinnate, and 2 to 12 paired. Generally, clear points and glands at the base of the bordering vein may occasionally be present [8]. The species is frequently deciduous and possesses thin, interpetiolar stipules as well. The interior hirsute sepal containing a tetra chalice of the monoclamid, small, many, sessile flowers creates short tubes. Small bracts provide protection for the flower buds, and the spikes of flowers are alternating panicles. The gynoecium features a sessile in nature receptacle with two elongated eggs, a filiform fashion, and a cylindrical and papillary stigma as opposed to the androecium, with its ten loose stamens that are smooth fillets, and a rectangular, rimose anther [9].

The fruits are laterally compressed, dehiscent, bivalved, and monospermic. The seed is pendulous, oblong-globular, and densely coated in white or yellow arils, and the endosperm is absent. The blooms are minor, apetalous, hermaphrodite, and grouped in axillary panicles. The rectangular seed of the fruits is encircled by a swarm of vivid arils [10].

Although the *Copaifera* genus has undergone extensive taxonomic examination, certain species remain difficult to discern, mostly because of their delicate floral morphology and the lack of reproductive systems in the samples studied. The primary obstacle to botanical identifying the collection with respect to Amazonian species is the paucity of field data and specimen pictures [11]. The development of programmes, strategies, and plans for the long-term preservation and conservation of commercially important species has also been hampered by these taxonomic issues. These issues have also impeded the advancement of chemical and medical research, as well as the industrial and practical uses of resin oils and the use of wood [12].

Significant sources of fatty acids and timber are the aforementioned trees. The liquid known as oleoresin varies in colour (from yellow to light brown) and viscosity. Its non-volatile component, which is mostly made up of acid compounds, and its dynamic component, which is a combination of sesquiterpenes, are both solid forms and polymers [13].

Numerous traditional remedies employ this oleoresin. The molecules with the kaurane, clerodane, and labdane skeleton types can be found in all oleoresins despite the fact that the species and individuals within the same species exhibit substantial variability in the chemical profile of the oleoresin. It is notable that copalic acid, a labdane-type diterpene, is present in the majority of industrial samples of the drug [14].

The major components of the volatile fraction are thought to be sesquiterpenes that have two forms, oxygenated and non-oxygenated, such as caryophyllene, copaene, humulene, and caryophyllene oxide [11]. Researchers in this area have shown the most interest in the *Copaifera langsdorffii* L. After the leaves' hydroalcoholic extract was subjected to phytochemical analysis, flavonoid heterosides such as kaempferol-3-o-alpha-L-rhamnopyranoside (afzelin), galloylquinic and methylated galloylquinic acids, quercetin-3-o-alpha-L-rhamnopyranoside (quercitrin), and others were discovered [15].

CHAPTER 5

Pharmacognostic Profile of a Potent Medicinal Herb: *Nardostachys Jatamansi*

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Abstract: *Nardostachys jatamansi* DC, a small, erect, perennial, rhizomatous herb growing on steep, moist, rocky, undisturbed grassy slopes, is a popular species of aromatic and medicinal plant. The Sanskrit word "Jata," which denotes a matted and uncombed lock of hair, is similar to its rhizome, hence the name "*Jatamansi*." The plant is found between 3000 and 5200 m above sea level in the alpine Himalayas, which include parts of Uttarakhand, Himachal Pradesh, Arunachal Pradesh, and Sikkim in India, as well as numerous regions of Nepal, Tibet, China, and Bhutan.

