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Turmeric: A golden spice with medicinal properties

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Abstract
Turmeric is a yellow-colored spice obtained from rhizomes of the plant *Curcuma longa*, a member of ginger family *(Zingiberaceae)*. This golden-colored spice is used in Asian culture and cuisine for centuries. Curcumin, the principal curcuminoid and most active constituent of turmeric. It is a polyphenolic molecule used to treat human ailments such as pain, digestive disorders, inflammation, dermatitis, acne, rash, and wound healing. Other curcuminoids include demethoxycurcumin and bisdemethoxycurcumin. Curcumin and other constituents show a wide spectrum of biological actions. This includes antibacterial, anti-inflammatory, antioxidant, antifungal, antiviral, and anticancer activities. It has a potential against various malignant diseases, arthritis, allergies, Alzheimer's disease, diabetes, antineoplastic, anti-proliferative, antimicrobial effects, and other chronic illnesses. Based on scientific literature, Aim is to review the various pharmacological properties of this herbal plant.

Keywords: turmeric, curcumin, anti-oxidant, anti-cancer

Introduction
Turmeric is also called as 'Golden Spice of India' (Fig.1). World turmeric production is about 78 percent. India is the largest producer of turmeric and also the biggest consumer and exporter of turmeric. This spice is widely used in middle-east and Asian countries including China, Bangladesh and South East Asia. It is mainly cultivated in China, Bangladesh, Burma (Myanmar), Taiwan, Sri Lanka, Nigeria, Australia, Jamaica West Indies, Peru and other Caribbean and Latin American countries. Turmeric (*Curcuma longa*) is widely used in Ayurveda, Unani and Siddha medicine as a home remedy for many diseases. Turmeric has been used for thousands of years and has become an integral part of a food and traditional medicine. Pharmaceutical companies are understanding the composition of turmeric and making various products out of it. Curcuminoids are polyphenols that give yellow color to turmeric. Traditional medicinal uses of turmeric are for cough, diabetes, wound healing [1, 2].

Fig 1: *Curcuma longa*; Medicinal hurb[2]

Plant description
Classification of *Curcuma longa* is shown in (Table 1). The rhizomes are tuberous with rough and segmented skin. Rhizomes have a length of 2.5 -7.0 cm and diameter of 2.5 cm. They are yellowish-orange outside and deep orange color interial [2].

Table 1: Scientific classification of *Curcuma longa*

Kingdom	Plantae – Plants
Sub kingdom	Tracheobionta – Vascular plants
Division	Magnoliophyta – Flowering plants
Class	Monocotyledons
Subclass	Zingiberidae
Order	Zingiberales
Family	*Zingiberaceae*
Genus	Curcuma
Species	C. longa

Local Names
Haldi, Haridra

Ecology
Temperature- 20-30 °C
Rainfall- 1500 mm
Soil- Light black loam, red soil to clayey loam, rich soils to clayey loams

Chemical Constituent
Curcumin (Principle Curcuminoid) - 2-5% and it comprises of curcumin I- 94%, curcumin II- 6%, curcumin III- 0.3%
Protein – 6.3%
Carbohydrates – 69.4%
Minerals – 3.5%
Fats – 5.1%
Moisture – 13.1%
Essential oil– 5-8%

α-phellandrene - 1%
Cineol – 1%
Borneol – 0.5%
Sabiene – 0.6%
Zingeberene – 25%
Sesquiterpenes – 53% [1]

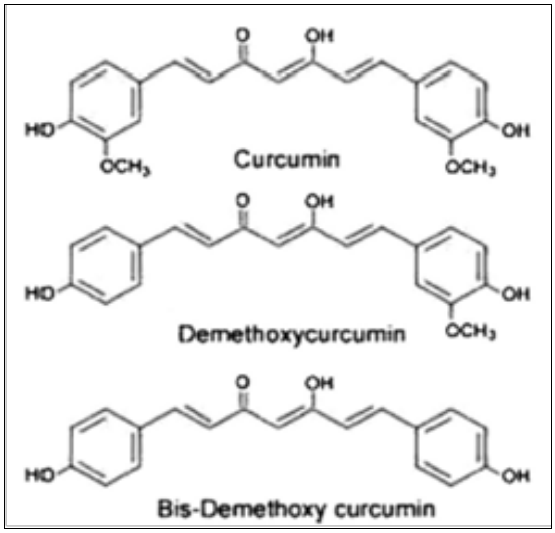

Fig 2: Chemical structures of curcuminoids[3]

