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The Health Benefits and Chemical Constituents of Turmeric (Curcuma Longa): A Review

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Abstract: *Turmeric (Curcuma longa), a perennial herbaceous plant of the ginger family, has been extensively studied for its phytochemical and pharmacological significance. This review explores the bioactive compounds, primarily curcuminoids, with curcumin being the most prominent, responsible for turmeric's vibrant yellow color and potent therapeutic properties. The phytochemical profile of turmeric includes volatile oils, such as turmerone, atlantone, and zingiberene, which contribute to its diverse pharmacological activities. Turmeric exhibits a broad spectrum of pharmacological actions including anti-inflammatory, antioxidant, antimicrobial, anticancer, and neuroprotective effects. These properties are attributed to its ability to modulate various molecular pathways and biological targets, making it a valuable agent in managing chronic diseases like cancer, cardiovascular diseases, diabetes, and neurodegenerative disorders. The review also highlights the challenges associated with the bioavailability of curcumin and the ongoing research to enhance its absorption and efficacy through novel delivery systems. Overall, turmeric's extensive therapeutic potential underscores its importance in traditional medicine and modern pharmacology, warranting further investigation and application in clinical settings.*

Keywords: Anti-inflammatory, Antioxidant.

I. INTRODUCTION

Plant components have been utilised by humans as a phytomedicine since prehistoric times. Because they contain both main and secondary chemicals that are bioactive, plants are significant. It has been discovered that secondary metabolites are very distinct compounds in terms of both taxonomy and chemistry. These metabolites are employed in a wide range of fields, including animal medicine, scientific research, agriculture, and human treatment. They are extensively used in veterinary medicine, scientific research, agriculture, human treatment, and several other fields. Approximately 80% of people in affluent nations utilise traditional medicine, which is derived from medicinal plants, as a source of strong and potentially effective medications [1]. Curcuma longa is a leafy, upright perennial plant that grows up to one metre tall on a short stem. It has yellow flowers that resemble funnels and oblong, pointed leaves. It is a member of the Zingiberaceae family. It is widely grown in tropical and subtropical parts of the globe, mostly in China and India, and is typically grown in Asian nations. "Haldi" is a plant that is well recognised in India and has oblong, ovate, pyriform, and often short branches on its rhizomes [2, 3, 4]. According to recent study, curcumin possesses anti-inflammatory and anticancer properties, giving it a new level of promise [5]. Curcumin, a yellow powder made from rhizomes, has therapeutic use. Curry powder is made from dried Curcuma longa, the plant from which turmeric is derived. It has a yellow tint. Turmeric is frequently used in cuisine due to its flavour and colour, and it is also employed in Hindu religious rites and traditional Indian medicine. Turmeric is regarded as an aromatic stimulant and carminative in ancient Hindu writings [3, 4]. Turmeric powder has recently gained popularity as a traditional remedy for gastrointestinal disorders, particularly hepatic and biliary disorders, diabetic wounds, rheumatism, inflammation, sinusitis, anorexia, coryza, and cough. In order to fight AIDS, turmeric has anti-HIV action as well as anti-cancer, anti-diabetic, antioxidant, hypolipidemic, anti-inflammatory, antibacterial, anti-fertility, anti-venom, hepatoprotective, nephroprotective, and anticoagulant properties [4, 6, 7].

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TAXONOMICAL CLASSIFICATION

Plantae is the Kingdom Sub-Republic: Tracheobionte Division: Magnoliophyta Superdivision: Spermatophyta The Zingiberidae subclass Family: Zingiberaceae; Order: Zingiberales Curcuma, genus Longa is the species. Name in science: Curcuma longa

DESCRIPTION

plant with a root stock and no stem. Largely lanceolate or oblong leaves with a rich ferruginous purple colour. Sheath and petiole length equal to blade length. sprouting up ahead of the leaves. Bract green with a ferruginous tint, delicate yellow blossom with a reddish hue at the periphery.

MEDICINAL USES

Rhizome: Clears blood, strengthens the heart and brain, treats leucoderma, piles, bronchitis, asthma, tumours, enlarged spleen, and regulates leucorrhal and gonorrhoeal discharge.