N. jatamansi has been used in ayurveda, ethnomedicine and alternative medicine for a very long time, going all the way back to the Vedic era (1000–800 B.C.). Its rhizomes were used as a bitter tonic to cure epilepsy, stimulant, antispasmodic and to treat hysteria in the traditional Ayurvedic medicinal system. It has a wide range of therapeutic benefits, including anti-inflammatory, antidepressant-like action, anticonvulsant, hypotensive, anti-asthmatic, anti-estrogenic, cardioprotective, neuroprotective, antidiabetic, antifungal, antibacterial, and anticancer characteristics. Additionally, it functions as a sedative, tranquillizer, hypolipidemic, anti-lipid peroxidative, antioxidant, and anti-oxidant. In addition, it is used to treat a variety of neurological conditions, including insomnia, excitation, epilepsy, neurosis, Alzheimer's disease, and issues with learning and memory. As per various phytochemical studies, esters, phenolic chemicals, and terpenic ketone are the major components present. Due to the frequently observed variations in the types of metabolites in the plant, tremendous medicinal applications can be precisely explored using the database of antioxidant, antimicrobial, anticancer, antidiabetic and anti-inflammatory activities, making it a potential candidate for treating oxidative stress and other diseases produced during pathogenic conditions. For the prevention and treatment of a variety of pathological illnesses, as well as the side effects associated with them, the use of plants like *N. jatamansi* may thereby lessen reliance on synthetic pharmaceuticals.

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Keywords: Antioxidant, Antimicrobial, Antidiabetic, Jata, Oxidative stress, Perennial.

INTRODUCTION

People have relied on nature for healthcare for millennia, including plants, insects, animals, and fungi. Communities have found several plant species with varied medical applications over time and have maintained significant ethnobotanical knowledge to improve the quality of their lives. Despite the fact that current science has discovered plants and plant extracts that can treat and cure ailments, it may have been challenging for prehistoric humans to identify and classify plants having components beneficial to health. According to the earliest known medical records between 5000 and 3000 BC, Sumerian clay tablets show that people were aware of ailments and thus used plants with medicinal properties to protect and restore health. People were aware of the medical plants, as evidenced by the medicinal herbs found on the preserved remains of Tzi, the Iceman, who was unintentionally murdered between 3400 and 3100 BC in the icy, high Alps. Plants probably flourished by producing disgusting, unpleasant chemical components that repulsed animals, as they may be susceptible to destruction owing to being used as fodder by animals and insects [1]. Humans may have developed the selective practice of eating particular plant parts as a result of their observations that various plant tissues, such as fruits, leaves, or roots of particular plants, improved their mood. From these foundations, lovely plant gardens have been created for the food and plant components that contribute to people's continued health.

The World Health Organization (WHO) defines “conventional medicine” as the totality of knowledge, skills, and practices derived from theories, beliefs, and stories that are precise to numerous cultures and used in the maintenance of health as well as through preventive and therapeutic measures for physical and mental illness. Because of its potential and effective applications and minimal side effects, herbal treatment for many ailments is currently gaining popularity. In the human community, medicinal and aromatic plants (MAPs) are a significant source of medications and are being used as a main component in the field of healthcare. MAPs are a large group of species with a variety of sources, traits, and functions that are a component of traditional medical systems that may be found in many local cultures all over the world. The usefulness of medicinal and aromatic plants depends on their accessibility and active therapeutic capability to manage particular illnesses. Each medicinal and aromatic plant contains a unique kind and quantity of chemical components that vary according to the plant species. Additionally, when plants get older, their concentration changes. According to Zhang's report 1996 [2], the significance of traditional medicinal herbs in the prevention or control of some metabolic disorders like diabetes, heart disease, and specific types of malignancies has been amply demonstrated by research-based data. Since ancient times, herbal medicines have been utilized in treating a variety of illnesses throughout the world [3, 4]. It has been documented that medicinal plants can be used alone, in combination, or even as the main source of raw materials for other medications [5].

Higher plant species, which represent by far the highest use of the natural world in terms of species, have been used in traditional and modern medicine all over the world in amounts ranging from 50,000 to 70,000 species, with many more species important to the expanding market for plant-based cosmetics and other products. These species now play a crucial role in healthcare in many poor nations, delivering effective medicines for sizable segments of the population in places where other types of medication are either unavailable or unaffordable. According to estimates, 80% of the populations in Africa and Asia rely heavily on these plant-based medications for their healthcare requirements, and the WHO [6] predicted that in the ensuing decades, a similar percentage of the global population may do the same. The majority of the MAP trade takes place on a local level within countries, and the majority of these species are only used in traditional medicine [7 - 9]. Approximately, 3000 of these plant species have been traded globally. An estimated 1,77,000 metric tons of herbal medicine were traded in India each year that included 960 plant species [10]. Around 2500 medicinal plants from the Indian subcontinent are used locally for medical purposes and/or are traded, particularly in the pharmaceutical industries. Of these, 1748 species have their origins in the Indian Himalayan Region, a majority of which are found in the Uttarakhand region [11].

