



ORIGINAL RESEARCH PAPER

Pharmacology

MEDICINAL & PHARMACOLOGICAL PROPERTIES OF TURMERIC (CURCUMA LONGA): THE GOLDEN SPICE OF INDIA

KEY WORDS: medicinal plant, curcuma longa, golden herb, curcuminoids, pharmacological properties.

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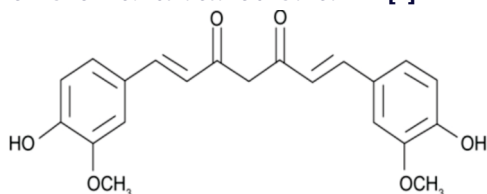
ABSTRACT

Curcuma longa is a traditional Indian spice, a member of the Zingiberaceae family and is cultivated and consumed in many Asian countries. The primary active constituent of C.longa is the flavonoid curcumin, which possess tremendous anti-inflammatory and antioxidant properties making it a wonder herb. In today's age of antibiotic resistance where various allopathic drugs are struggling to serve its purpose, there is a urgent need for us to explore the alternative field of medicine. Not only resistance, we also have to suffer from various side effects and unwanted action of allopathic drugs which gives us another reason to push ourselves to age old home remedies which our ancestors used to follow. Turmeric is one such herb which has been used for centuries for multiple conditions like common cold, cough, wound healing, skin care and many more. Our article aims to rekindle our interest back to our golden spice and appreciate the numerous benefits of this naturally occurring medicinal plant.

Background-

Turmeric is popularly known as golden spice due to its numerous health benefits which comes from the root of Curcuma longa which is a member of Zingiberaceae family [1]. In India, it has been used for more than 6000 years as a household spice, a common food preservative, a coloring agent and also used for its numerous medicinal properties. Turmeric consists of three flavonoids curcuminoids: curcumin, demethoxycurcumin and bisdemethoxycurcumin [2]. Curcumin constitutes about 90% of the total curcuminoid content and comprises 0.3-5.4% of turmeric. Thus it forms the key area of research and studies when it comes to studying the health benefits of Curcuma longa [3].

Figure 1: Chemical structure of Curcumin [4]



C21H20O6; molecular weight: 368.38

Curcumin also called diferuloylmethane is an orange-yellow crystalline powder. It is the most significant natural polyphenol of Curcuma longa[5]. There are several studies implicating towards its positive role in the treatment of inflammatory diseases such as arthritis and cardiovascular disease, also it is efficacious in the treatment of cancer, diabetes and many other clinical conditions[6,7].

Table 1: Nutritional Value of Curcuma Longa [8,9]

Nutrients Value per table spoon (7g)	Calories 23.9
Water 0.8g	Cholesterol 0 mg
Protein 1.5(6.3kj)	Fat 5.6(23.4kj)
Carbohydrate 16.8(70.3Kj)	Fiber 1.4g
Minerals	Calcium 12.4mg
Phosphorous 18.1mg	Iron 2.8mg
Zinc 0.3mg	Magnesium 13.0mg
Potassium 170mg	Sodium 2.6 mg
Vitamins	Thiamine 0.0mg
Riboflavin 0.0 mg	Betaine 0.7 mg
Vitamin C 1.7mg	Vitamin A 0.0 IU
Folate 2.6mcg	Choline 3.3mg

More than 235 compounds, such as 109 sesquiterpenes, 5 diterpenes, 3 triterpenoids, 68 monoterpenes, 22 diarylheptanoids, diarylpentanoids, 8 phenylpropenes,

phenolic compounds, 4 sterols, 2 alkaloids, and 14 remaining compounds have been isolated from Curcuma Longa [10].

The objective of this article is to summarize the various pharmacological properties of Curcuma Longa and highlight its clinical implications and therapeutic utilization.