PRELIMINARY PHYTOCHEMICALSCREENING

Qualitative chemical tests have been used in the chemical assessment process to identify the different phytoconstituents found in the powdered crude medication. Many researchers conducted preliminary phytochemical investigations of the Curcuma longa rhizome's aqueous extract, acetone extract, ethanolic extract, chloroform extract, and methanolic extract using widely used precipitation and coloration reactions. These investigations revealed the presence of various substances, including proteins, carbohydrates, alkaloids, glycosides, terpenes, steroids, flavonoids, tannins, and saponins [1, 8, 9]. The following describes the standard published literature from which the related tests conducted by different researchers were assembled.

Preparation of the Extract

Curcuma longa rhizomes were gathered, sun-dried, and then chopped into little pieces. After that, the little dried rhizome piece was ground into a fine powder that was suitable for usage [8, 9].

Test for Alkaloid

Following a thorough filtering, the extract was combined with 3 millilitres of diluted hydrochloric acid. The filtrate was meticulously examined using the following test [9]:

Mayer's Test: A few drops of Mayer's reagent are added by the test tube's edge to one or two millilitres of filtrate. The presence of alkaloids, as evidenced by the white or creamy precipitate, indicated a positive test [1, 5, 8, 10].

Wagner Test: Wagner's reagent was applied to 1 or 2 millilitres of the filtrate extract; the production of a brown, reddish precipitate indicates the presence of alkaloids [1, 5, 8].

Dragendroff's Test: A noticeable yellow precipitate that formed after adding 1-2 ml of Dragendorff's reagent to a few millilitres of filtrate suggests the presence of alkaloids [5, 8].

Test for Glycosides

Gleich amounts of Fehling's solutions A and B were added to a 2 ml test solution, and the solution was heated to get a glycoside result. Precipitation was seen to be brick red [8].

Borntrager's Test: The extract was first heated to a boil using diluted sulfuric acid, then filtered. Chloroform was then added to the filtrate and well shaken. After the organic layer was separated, ammonia was gradually added. Positive results are also indicated by the ammonical layer's pink to red hue [5].

Test for Flavonoids

Shinoda Test: A little amount of magnesium ribbon pieces were put to a 2 ml test solution, then H_2SO_4 was added dropwise. The hue of the products is either crimson red or pink scarlet [1, 8].

Alkaline Reagent Test: Sodium hydroxide solution, which imparts a yellow or red hue, was applied to the test solution [1, 8].

Zn Test: A few minutes after mixing 2 ml of extract with Zn dust and concentrated HCl, a red colour was seen, indicating the presence of flavonoids [1, 8].

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Test for Tannins

Ferric Chloride Test: Drops of ferric chloride solution were combined with the extract solution. Gallic tannins were found to be blue in colour, while catecholic tannins were found to be green-black in colour [1, 5, 8].

Gelatin Test: Mixing 1% Gelatine solution with 10% sodium chloride and 2 ml test solution yields a white precipitate [8].

Test for Saponins

Foam Test: The following are the methods used by researchers to look for saponins: Following a 20 ml distilled water shake, 5 ml of extract was brought to a boil. Saponins are visible in frothing [1, 5].

Test for Triterpenoids

Salkowski Test: After adding 2 ml of chloroform and a few drops of concentrated sulfuric acid (3 ml), the test solution was well agitated. Steroids are indicated by the formation of a reddish brown colour at the bottom layer, while triterpenoids are indicated by the formation of a yellow hue [8].

Test for Phenol

Ferric Chloride Test: The test extract had four drops of an alcoholic FeCl3 solution added to it.
Appearance of bluish black colour indicatesthe presence of phenol [9, 10].

Test for Fats and Fixed Oils

Stain Test: A little quantity of the extract was squeezed between the two filter sheets; the stain on the filter paper shows that fixed oils are present [8].

Saponification Test: A little amount of 0.5 N alcoholic potassium hydroxide was added to the extract solution along with a drop of phenolphthalein, and the mixture was heated for one to two hours in a water bath. The presence of lipids and fixed oils is indicated by the development of soap or partial neutralisation for the alkali [8].