Nardostachys jatamansi is a medicinal and aromatic plant local to the Himalayan region that has an extended record of use in conventional Indian remedies and historic Greco-Arab remedies. Due to *N. jatamansi*'s medicinal and aromatic properties, 300 metric tons of raw materials (dry rhizome) are needed in India each year [10].

Botanical Classification

Contrary to what is stated in all the documented material about this plant, *N. jatamansi* actually belongs to the *Caprifoliaceae* family, not the Valerianaceae.

Kingdom: Plantae

Division: Mangnoliophyta

Class: Mangnoliopsida

CHAPTER 6

Potentials of Wild Edible Bush Onion (A*frostyrax Lepidophyllus)* Plant as a Source of Essential Food and Medicinal Constituents

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Abstract: The Bush Onion (*Afrostyrax lepidophyllus*) plant is an unconventional tropical West African plant characterized by a strong onion-like aroma. It is a member of the Huaceae family, and its bark is used as food sauces, condiments, spices, and flavorings due to its strong aroma. The seed is used trado-medicinally to treat venereal diseases and gastro-enteric diseases and as a laxative and mouthwash. It also has anti-cancer, antioxidant, estrogenic and insecticidal properties. These effects have been attributed to its content of phytochemical compounds such as polyphenols, flavonoids, glycosides, saponins, alkaloids, and anthocyanins. It also contains appreciable concentrations of certain important phytonutrients. Its potential as an affordable nutritive source of non-synthetic constituents can be exploited as a valuable contribution to food and medicine sources, especially in the developing world.

Keywords: Antioxidant, Bush onion, Estrogenic, Medicinal, Phytonutrients, Unconventional.

INTRODUCTION

The 'Bush Onion' plant (*Afrostyrax lepidophyllus*) is a wild edible plant that grows in some parts of tropical Africa and is characterized by a strong onion/garlic-like aroma. The tree bark is used in food as sauces, condiments, spices, and flavorings. The seed is believed to possess anti-cancer activity and is repulsive to poisonous animals such as snakes and scorpions [1]. It is used as a febrifuge to treat venereal and gastro-enteric diseases and as an antidote for snake bites [2]. The root bark decoction is consumed as an anthelmintic and an enema to treat urinary infections [3], while the bark is used to treat convulsions in Ghana [4].

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The plant extract has been shown to have antioxidant activity, estrogenic properties and insecticidal effects [5], as shown on the cowpea weevil, *Callosobruchus maculatus* [6]. The essential oils extracted from the bush onion seed were reported to exhibit cytotoxic and antimicrobial properties [7].

The seed contains important food nutrients that can contribute significantly to the daily nutrient requirement of all age groups. It is an important potential flavoring agent in food processing with several industrial and commercial applications. As indigenous people globally depend on plants obtainable from the forest, the bush onion seed, though edible and underutilized, is a potential source of readily available natural phytoconstituents thatcan alleviate malnutrition and provide an array of substances of medicinal importance, which can be exploited as a medicinal food.

Plate. (1). ***Afrostyrax lepidophyllus*** plant. Source [8]:

Plate. (2). ***Afrostyrax lepidophyllus*** dried seeds. source [8]:

Botanical Description and Historical Cultivation

Afrostyrax lepidophyllus, commonly known as 'country onion' or ‘bush onion plant’, belongs to the family Huaceae [2]. Plate (**1**) shows the *Afrostyrax lepidophyllus* plant [8]. It is a non-timber forest product. The tree grows up to 20 m high in the green forests of the Democratic Republic of the Congo, Nigeria, Ghana, the Central African Republic, and Cameroon, where its natural existence is becoming threatened due to the conversion of natural forests into commercial plantations and in some cases mining activities. The tree, leaves and fruit have a strongly offensive smell of onion or garlic, and the bark slash is particularly strong. The oval-shaped fruit [8] has a pleasant aroma (Plate **2**). The seeds ripen between July and August but appear as vulnerable on the International Union for Conservation of Nature’s (IUCN) red list [9].