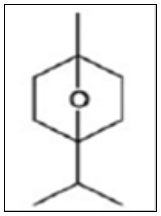

Fig 3: Structure of Cineol[4]

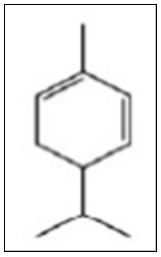

Fig 4: Structure of phellandrene[4]

Chemical structures of some chemical constituents are shown in (figs. 2, 3, 4)

Pharmacological Properties

Turmeric has many of pharmacological activities and the disease targets are shown in (Fig.5).

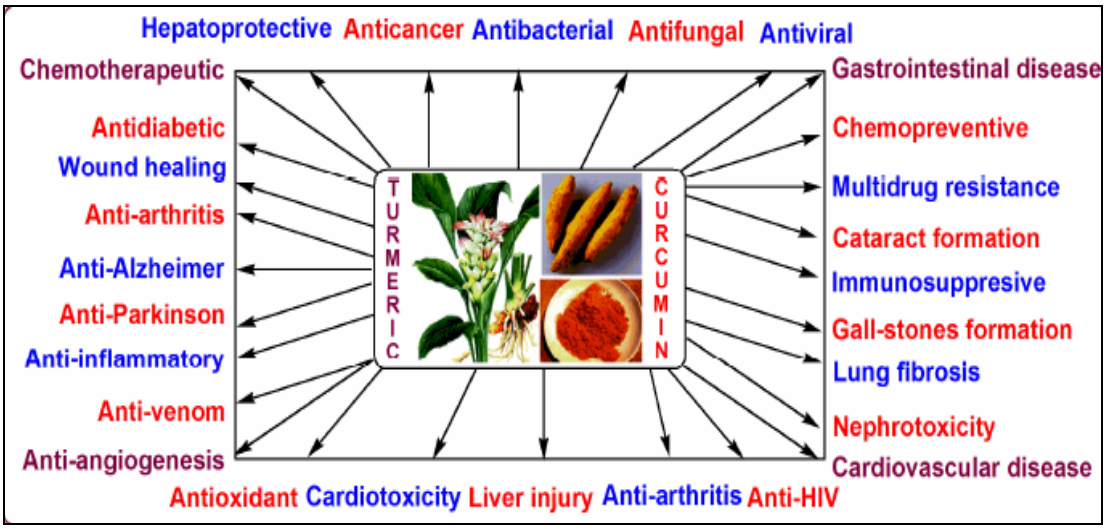

Fig 5: Disease targets of Turmeric[2]

Anti-oxidant activity

The aqueous extract of turmeric shows anti-oxidant activity greater than vitamin E. TRAP and FRAP assays are used to determine anti-oxidant activity. Oxidative stress is a result of an imbalance between oxidants and defensive mechanisms which results in the pathogenesis of many human diseases. Turmeric increases the activity of certain endogenous enzymes such as SOD (Superoxide dismutase), GSH (Glutathione), catalase by scavenging different forms of free radicals like ROS (reactive oxygen species) and RNS (reactive nitrogen species). It also inhibits lipoxygenase/cyclooxygenase, xanthine hydrogenase/oxidase which are ROS generating enzymes. Phenolic functional groups are responsible for anti-oxidant activity of turmeric. It enhances lipid peroxidation inhibitory activity and potentiates the radical scavenging activity [5, 6, 7].

Rheumatoid arthritis

It is a condition associated with an ongoing chronic inflammation process characterized by hyperplasia of the synovial fibroblasts. Systemic review and meta-analysis have shown that turmeric extracts can reduce pain and inflammation related symptoms through downregulation of tumor necrosis factor (TNF), COX2 and other inflammatory cytokines. As per the pilot clinical study, curcuminoid preparation was found to be safe, effective and with lesser side effects compared to diclofenac sodium and a few other NSAIDs [3, 7, 8].