Test for proteins and amino acids

Millon's Test: When Millon's reagent is applied to 2 millilitres of test solution, a white precipitate is produced that becomes red when heated [1, 5, 8, 10].

Ninhydrin Test: After treating the ninhydrin solution, it was heated and added to a 2 ml test solution. Amino acid content is shown by the formation of blue hue. Once again, 2 millilitres of the 0.2% ninhydrin solution was treated with proteins and amino acids before boiling to reveal a violet hue [1, 8].

Test for Carbohydrates

After dissolving the extract in 5–10 millilitres of distilled water, the filtrate was passed through Whatmann No. 1 filter paper and used for the subsequent carbohydrate test.

Molish Test: In a test tube, 2 ml of solution was first added, and then 1 drop of Molish Reagent. Conc. HCl was added in a volume of 2 millilitres via the test tube walls. There was a violet ring visible in the test tube. Carbohydrates are present when a violet ring forms at the intersection of the two liquids [5, 9].

Fehling Test: A crimson precipitate that forms when diluted HCl is hydrolyzed with two millilitres of extract, neutralised with alkali, and heated with Fehling's solutions A and B is a sign that reducing sugar is present [1, 9].

Benedict's Test: Benedict's reagent was added to the filtrate, and after a gentle heating period, the presence of reducing sugar was indicated by the formation of an orange-red precipitate [1].

Iodine Test: When 2 ml of extract is added to 5 drops of iodine solution, the result is a blue hue, which signals a positive test [9].

PHYTOPHARMACOLOGY

There are several pharmacologic and therapeutic uses for turmeric. The most significant phytopharmacology and medicinal qualities of turmeric are listed here.

Anti-inflammatory

Curcuma longa's volatile oils and curcumin combine to provide strong anti-inflammatory properties. When taken orally, one half of curcumin has been shown to be as beneficial for treating chronic inflammation as cortisone or

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phenylbutazone is for treating acute inflammation [11]. Due to its unique ability to inhibit lipoxygenase and COX-2, turmeric is recognised for its heat potency and anti-inflammatory effects. Inflammatory alterations in the joints are often linked to rheumatic symptoms. It heals inflammation's pathogenic alterations and etiological causes [6, 12]. LOX, COX, phospholipases, leukotrienes, prostaglandins, thromboxane, nitric oxide elastase, hyaluronidase, collagenase, monocyte chemoattractant protein-1, interferon inducible protein, TNF, and interleukin-12 are among the substances that curcuminoids suppress [5]. Application of curcumin at levels ranging from 50 to 200 mg/kg has decreased oedema in mice used as an animal model. Curcumin given at a dosage of 48 mg/kg body weight may decrease oedema by 50%. At comparable dosages, it has the same efficacy as cortisone and phenylbutazone. Once again, paw oedema and inflammation were reduced in rats when a lower dosage of 20–80 mg/kg was administered. Rats treated with formaldehyde-induced arthritis were able to avoid acute toxicity with dosages of curcumin as high as 40 mg/kg, even at daily doses of up to 2 g/kg. The application of an intraperitoneal injection of turmeric extract containing 4 mg total curcuminoids/kg/day for four days prior to induction of arthritis inhibited joint inflammation in both acute (75%) and chronic (68%) phases of rheumatoid arthritis induced by streptococcal cell wall, according to an animal study [4, 13].

Antimicrobial Properties

The essential oil of Curcuma longa and turmeric extract inhibit the development of several parasites, bacteria, and harmful fungus. an investigation on chicks with a caecal parasite infection. Turmeric supplements have been shown by Eimera maxima to enhance weight growth and lower small intestine lesion scores. In another research, when guinea pigs were infected with either pathogenic moulds, yeast, or dermatophytes, topically administered turmeric oil suppressed the growth of fungus and dermatophytes. The guinea pigs affected with fungus and dermatophytes showed no further lesions seven days after the turmeric treatment. Curcumin has been shown to have modest efficacy against major Leishmania organisms and Plasmodium falciparum [4, 14, 13].