Chemical and Nutritional Composition of Bush Onion

The seed oils, as well as tree bark of *Afrostyrax lepidophyllus*, showed the presence of sulfur-containing compounds, mainly thio-ethers with 2,4,5,7-

CHAPTER 7

Essential Oil: Its Chemistry, Biochemistry and Application

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Abstract: Essential oils are secondary metabolites that are produced by a variety of medicinal plants. These are mostly composed of a blend of terpenic hydrocarbons and oxygenated derivatives like ketones, alcohols, epoxides, aldehydes, and esters. These are insoluble in water but are soluble in ether, alcohol, and fixed oils. The majority of these volatile oils are liquid and colourless at room temperature. The majority of the components found in essential oils are from the terpene family and are concentrated in the cell secretions of specific plants. The chemical makeup and positioning of functional groups on molecules affect the mechanism of action of essential oils. When it comes to their antibacterial activity, essential oils' chemical makeup influences how they work. The content is about several essential oils, such as lavender oil, which has antibacterial and antifungal properties due to its primary ingredients, linalool and β-ocimene. Both anti-inflammatory and antibacterial properties can be found in eucalyptus oil, which contains the primary ingredients 1,8 cineole, cryptone, p-cymene, and pinene. Sulphur molecules found in garlic essential oils are effective in preventing cancer. In order to confirm the safety and effectiveness of essential oils, more clinical trials are obligatory. Essential oils possess the ability to be employed as defensive as well as therapeutic agents for a variety of ailments.

Keywords: Constituents, Essential oil, Efficacy, Metabolites, Terpene.

INTRODUCTION

Essential oils are metabolites (secondary metabolites) that are developed by a diversity of plants having medicinal value. These are mostly composed of a combination of terpenic hydrocarbons and compounds like ketones, alcohols, epoxides, aldehydes, and esters [1 - 4]. These are obtained by fermentation, expression, effleurage or extraction of different plants having medicinal value.

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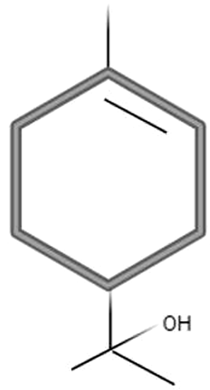
Aside from these procedures, hydro distillation and steam distillation are the most often employed procedures for producing essential oils [5, 6]. Approximately 3000 EOs have been discovered so far. These are primarily found in the flavedo part and cuticle oil glands or sacs that are present at various depths in fruit peels [7, 8]. Essential oils are derived from different parts of plants, including barks, seeds, flowers, leaves, and peels. They have antifungal, antiviral, antioxidant, and antibacterial properties and can be employed as safe alternatives to harmful chemical preservatives and substances that promote food preservation. Since ancient times, the consumption of essential oils for various dental as well as medical issues has been documented [9 - 12].

The compositions of EOs vary significantly. Even the chemical makeup of EOs isolated from plants belonging to the same species varies according to location. The constitution of the EOs also relies on how mature the plant is from which they are harvested, and their use is still widespread but restricted to the fields of cosmetics and perfumes. These are insoluble in water and can dissolve in ether, alcohol, and fixed oils [13]. At room temperature, the majority of these volatile oils are liquid and colourless. With the exception of a few instances, they smell distinctively and have a density that is lower than that of cinnamon, sassafras, and vetiver). They are very optically active and have a refractive index. Herbs contain volatile oils, which are the source of the various aromas that plants release. These are frequently employed in perfumery, cosmetics, and aromatherapy fields. The latter includes massage, inhalations, or baths employing these volatile oils as a therapeutic approach [14 - 17].