1. Anti-oxidant agent- There have been studies suggesting that consumption of curcumin curry regular maintains mental performance in aged people and protects brain aging in general hence results in increased scores on Mini-Mental State Examination Test [11]. Administration of curcumin to rats is said to protect their brain by enhancing SOD, GPx and Na⁺,K⁺- ATPase levels and also reduces lipofuscin and lipoperoxide levels which are markers of lipid peroxidation [12]. Also there are references implicating that curcumin can somewhat inhibit ischemia induced neuronal cell death and lessens the effects of oxidative stress, lipid peroxidation and mitochondrial dysfunction [13]. Turmeric consumption protects against mitochondrial disruption, loss of 'cytochrome c' and also simultaneously helps in activation of caspase-3 as well as apoptosis of the cortical neurons [14]. Curcumin can protect astrocytes from neurotoxicity by stimulating GSH and GPX synthesis. It also provides prevention against Parkinson's disease and other neurodegenerative diseases [15-17]. There are also some studies depicting its positive role in spinal cord injury due to its antioxidant activity [18]. Curcumin is said to activate hemoxygenase thus providing neuronal protection [19,20]. A study reported that curcumin administration decreased amyloid protein and neurofibrillary tangles by 43% in Alzheimer's disease. [21]

2. Anti-inflammatory action - Curcumin is said to have multiple anti-inflammatory action in conditions such as asthma, periodontitis, osteoarthritis and rheumatoid arthritis, acute anterior uveitis, in ammatory bowel disease etc. This action is exerted through the modulation of in ammatory mediators such as IL-6 & 8, TNF-α& β, substance P, CRP, CGRP and MCP-1. Curcuminoids and its efficacy have been well established in the clinical trials as well and was found safe for the same [22].

3. Chemo-protective action- Curcumin acts as an anti cancer agent by inhibiting tumor promotion, angiogenesis and tumour progression [23]. Several studies have proved that antioxidants which are present in the curcuma neutralizes the carcinogenic free radicals [24]. Curcumin is said to induce apoptosis in the human leukemia cells [25]. Studies have also demonstrated that dietary curcumin has an inhibitory effect of

cyclooxygenase-2 in human colon cancer cells. [26]. As per another study, Curcumin is also effective against breast carcinoma cells [27,28].Turmeric oil is shown to be highly effective against some of the direct acting mutagens like sodium azide, 4-nitro-O-phenylenediamine etc. Some studies have demonstrated that turmeric oil blocks the activation of carcinogens by inhibition of various isoforms of cytochrome p450 [29].Moreover, it is also said that curcuma inhibits the mutagenic induction effect of UV rays [30-34].In patients suffering with advanced stage of colorectal cancer, it was demonstrated in a study that after consuming 3.6 g curcumin per day for 4 months, a reduction in prostaglandin E2 levels which is an indicator of cyclooxygenase (COX) 2 activity was observed [35]. One of the other studies shows that curcumin was responsible for lowering the number as well as the size of polyps in patients with familial adenomatous polyposis [36]. A study was conducted where the results of a phase 2 study of gemcitabine in combination with curcumin were reported for 12 months. This combination showed promising results for pancreatic cancer [37,38]. Preclinical experiments and studies implies that curcumin can indeed suppress several stages of cancer in various tumor models.

4. Anti-microbial action- Curcuma longa and its essential oil is shown to cause retardation of growth of several bacteria, parasites and pathogenic fungi. There is a study which demonstrated that when chicks infected with the caecal parasite, *Eimeria maxima* were given turmeric in their diet, it resulted in better weight gain and reduced small intestinal injuries [39]. In another study, it was shown that topical application of turmeric oil inhibited the growth of dermatophytes and pathogenic fungi. Some action of Curcumin is also observed against *Plasmodium falciparum* and *Leishmania major* organisms [40].According to a study ethanolic extract of turmeric demonstrated antifungal, antibacterial and insecticidal activity. [41] It was demonstrated that when a rabbit was treated with Curcuma longa, he displayed higher mean value for contraction of the wound in comparison to the control group and his wounds also showed less inflammation and increased collagen formation[42].The base solution after isolation of curcumin from oleoresin consists about 40% oil. Among various fractions, the one eluted with 5% ethyl acetate in hexane was the most effective as an antibacterial agent [43].

