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Exploring the potential pharmacological properties of Curcuma longa L: A review

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ABSTRACT:Turmeric (Curcuma longa L.), native to South Asia and often referred to as "Indian saffron," is esteemed for its rhizomes, which contain bright yellow pigments widely used as a food coloring agent and traditional medicine. Rhizome of turmeric, is composed of protein (6.3%), fat (5.1%), minerals (3.5%), carbohydrates (69.4%), and essential oil (5.8%). It is notably rich in curcuminoids (2.5–6%), predominantlyCurcumin I (curcumin), Curcumin II (demethoxycurcumin), and Curcumin III (bisdemethoxycurcumin), which exhibit potent biological activities including anti-inflammatory, anti-bacterial, antioxidant, and anticancer properties. These attributes have fostered its extensive use in culinary, medicinal, cosmetic, and nutraceutical applications.In conclusion, turmeric emerges as a versatile crop with profound implications for various industries. Future research should prioritize sustainable cultivation practices and advanced extraction techniques to maximize turmeric's potential as a source of bioactive compounds in diverse applications.

KEYWORDS: Curcuma longa L, turmeric, curcumin,chemicalcomposition, pharmacological activities.

I. INTRODUCTION

Turmeric is native to South Asia and is highly valued for its rhizomes, which are the most economically important part of the plant. Often referred to as "Indian saffron," turmeric is derived from the root of Curcuma longa L., a member of the Zingiberaceae family. Its bright yellow pigments are widely used as a food coloring agent. For centuries, turmeric has been utilized as a spice, food preservative, and for its medicinal properties(1,2).

Numerous studies have confirmed that turmeric extracts possess powerful biological activities, including anti-inflammatory, antibacterial, antidepressant, anti-diabetic, antitumor, and gastro-protective properties. In addition, it has been successfully used in the treatment of Alzheimer's disease and cardiac disorders. Due to its high antioxidant activity, turmeric is considered one of the most potent spices, making it valuable in cosmetics, nutraceuticals, and phytomedicines. These medicinal attributes are largely due to its high content of curcuminoids, especially curcumin, a key chemical marker of this species (3).

Curcumin is an oil-soluble pigment that is practically insoluble in water at acidic and neutral pH but soluble in alkaline conditions. Various solvents, including acetone, have been used to prepare water-soluble curcumin (3). Curcumin is stable at high temperatures and in acidic environments but unstable in alkaline conditions and under light exposure (4).

This review aims to explore the potential of turmeric as a source of bioactive compounds, particularly curcumin, and its associated biological activities, extraction techniques, and utilization. Therefore, this review will be instrumental in shaping current and future agricultural practices for the commercialization of turmeric across the food, nutraceutical and cosmeticindustries.

Taxonomy

Curcuma longa L (Turmeric) is a species of the genus Curcuma, belongs to the family of Zingiberaceae and its taxonomic classification is as follows:

Class	Liliopside
Subclass	Commelinids
Order	Zingiberales
Family	Zingiberaceae
Genus	Curcuma
Species	Curcuma longa L

The wild turmeric is called C. aromatica, while the domestic species is referred to as Curcumalong L.(5). In Sri Lanka, there are about 70

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species of turmeric. Among these species, there are 10 spices are cultivated domestically (6).

Morphological Characteristics

Curcuma longa L. is a typical of herbaceous plant with thick and fleshy rhizomes.

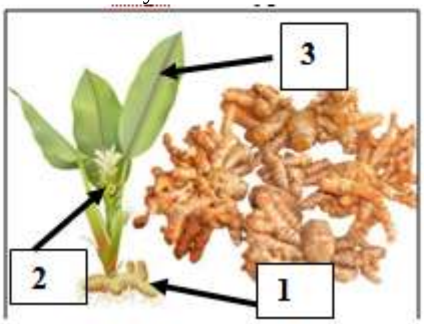

Figure 1: Plant parts of Curcuma longa L. 1: Rhizome, 2: Inflorescence, 3: Leaf

Leaves

The leaves have a sheath and are oblong, alternate, obliquely erect and dark green in color. Leaf sheaths taper near the leaf and broaden near the base. The length of the leaf is around 30cm. Each plant typically has around 6 – 12 leaves (2).

Inflorescence

The inflorescence is terminal on leafy spurious stems appearing between the sheaths. Flowers, occasionally seen on cylindrical spikes bearing numerous greenish-white bracts, are narrow, and yellowish white (2).