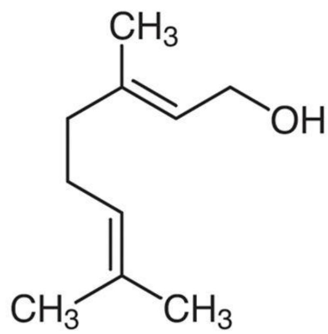
CHEMISTRY OF ESSENTIAL OILS (EOs)

Production of essential oils involves a variety of distinct structures; the quantity and make-up are highly varied. EOs are concentrated in the cytoplasm of specific secretions of plant cells, which are found in more than one organ plant [18, 19]. Essential oils are intricate combinations that include more than 300 distinct chemicals [20]. They are primarily composed of organic volatile chemicals with low molecular weights (under 300). They are found in part in the vapour state due to their high vapour pressure at atmospheric pressure and room temperature [21].

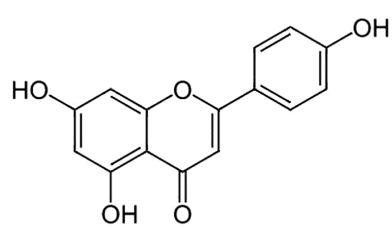
Essential oils are composed of hydrocarbon molecules, like other organic chemicals, and can be further divided into phenols, alcohol, terpenes, esters, aldehydes, and ketones, among other categories. Numerous other aromatic compounds are available from aldehydes, alcohols, and ketones, including fruity ((E)-nerolidol), herbal (-selinene), floral (Linalool), citrus (Limonene), and more as shown in Fig. (**1**) [22, 23]. Some structures related to the chemistry of essential oils are [24 - 28]:



Structure of Terpenoids



Structure of Geraniol



Structure of Chamomile

Fig. (1). Some structures related to the chemistry of essential oils [24 - 28].

Terpenoids

The main elements of essential oils produced by several species of plants and flowers are terpenes and terpenoids. The monoterpenoid and sesquiterpenoid

CHAPTER 8

The Plant Proteases-A Group of Potential Pharmacological, Biotechnological, and Industrially Important Enzymes

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Abstract: Proteases play an active role in all living organisms. In plants, they exhibit essential roles in various biological processes throughout the life cycle by proteolysis, like cell growth and development, differentiation, seed germination, reproduction, senescence, development of stomata, chloroplast biogenesis, apoptosis, plant resistance, *etc*. Nowadays, it is a well-known group of enzymes for its industrial and therapeutic values. Plant proteases *viz.* papain (papaya), bromelain (pineapple), ficin (fig tree), and cucumisin (melon) are well-characterized proteases that have medicinal values for the treatment of upset stomach, diabetic thrombosis, wounds, tumor, asthma, angina, rheumatoid arthritis, bronchitis, sinusitis, *etc*. In addition, some common Indian spices are found to be good sources of natural proteases, such as *Withania coagulans* (vegetable rennet), *Carum copticum* (Ajwain), *Syzygium aromaticum*(Clove), *Cuminum cyminum* (Cumin), *Nigella sativa* (black cumin), *Cinnamomum verum* (Cinnamon), *Foeniculum vulgare* (common fennel), *Zingiber officinale* (ginger), *Cinnamomum tamala* (Indian Cassia), *Curcuma longa* (turmeric), *etc*. which have traditional usage as healing agents in multiple disorders. This chapter highlights the pharmaceutical, industrial and biotechnological aspects of various plant proteases as well as the structure, properties and catalytic mechanisms.

Keywords: Bromelain, Cucumisin, Enzymes, Peptidase, Proteinase, Proteolysis, Spices.

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INTRODUCTION

Proteases (E.C.3.4.21.14) are a set of enzymes that catalyze the breakdown of peptide linkages in proteins through hydrolysis and are generally referred to as proteolytic enzymes, peptidases or proteinases. Proteases are omnipresent in biological systems and are required for cellular metabolism [1]. Different groups of hydrolytic enzymes come under proteases, which are classified on the basis of their site of action, structure of the active site and specific reaction mechanisms [2]. Proteases play a major role in regulating cellular functions in all living organisms, including the human body, which incorporates cell differentiation, division and cell death. Also, they are biochemically involved in acquiring nutrition, growth, and adaptation. Intracellular proteases are involved in protein degradation processes using lysosomes and proteosomes [2]. Plants, animals and especially microorganisms are the foremost sources of proteases.