5. Metabolic actions-

a) Anti-diabetic action-

In an experimental study, efficacy of turmeric on blood sugar was shown in albino rats and it was found that turmeric decreased blood sugar level in alloxan-induced diabetes. Curcumin can also reduce the complications associated with diabetes mellitus. As per reports , turmeric stimulates pancreatic cells and insulin production which is responsible for its antidiabetic action. The ethanolic preparation of turmeric lowered the blood glucose level when given to experimental rats. Multiple experimental studies using rats have showed the efficacy of turmeric as an antidiabetic agent as it reduces hyperglycemia and other effects related to diabetes .Not only it reduces blood glucose levels, curcumin also is said to increase plasma insulin levels, inhibit diabetic cataracts and relieves neuropathic pain .Curcumin also inhibits glycosylation of protein. According to a in vitro study , curcumin may improve islet transplantation outcomes as it enhances the survival of cells of human pancreatic islets .One of the preparation of curcuminoids caused improvement in inflammatory stress biomarkers in patients with type 2 diabetes along with improvement in endothelial dysfunction [44].

b) Anti-Obesity Curcumin has proven its effectiveness in obese patients too. It reduces the symptoms of anxiety and depression associated with obesity. Curcumin modulates circulating levels of IL-1 β , IL-4 and VEGF, thus exhibiting an immunomodulatory effect and also reduces oxidative stress in obese patients [45]

6. Hepato-protective action- Several studies have proved the ability of turmeric to protect the liver from various hepatotoxic injuries like carbon tetrachloride galactosamine and acetaminophen. This hepatoprotective effect of turmeric is an outcome of its antioxidant properties along with its ability to reduce the formation of proinflammatory cytokines. Administration of curcumin reduces liver injury .Infection with *Aspergillus parasiticus* and fungal aflatoxin production is reduced by almost 90% with administration of turmeric. Curcumin also reversed biliary hyperplasia and fatty changes along with aflatoxin related necrosis. Sodium curcumin, a salt of curcumin, is said to be useful in preventing and treating cholelithiasis. Curcumin owing to its antioxidative property also protects cells against lipid peroxidation induced by paracetamol. In a study curcumin proved to be ten times more effective than the regular treatment where human hepatocytes had been destroyed by taurine .Curcumin administration decreased levels of serum aspartate transaminase , alkaline phosphatase activity, levels of serum free fatty acids, cholesterol and phospholipids on alcohol induced hepatotoxicity in alcoholic rats [46] One of the studies proved that curcumin was protective against membrane phospholipid peroxidation . Curcumin was also effective against malnutrition induced liver peroxidation and caused reversal of GSH decay done by oxidative stress in mice [47].Clinical trial using turmeric for treating infective hepatitis was found to be very effective with no side effects. In a study conducted in Japan, crude turmeric rhizomes were tested in experimental animals against CC14-induced hepatotoxicity. Curcumin when given with *Eclipta alba* and *P. fraternus* was found to be highly effective against liver injuries and reduced level of serum bilirubin in CC14-induced hepatotoxicity in experimental rats. According to a study, turmeric oil could inhibit the activities of CYP450 isoforms CYP2C9 and CYP2D6 in vivo in cirrhotic rats at the dose of 100mg/kg, while dose of 400 mg/kg could induce the activity of CYP2C19.