Rhizome

The underground rhizome consists of two distinct parts; the egg-shaped primary or mother rhizome, an extension of the stem, and several long, cylindrical multi-branched secondary rhizomes growing downward from the primary rhizome. Both forms have transverse rings of leaf scars and dents of root scars. Inside the rhizome is a dark orange color to yellow color and also turmeric has a unique flavor and smell (2).

Chemical Composition of Turmeric

The chemical composition of turmeric, as determined by (7) includes protein (6.3%), fat (5.1%), minerals (3.5%), carbohydrates (69.4%) and moisture (13.1%). The rhizomes contain curcuminoids (2.5–6%) and impart the yellow color. Curcuminoids (diferuloylmethane) contain Curcumin I (curcumin), Curcumin II (demethoxycurcumin) and Curcumin III (bisdemethoxycurcumin), which are found to be natural antioxidants. The essential oil (5.8%) obtained by steam distillation of rhizomes has α-phellandrene (1%), sabinene (0.6%), cineol (1%), borneol (0.5%), zingiberene (25%) and sesquiterpenes (53%). Curcumin was first isolated in 1815 and its chemical structure was determined by Roughley and Whiting in 1973. It has a melting point of 176–177 °C; forms a reddish-brown salt with alkali and is soluble in Ethanol, Alkali, Ketone, Acetic acid and Chloroform (8).

Curcumin is poorly soluble in hydrocarbon solvents. Curcumin is an oil soluble pigment, practically insoluble in water at acidic and neutral pH, and soluble in alkali. Preparation of water-soluble curcumin by incorporation into various solvent systems (acetone, methanol, and ethanol) has been reported. Curcumin is stable at high temperatures and in acids, but unstable in alkaline conditions and when exposed to light (9).

The choice of solvent for extraction is restricted to the few solvents of defined purity allowed by national and international food laws in the processing of food materials. Hexane, acetone, alcohol ethanol, methanol, isopropanol and ethyl acetate are used in the extraction of oleoresins from spices. Alcohol and acetone are good extractants and the yields can also be expected to be high because of the extraction of non-flavor components (1).

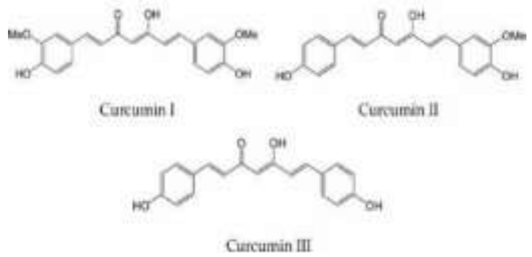

Figure 2: Chemical structures of curcuminoids

Uses of Turmeric

Turmeric is a popular spice widely used in India and South Asia, as a spice giving curry its characteristic 'yellow-orange' colour. Beyond its culinary uses, turmeric has been widely used for various purposes in South Asian countries since ancient times. In many homes, turmeric has been used as a cosmetic, dye, food preservative, anti-inflammatory, disinfectant, and remedy for colds and coughs. In Hindu temples, turmeric is considered very auspicious to the mother goddess. Additionally, turmeric is used extensively in traditional medicine practices for treating various illnesses. Also, it is used in the textile,

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nutraceuticals, and phytomedicines industries (10,11).

Numerous studies have confirmed that turmeric extracts possess powerful biological activities, including antioxidant, anti-inflammatory, antibacterial, antidepressant, anti-diabetic, antitumor, immunomodulatory and gastro-protective properties. Additionally, turmeric has been successfully used in the treatment of Alzheimer's disease and cardiac disorders (12).

Pharmacological activities of turmeric and its extract

Antioxidant activity

Numerous studies have highlighted the antioxidant properties of turmeric rhizomes and the changes in these properties in processed products. The antioxidant activity of turmeric has been assessed using methods such as diphenyl-picrylhydrazyl (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), and 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS). Curcumin, a well-known bioactive compound in turmeric, plays a significant role in scavenging free radicals. Various studies have demonstrated the antioxidant potential of curcumin through different assay methods ((13–15). According to (15) revealed that curcumin exhibited an antioxidant potential of 104.91 mg/ml, necessary for 50% inhibition of DPPH radicals. (13), found that turmeric extract had a higher hydroxyl radical scavenging and superoxide dismutase scavenging ability than ascorbic acid. Additionally, high dietary intake of natural antioxidants like curcumin among Indians is believed to contribute to the low incidence of large bowel cancers in this population ((16). Therefore, turmeric shows promising potential in preventing oxidative damage linked to diseases such as cardiovascular diseases, cancer, and arthritis.