Anti-diabetic activity

Turmeric extract shows its anti-diabetic activity by reducing oxidative stress by quenching reactive oxygen species (ROS) and thus prevents oxidative damage. Curcumin inhibits superoxide production and vascular protein kinase C which is the cause of diabetes. It also lowers lipid

peroxidation by maintaining the activity of anti-oxidant enzymes. In type II diabetes mellitus, the study shows that turmeric reduces the level of blood sugar and glycosylated hemoglobin level in alloxan-induced diabetic rat model. Curcumin increases glucose metabolism, insulin sensitivity and decreases glycation end products [4, 8, 9].

Wound healing activity

The topical application of curcumin extract on wounds on diabetic rats has shown an increase in cellular proliferation and collagen synthesis at the wound site. Its mechanism involves the improved activity of nitric oxide synthase along with increased levels of beta transforming growth factor. Turmeric contains proteins, fats, vitamins which plays role in wound healing as well as regeneration by an early synthesis of collagen fibers. It also causes tissue remodeling, fibroblast proliferation, granulation, collagen deposition. Turmeric formulation applied at the wound site causes an increased in DNA, hexosamine, protein, hydroxyproline content [4, 9, 10].

Anti-bacterial activity

Different extracts of turmeric showed anti-bacterial activity against different bacteria, parasites and pathogenic fungi. Bacterial apoptosis is caused by the formation of reactive oxygen species and DNA damage. Growth of certain bacteria like Staphylococcus, Lactobacillus is suppressed curcumin oil fraction. *In vivo* study shows that curcumin has a poor activity for complete eradication of H. pyroli [1].

Anti-inflammatory activity

Acute and chronic inflammation gives rise to many pathological conditions. Turmeric acts as an anti-inflammatory agent by different pathways. It causes suppression of NF (nuclear factor) κB activation through downregulation of cyclooxygenase-2, xanthine oxidase and inducible nitric oxide synthase and upregulation of PPAR-ϒ. It also reduces pro-inflammatory cytokines like interleukin-1β, interleukin-4, interleukin-6, interleukin-8, Interleukin-12 and inhibits the activity of lipoxygenase, cyclooxygenase, nitric oxide synthase. In this way, it inhibits inflammatory cell proliferation, metastasis, and angiogenesis and improves inflammatory and immune responses [11].

Anti-venom activity

Ar-tumerone acts as an anti-venom agent and is isolated from turmeric. It has proteolytic and hemorrhagic activity against the venom enzyme by acting as an enzymatic inhibitor. Turmeric also acts against toxins of Indian cobra. Turmerin is a protein which inhibits enzymatic activity and neutralizes edema and myotoxicity of phospholipase A2 of the cobra. Beta-sitosterol shows a 70% neutralization potential of cobra venom [12, 13].

Cardioprotective effects

Turmeric is effective against many cardiovascular diseases including myocardial infarction, arrhythmia, cardiomyopathy, myocardial ischemia as studied in both *in vivo* and *in vitro* animal models. It decreases levels of triglycerides, LDL (low-density lipoproteins), VLDL (very low-density lipoproteins) and thus decreasing lipid peroxidation. Turmeric decreases cholesterol level by decreasing its uptake by the intestine and thereby increasing the conversation of cholesterol into bile by the liver. It potentiates prostacyclin synthesis and inhibits thromboxane synthesis by inhibition of platelet aggregation [14, 15].

Anti-cancer activity

Turmeric acts as a chemoprotective agent through various signaling cascades. Turmeric effects are studied on different signaling pathways including Ras signaling, β-catenin signaling pathways, transcription pathways such as NF-κB and AP-1 families and STAT family transcription factors. Turmeric has been shown to suppress transformation, tumor initiation, tumor promotion, angiogenesis, proliferation, and metastasis. It also acts through the downregulation of transcription factors, inflammatory cytokines, protein kinase, growth factor and other oncogenic molecules. Glutathione levels in cancer cells are lower than normal cell so it increases sensitivity to curcumin and its uptake in cancer cells is high. According to the recent work curcumin decreases the glucose uptake and lactate production in cancer cells through down regulation of pyruvate kinase M2 (PKM2). Turmeric and its derivatives have the ability to act against different types of carcinomas. It acts against different cancers like oral cancer, lung cancer, multiple myeloma, prostate cancer, pancreatic cancer, breast cancer, head and neck squamous cell carcinoma, colorectal cancer. Turmeric has the limitation of poor water solubility and poor bioavailability so it can be converted into different nano formulations and effectively used as an anti-cancer agent [16, 17, 18, 19, 20].