Proteases account for 65% of total enzymes, considered as enzymes with high industrial demand for their role in food, detergent, leather processing, and chemical and pharmaceutical applications [3, 4]. Proteases are enzymes used in several therapeutic applications, including diagnosis of diseases like treating wounds, cancer, and digestive disorders. In the food industry, it has been used for different processes such as brewing, clotting of milk and meat tenderizing. Plant proteases can be obtained with cost-effective production and are safe as they do not carry pathogenic infectious agents [5]. They have an estimated market value of 3 billion US$, with a compound annual growth rate of 6.1% by the year 2024 [6].

Proteases are found in almost all living beings starting from simple prokaryotes to higher eukaryotes. The majority of proteases are obtained from microbial sources, but newer technologies are being developed to utilize plant sources as well. In plants, the most abundant among them is cysteine protease, while aspartic protease is the rarest. Proteases have been obtained and studied extensively from the latex of a number of dicot plant families, such as Asteraceae, Apocynaceae, Asclepiadaceae, Caricaceae, Euphorbiaceae and Moraceae [7].

Plant-derived proteases are also now being explored as an alternative for calf rennet which is a complex of different proteases and is frequently used in cheese making [8]. In recent years, the demand for cheese has increased, whereas calf rennet production has decreased, which has led to an increase in the price of cheese as well as paved the way for finding new and appropriate rennet substitutes [9]. Different animal, microbial and plant sources for proteases were studied for the same. The development of plant proteases for the production of cheeses is suitable for vegetarians. Different plant parts such as stem, fruit, and leaves of

Withania coagulans, Carica papaya, Ananas comosus, Ficus carica and *Actinidia deliciosa* are being used to produce conventional plant proteases such as bromelin, ficin, papain, actinidin, *etc*. and are involved in meat tenderization, dairy industry, baking industry, animal feed, biomedicine, alcohol production and many other industrial processes [1]. Besides these plant sources, research on new plant proteases with higher industrial efficiency through *in vitro* culture or genetic engineering is still ongoing.

CLASSIFICATION OF PROTEASES

Proteases are broadly classified into two categories: "endopeptidases" and "exopeptidases" according to their position of action, *i.e.*, where they cleave the peptide bond. The endopeptidases are further categorized by their catalytic types. Exopeptidases are also divided into two classes according to whether they act at the N- or C-terminus (Fig. **1**).