Antidiabetic Properties

An experimental investigation has shown the important impact that turmeric plays in diabetes. Adipocyte differentiation has been observed to be dose-dependently stimulated by a hexane extract containing ar-turmerone, an ethanolic extract containing ar-turmerone, curcumin, demethoxycurcumin, and bisdemethoxycurcumin, and an ethanolic extract from the residue of the hexane extraction containing curcumin, demethoxycurcumin, and bisdemethoxycurcumin. The findings indicate that the ethanolic turmeric extract, which contains both sesquiterpenoids and curcuminoids, has a stronger hypoglycemic effect than either compound alone. Turmeric has amazing effects on insulin and postprandial plasma glucose. Six grammes of Curcuma longa were shown to have no discernible impact on the glycemic response [15–20]. After the OGTT, insulin levels significantly increase for 30 and 60 minutes, encompassing Curcuma longa. Additionally, it has been shown that consuming Curcuma longa and OGTT considerably raises the AUC of insulin [5]. Additionally, diabetes mellitus complications are reduced with turmeric. Turmeric's impact on blood sugar was shown in an albino rat experiment, and the polyol pathway discovered that curcumin and turmeric both lowered blood sugar levels in alloxan-induced diabetes [12].

Antioxidant Effects

Strong antioxidant activity is shown by water- and fat-soluble preparations of turmeric and its curcumin component, which is equivalent to that of vitamins C and E. Pre-treatment with curcumin reduces the effects of ischemia-induced cardiac alterations. Curcumin's impact on endothelial hemeoxygenase-1, an inducible stress protein, was measured in vitro using endothelial cells from cows' aortas. In this research, an 18-hour curcumin incubation period also improved cellular resilience to oxidative damage. Haemoglobin or lipids may be shielded from oxidation by it. Due to its antioxidant qualities, curcumin may effectively prevent activated macrophages from producing reactive oxygen species (ROS) such H2O2, superoxide anions, and nitrite radicals. Because derivatives (bis-demethoxycurcumin and demethoxycurcumin) also exhibit antioxidant properties, they may be used to treat and prevent cholelithiasis [4, 11, 13].

Hepatoprotective Effects

Due to its antioxidant qualities and capacity to prevent the production of pro-inflammatory cytokines, turmeric showed both hepatoprotective and reno-protective characteristics akin to those of silymarin (3– 5). Studies on animals have shown the hepatoprotective properties of turmeric against a range of hepatotoxic stimuli, such as Aspergillus aflatoxin, galactosamine, acetaminophen (paracetamol), and carbon tetrachloride (TCC). It has been shown that the injection of curcumin significantly reduced liver damage in test animals as compared to controls in rats with acute and subacute

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liver injury produced by $CCl4$. When tested on ducklings infected with Aspergillus parasiticus, turmeric extract was found to be highly effective, inhibiting the production of fungal aflatoxin by 90%. Sodium curcuminate, a salt of curcumin, also exerts choleretic effects by increasing biliary excretion of bile salts, cholesterol, and bilirubin, as well as bile solubility, which in turn prevents and treats cholelithiasis [4, 11].

Anti-Cancer Effect

Turmeric's impact on carcinogenesis has been studied extensively in vitro using human cell lines and in animals, including rats and mice. Curcumin has been shown in many in vitro experiments to regulate the three phases of carcinogenesis: angiogenesis, tumour promotion, and tumour development. Two investigations involving colon and prostate cancer have shown that curcumin inhibits the development of tumours and the multiplication of cells. Turmeric and curcumin also inhibit the activities of a number of common mutagens and carcinogens. The anti-carcinogenic properties of curcumin and turmeric have been linked to their capacity to indirectly raise glutathione levels, which helps the liver detoxify carcinogens and mutagens and prevents the formation of nitrosamines, as well as their direct antioxidant and free-radical scavenging effects. It has also been shown that curcumin prevents UV radiation from inducing mutagenicity [11, 13].