7. Cardio-protective action-

a) Dyslipidemia- Turmeric aids in lowering cholesterol levels and triglyceride levels. It also reduces the overall susceptibility of low density lipoprotein to lipid peroxidation. A study was conducted with 18 atherosclerotic rabbits who were given low dose of turmeric extract , the result showed that these rats had reduced susceptibility of LDL to lipid peroxidation and also lower serum cholesterol and triglyceride levels. Decreased cholesterol uptake in the intestines and increased conversion of cholesterol to bile acids in the liver was found to be responsible for cholesterol lowering effect of turmeric. Curcuma longa also stimulates prostacyclin synthesis and causes inhibition of thromboxane synthesis which further results in inhibition of platelet aggregation.

b) Myocardial infarction- Curcumin owing to its anti-inflammatory action protects the heart against various injuries. There are many animal studies which proves that administration of curcumin does protects the heart from damage which may be caused due to cardiac ischemia and reperfusion and also from cardiopulmonary bypass .[48]Curcumin acts by inhibits the pathways responsible for generation of reactive oxygen and lipid peroxidation and also by promotes detoxification of free radicals. In an experimental study done with mice, it was demonstrated that administration of curcumin daily for about a year caused inhibition of p300 histone acetyltransferase which in turn prevented artificially or experimentally induced cardiac hypertrophy, fibrosis and inflammation .The various ways by which curcumin suppresses development of atherosclerotic lesion includes its ability to inhibit low-density lipoprotein oxidation, reduced proliferation of vascular smooth muscle cells, reduction in thrombosis, reducing the formation of aortic fatty streak and by inhibiting endothelial dysfunction

which may be caused by homocysteine. Most of these beneficial cardiovascular effects of curcumin are as result of antioxidant and anti-inflammatory actions. In an experimental study where curcumin was given after inducing myocardial injury by isoproterenol it was found that previous exposure with curcumin aided in partial restoration of cellular antioxidants and also reversed myocardial injury. In a human study, oral intake of 20mg of curcumin for a duration of 60 days caused reduction in both HDL and LDL cholesterol lipoperoxidation.

c) Acute coronary syndrome. Acute coronary syndrome (ACS) is used to represent symptoms associated with acute myocardial ischemia [49]. Effect of curcumin on lipid levels was studied through a randomized controlled trial with 75 ACS patients. In this study curcumin was given to the patients at increasing doses three times a day. The findings of this study suggested and proved that at low doses curcumin was indeed beneficial in reducing the total cholesterol and low density lipoprotein cholesterol levels in the patients [50].

8. Gastrointestinal action- Curcumin's anti-inflammatory action have demonstrated therapeutic effect in several gastrointestinal disorders like dyspepsia, H. pylori infection, peptic ulcer, irritable bowel syndrome and inflammatory bowel conditions. In one of the clinical trials, during phase of the study, 45 subjects who were endoscopically diagnosed with peptic ulcers were administered 600mg of curcumin, five times in a day for 12 weeks. The findings suggested that in 12 patients after four weeks no ulcers were found and in 18 patients ulcers were absent after eight weeks and in 19 patients after 12 weeks. It was observed that ethanolic extract of curcuma when given orally had similar effects comparable to the action of ranitidine on gastric acid, gastric juice secretion and ulcer formation [51]. A pilot study was conducted for 8 weeks with patients of irritable bowel syndrome. It was found that after four weeks of curcuma administration, there was 53% and 60% reduction in IBS prevalence among them. Also abdominal pain and discomfort scores were reduced by 22 and 25%. A study was also conducted to study the possible therapeutic effect of curcumin on experimental esophagitis in rats to validate its use in Gastroesophageal Reflux disease

9. Respiratory action- In a clinical trial, it was demonstrated that oral administration of turmeric oil was highly effective in the treatment of bronchial asthma. Fresh rhizome of the herb showed promising result against whooping cough and other coughs and also in dyspnea. As per old studies, inhalation of burning turmeric fumes lead to copious mucous discharge which provided instant relief in catarrh and coryza. An amalgamation of several clinical trials done for respiratory diseases like bronchial asthma, bronchitis, bronchiectasis etc. revealed the role of turmeric as an adjuvant in improving the airway resistance.