Anti-inflammatory

The use of turmeric as an anti-inflammatory agent has been recognized for over a century.Curcumin, the active component of turmeric, is a potent inhibitor of the proliferation of various tumor cells and acts as an anti-inflammatory agent (16). Additionally, curcumin has been reported to decrease prostaglandin formation and inhibit leukotriene biosynthesis via the lipoxygenase pathway. Oral administration of curcumin in cases of acute inflammation was found to be as effective as cortisone or phenylbutazone (17,18).

Antidiabetic

Various studies have suggested the antidiabetic potential of curcumin through different mechanisms (19–21). Pretreatment of primary mouse pancreatic islets with curcumin (10 µM) for 24 hours increased streptozotocin (STZ)-induced islet viability and insulin secretion (22). Curcumin supplementation significantly decreased fasting plasma glucose, HbA1c, and insulin resistance by reducing serum free fatty acids in type 2 diabetic patients (23). Previous studies have reported that curcumin therapy significantly reduced fasting plasma glucose, HbA1c, and insulin resistance in type 2 diabetic patients (24). Additionally, curcumin decreases amylase activity in rat pancreatic cancer cells (25).

Anticancer

Numerous in vitro and in vivo studies have demonstrated the ability of curcumin to inhibit cancer cells through variousmechanisms (26,27). In a mouse xenograft model of human breast cancer, curcumin in conjunction with paclitaxel significantly inhibited breast cancer metastasis to the lungs more effectively than either curcumin or paclitaxel alone (28).Another study investigated the protective effect of turmeric extract on chemically induced mutagenicity in Salmonella typhimurium strains and clastogenicity in mammalian bone marrow in female Swiss mice (29).

Antimicrobial

Turmeric extract has been reported to inhibit the growth of various bacteria, parasites, and pathogenic fungi (30–32).One study revealed that chicks infected with Eimeria maxima showed a reduction in small intestinal lesion scores and increased weight gain when their diets included turmeric (31). (32) reported that turmeric extract exhibited strong antifungal activity against Trichophyton longifusus and Microsporum canis.

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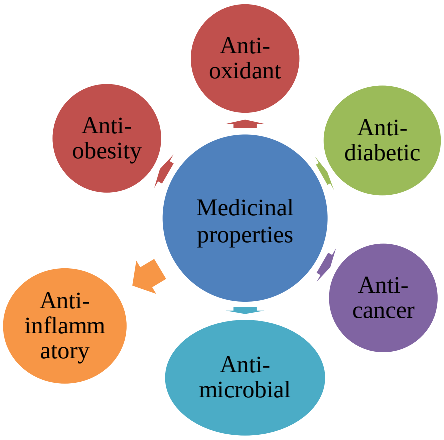

Figure 3: Major pharmacological properties of turmeric.

Extraction of Curcumin

According to (33), curcumin is extracted from the dried rhizome roots of Curcuma longa. The extraction process begins by grinding the raw materials into a powder, which is then washed with a suitable solvent to selectively extract the colouring matter. This initial extraction process yields an oleoresin containing 25-35% colouring matter, along with volatile oils and other extractives. The oleoresin undergoes further washes using selective solvents that isolate the curcumin pigment. This purification process results in a highly concentrated food colour known as Curcumin, containing approximately 90% colouring matter with minimal volatile oil and other dry matter. The effectiveness and regulatory compliance of the extraction process depend on the choice of solvent. Numerous solvents are used for curcumin extraction including Isopropanol, ethyl acetate, acetone, and methanol (1).

II. CONCLUSION

In conclusion, turmeric, particularly its principal component curcumin, stands out as a highly valued spice and medicinal plant with a rich history in South Asian culture. Turmeric's wide array of bioactive properties, including anti-inflammatory, antibacterial, antidepressant, anti-diabetic, antitumor, and gastroprotective activities, as well as its effectiveness in treating Alzheimer's disease and cardiac disorders, highlight its significant therapeutic potential. Turmeric stands as a potent bioactive source with significant implications for health and industry. Its historical and contemporary applications demonstrate its versatility and importance. Future agricultural practices and commercialization strategies should focus on sustainable cultivation and advanced extraction techniques to ensure the optimal utilization of turmeric in various sectors.

Declaration of Competing Interest

The authors report no declarations of interest.

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