Turmeric in the diet has been shown to be an effective chemopreventive agent in benzo-(alpha)-pyrene-induced stomach tumours in Swiss mice. It has been shown that using an ointment containing curcumin and an ethanolic extract of turmeric may significantly reduce symptoms in individuals with external malignant tumours. Turmeric's antioxidant properties show that they may neutralise free radicals that cause cancer. Acetyl curcumin was discovered to be inert. Turmeric was shown to suppress tumour necrosis factor (TNF) in several investigations.Apoptosis or programmed cell death (PCD) in human myeloid leukaemia cells (HL—60) can be induced by α-induced expression of intercellular adhesion molecule-1 (ICAM-1), vascular cell adhesion molecule-1 (VCAM-1), and E-selectin by human umbilical vein endothelial cells. These agents also function as antitumor agents. The test clearly shows the cytotoxic, antioxidant, and anti-inflammatory effects of curcumin I, II, and III from turmeric. Numerous studies have shown the potent intrinsic properties of these compounds against cell lines of leukaemia, colon, central nervous system (CNS), melanoma, renal, and breast cancer [12].

Cardiovascular Effects

Turmeric's antioxidant properties protect the cardiovascular system by reducing triglyceride and cholesterol levels, reducing low-density lipoprotein (LDL) susceptibility to lipid peroxidation, and preventing platelet aggregation. According to a research, giving low-dose turmeric extract (1.6–3.2 mg/kg body weight daily) to eighteen atherosclerotic rabbits has been shown to reduce the susceptibility of low-density lipoprotein (LDL) to lipid peroxidation, as well as to decrease levels of triglycerides and plasma cholesterol. The increased dosage lowers triglyceride and cholesterol levels, but it has no effect on LDL lipid peroxidation. Turmeric extract may have an impact on cholesterol levels because it increases the liver's conversion of cholesterol to bile acids and decreases the intestinal absorption of cholesterol. Additionally, it has been shown that C. longa reduces platelet aggregation by inhibiting the production of thromboxane and potentiating the synthesis of prostacyclin [4, 11, 13].

Gastrointestinal Effects

Sodium curcuminate and p-tolymethylcarbinol, two components of Curcuma longa, exhibit a number of gastrointestinal tract-protecting properties. Sodium curcuminate is known to stimulate the production of pancreatic enzymes and secretin, secretin, gastrin, and bicarbonate while inhibiting intestinal spasm and p-tolymethylcarbinol. Turmeric has also been seen to significantly increase stomach wall mucus in rats exposed to gastrointestinal insults, such as alcohol, stress, indomethacin, pyloric ligation, and reserpine, which may all prevent the development of ulcers [11]. In an open, phase II trial, 600 mg of powdered turmeric was administered five times a day to 25 patients with endoscopically confirmed stomach ulcers. The results revealed that 48 percent of the patients had fully healed. No negative responses or blood abnormalities are shown by the data. Curcumin was shown to lessen mucosal damage in animals that had colitis that was created artificially. Curcumin was shown to reduce inflammation in rat models of pancreatitis produced by experimentation. Curcumin was also shown to be able to block the inflammatory mediators in other types of induced pancreatitis, such as cerulean or ethanol, as determined by histology, pancreatic trypsin, serum amylase, and neutrophil infiltration [13].

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II. CONCLUSION

A thorough analysis of the literature has shown that Curcuma longa, which has a variety of pharmacological properties, is regarded as a herbal medicine's universal cure-all. Because it contains a variety of chemical components, this plant is regarded as a versatile medicinal herb that has several uses. Therefore, it is clear that further study is needed to determine the therapeutic value of these treatments in order to tackle the illnesses. Since the beginning of time, it has been known that crude extracts from various plant parts have been used medicinally. Today, the process of developing new drugs involves extensive research on the pharmacotherapeutics, toxicity, manufacturing process, bioactivity, and other factors. Proper standardisation and clinical trials are then necessary. These days, non-toxic plant products used in traditional medicine, like Curcuma longa, require intensive research and development work to fully utilise their medicinal value. An effort should also be made to investigate the potential for real-world clinical applications as well as the specifics of unexplored and hidden areas of Curcuma longa's utility for human welfare.

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