Hepatoprotective activity

Turmeric shows a hepatoprotective effect due to the augmentation of antioxidant activity and reducing the proinflammatory cytokines formation (anti-inflammatory activity). In animal studies, turmeric has been found to protect the animal liver from various hepatotoxic substances like Thallium, beryllium, iron, thioacetamide, tetrachrobenzoquinone, ethanol, paraquat, aflatoxin B1, streptozotocin, acetaminophen, alcohol, lindane, CCl4(carbon tetrachloride), diethyl nitrosamine and heavy metals. In the mice model, CCl4-induced liver toxicity reduced by pre-treatment with curcumin normalized serum aminotransferase activities, decreased levels of malondialdehyde and the hepatic histo-architecture [21, 22, 23, 24].

Anti-fungal activity

Different extracts of turmeric show anti-fungal activity against different fungi such as *Aspergillus flavus, Fusarium verticillioides, Curvulariapallescens, Colletotrichum falcatum, Aspergillus niger, Aspergillus terreus, Fusarium oxysporum, Fusarium moniliforme, Fusarium graminearum, Cryptococcus neoformans, Candida albicans, Rhizoctonia solani, Phytophthora infestans, Erysiphe graminis, R. solani, Puccinia recondita, Botrytis cinerea, Fusarium solani, Helminthosporiumoryzae, Trichophyton rubrum, T. mentagrophytes, Epidermophyton floccosum and Microsporumgypseum.* In case of *candida albicans,* turmeric shows an inhibitory effect by preventing its adhesion to a buccal epithelial cell. Turmeric causes downregulation of enzyme desaturase. So, there is reduction of ergosterol of fungal cell and the generation of ROS results in cell death. Another mechanism may be by a reduction in proteinase secretion and alteration of membrane-associated properties of ATPase activity [25, 26, 27, 28].

Anti-ulcer activity

A study in rats has shown that turmeric can be used for a gastric and duodenal antiulcer activity. Turmeric taken as an adjuvant with other anti-ulcer drugs helps to achieve remission of ulcers. Its ethanolic extract inhibits gastric acid, gastric juice secretion and ulcer formation. Pre-treatment with turmeric extract reduces the intensity of ulcer formation. It is safer and cost-effective [29, 30, 31].

Anti-obesity

In an obese patient, the secretion of anti-inflammatory adipocytokines is inhibited and secretion of inflammatory adipocytokines increased. It also reduces macrophage invasion of adipose tissue, increased adiponectin production and inhibited adipose tissue inflammation. Curcumin inhibits weight gain, fat accretion and improves the serum lipid profile. Curcumin increased the adipose triglyceride lipase and hormone-sensitive lipase protein expression by activating PPAR gamma /alpha in adipose tissue. It broke down lipids and improved glycolipid metabolism. It causes a decrease in high-sensitivity CRP, TNF-alpha, IL-6 and LDL-cholesterol as well as an increase in HDL-cholesterol in the blood. It decreases angiogenesis and adipogenesis by lowering cholesterol levels and suppressing CCAAT/enhancer-binding protein alpha and PPAR expression. Curcumin modulates circulating levels of IL-1β, IL-4, and VEGF and thereby exhibiting immunomodulatory effect and also reduced oxidative stress in obese patients. It also shows anti-obesity effect by suppressing lipogenesis, inhibiting preadipocyte differentiation, reducing the inflammatory response and promoting fatty acid oxidation in adipose tissue. Oral administration of curcumin in NAFLD patients significantly improves BMI (Body mass index), body fat and bodyweight reduction were recorded [32, 33, 34, 35].

Conclusion

Turmeric has been used for thousands of years worldwide. It is a major part of Ayurveda, Siddha medicine, Unani and traditional Chinese medicine. India consumes nearly 80% of turmeric. Most people use turmeric in food and consumes it on daily basis. It has been studied in numerous clinical trials that turmeric is used for various human diseases and conditions. In this review, we have seen that turmeric has powerful biological properties. As turmeric is cost-effective and safer than many other drugs so it can be widely used for many pathological conditions and can act as a novel drug. Turmeric has a broad spectrum of action so it is used for the long term and on daily basis. Turmeric and its analogues attack multiple targets, so its effectiveness increases. Hence, many years of research justify turmeric as “The golden spice”.

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