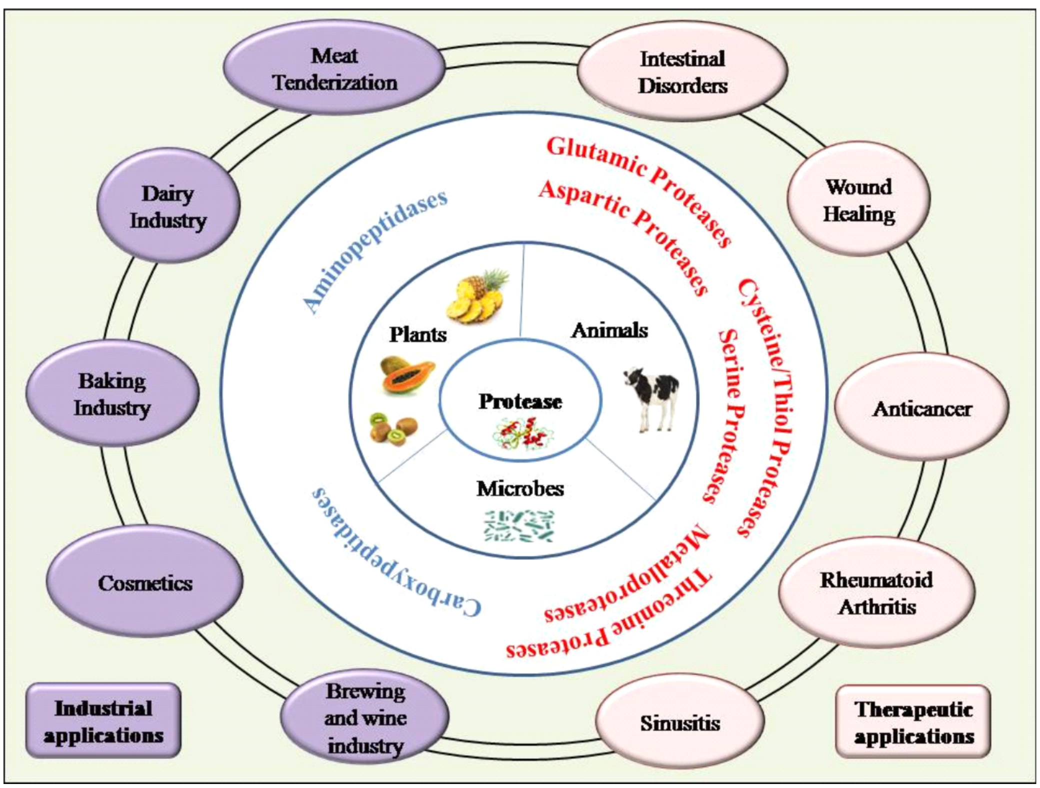

Fig. (1). Schematic illustration of different Protease families and multidimensional uses (Blue- Exopeptidases; Red- Endopeptidases).

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Pankaj Kumar Chaurasia

Dr. Pankaj Kumar Chaurasia did Ph.D. in chemistry and is an assistant professor in the PG Department of Chemistry, L.S. College, B.R. Ambedkar Bihar University, Muzaffarpur. He has experience of more than 6 years in teaching at post graduate (PG) and undergraduate (UG) levels. He qualified the 'National Eligibility Test' in 2009 as CSIR-JRF (NET) and was awarded with SRF-NET in 2012. He also worked as guest faculty in the Department of Chemistry, Central University of Allahabad, Prayagraj. He was also awarded with 'Research Associateship' by CSIR-New Delhi (India) and worked as CSIR-RA in Motilal Nehru NIT, Allahabad/Prayagraaj (India). He has more than 73 publications. He is also guiding four Ph.D. research scholars. He has worked in different areas of chemistry and has research expertise in biological chemistry, biotechnology, microbiology, enzymology, organometallic chemistry and environmental chemistry.

Shashi Lata Bharati

Dr. Shashi Lata Bharati, did Ph.D. in chemistry and is currently working as assistant professor in the Department of Chemistry, North Eastern Regional Institute of Science and Technology, Nirjuli, Arunachal Pradesh (India). She was awarded 'UGC-DSA fellowship' for the meritorious students during her Ph.D. program. She was also awarded with a UGC-post doctoral fellowship for women by UGC New Delhi and worked as post-doctoral fellow in the Department of Chemistry of DDU Gorakhpur University, Gorakhpur (India). She has published more than 50 publications in national and international journals/publishers of repute. She has guided many M.Sc. project students and one Ph.D. research scholar. She has expertise in the field of inorganic chemistry, organometallic chemistry, biological chemistry and enzymology.

Sunita Singh

Dr. Sunita Singh is an assistant professor of chemistry in the Navyug Kanya Mahavidyalaya since 2019. She pursued her Ph.D. in the year 2015 in chemistry. She was awarded with JRF and SRF from the University Grant Commission. She also worked as research assistant (2010-2011) on a CST sponsored project. She has published 25 research articles in journals of national and international repute. She has authored and co authored 8 book chapters with national and international publishing houses. She has two edited books with international publishers. She is also on the reviewer board of different journals. She delivered many invited talks and attended several conferences/webinars of national and international repute. She is also an active member of Association of Chemistry Teachers (India), International Clinical aromatherapy network and Global Harmonization Initiative. She has expertise in chemistry, phytochemistry, essential oil, oleoresin etc.