10. Cataract- A study involving wistar rats showed that the lipid peroxidation, levels of xanthine oxidase enzyme as well as opacities found in the lenses of animals was less in those treated with both curcumin and selenium in comparison to those animals who were only given selenium. Curcumin also prevents oxidative damage and development of cataract [52].

11. Acne – Efficacy of Curcuma longa has been established by studying its hemolytic effect on RBC's and is found to be safe for use in humans for treatment of acne and healing of wounds [53].

12. Reversible anti-fertility effect- Studies showed the androgen deprivations inhibit spermatogenesis and reflect in sperm density, motility and fertility of the extract treated rats. This showed the anti-spermatogenic activity of Curcuma longa extract thereby suggesting the potential of this plant in the regulation of male fertility [54].

13. Vitiligo- In a study it was demonstrated that along with

narrow band UVB plus topical tetra hydro curcuminoid cream was found to be beneficial in vitiligo. [55]

14. Psoriasis According to one of the trials, curcumin was found to possess an ability to alter PhK activity thus explaining its anti-psoriatic action. In another randomized, double-blind, placebo-controlled clinical trial, patients when treated with Meriva, a formulation of curcumin, showed improvement in symptoms. Curcuma also displayed synergistic effect when used with topical steroids in psoriasis. It has a great potential to be used as an adjuvant therapy against psoriasis and also it caused reduction in levels of IL-22 [56].

15. Neurological disease-

a) Alzheimer's disease- In a randomized, double-blind, placebo controlled study which included 34 patients suffering from Alzheimer's disease, curcumin was randomly given at two different doses or placebo. The treatment with curcumin resulted in rise in vitamin E levels, thus displaying antioxidant effects of curcuma [57].

b) Antidepressant action - Curcuma Longa is said to exhibit antidepressant properties through inhibition of monoamine oxidase-A. Studies have shown that ethanolic extract of curcuma reverses the reduction in levels of serotonin, noradrenalin and dopamine concentrations and is also responsible for the rise in serotonin levels, cortisol values and levels of serum corticotrophin-releasing factor. A study showed the role of oral curcumin on behavior in a chronic stress model of depression in rats in which curcumin displayed antidepressant effect similar to that of imipramine. These studies showed that curcumin causes selective increase in neurotropic factor in the frontal cortex and the hippocampus of the rats which in turn decreases serum lipid peroxides values and increase in level of HDL cholesterol and causes an overall reduction of total serum cholesterol (12%). Another study in which aqueous extract of curcuma longa was studied showed that phytochemical constituents like Curcuminoids which is a mixture of curcumin, monodemethoxycurcumin and bisdemethoxycurcumin, is responsible for its antidepressant activity along with its ability to inhibit MAO activity in a mouse whole brain in a dose dependent manner [58].

c) Antiepileptic activity - Oxidative stress is one of the factors responsible for epileptic attack and oxygen, superoxide and nitrite are said to be produced during epileptogenesis. Studies have showed antioxidant activity of curcumin in rat brain to an extent greater than dl α -tocopherol and dehydrozingerone. Curcumin is also said to reduce lipid peroxidation and increase the reduced glutathione levels, superoxide dismutase and catalase activities in lead induced neurotoxic rats [59]. This antioxidant effect of curcumin explains its anticonvulsive activity.

CONCLUSION-

There are several studies both animal and human which suggests that consumption of turmeric on regular basis is highly effective against several health condition specially the ones due to dysregulated inflammation and generation of oxidative stress like cancer, cardiovascular disease, inflammatory gastric disease, hepatic disease, metabolic syndrome etc. However, more in depth studies and research is needed in order to fully understand curcumin's impact in prevention and treatment of these diseases. In order to fully utilize and savor the benefits of this golden drug, we need to accumulate as much as data possible and further explore its virgin benefits.

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