

TURMERIC - AN AGE OLD TRADITIONAL REMEDY TO AN EXOTIC MODERN MEDICINE: A REVIEW

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ABSTRACT

Turmeric is a flowering, rhizomatous and herbaceous plant, which is basically vernacular to the Indian subcontinent and southern east part of Asia. It belongs to the family of Zingiberaceae. The binomial name of turmeric is *Curcuma longa*. In ancient time turmeric was excessively used in Ayurveda, Siddha and other traditional system of medicines which are popular in India. In India the utilization of turmeric is appreciable, generally in different disorders of joints, skin, respiratory tracts it is employed. In visual aspect turmeric is yellow color and this color is responsible for the biologically active compound present in turmeric which is Curcumin. In recent years Turmeric has acquired potential attention in the medical as well as scientific community because of its miscellaneous biological properties as well as vast extant healthcare practices. Safety and tolerability are pivotal consideration for any prospective therapeutic substances and every assessment proves turmeric's beneficiary role as well as its safety profile. Furthermore, this overview delves into the mechanism through which turmeric and curcumin extent their biological effects, such as modulating inflammatory pathways, oxidative stress and cellular signaling pathways. Additionally, we address the challenges associated with the bioavailability of curcumin and strategies employed to enhance its absorption. In conclusion it holds immense promise as a natural dietary component that may contribute to improve health outcomes. While numerous studies suggest it's potential benefits, ongoing research is essential to better understand the full scope it's therapeutic applications and to establish evidence-based recommendations for its consumption in various populations. The overview also highlights the need for further clinical research to substantiate many of the promising findings from preclinical and epidemiological studies. The potential role of turmeric as part of a balanced diet and its safety profile are discussed, along with considerations for supplementation.

KEYWORDS: Turmeric, Curcumin, Antibacterial, Antifungal, Antioxidant.

INTRODUCTION

Turmeric is an herbaceous, rhizomatous and flowering plant, which is basically cultivated in the Indian subcontinent and southern east region of the Asia.^[1] Turmeric is widely used as a spice, food conservative, coloring substance and source of various medicinal substances in India, China, Myanmar as well as southern east part of Asia. It is well accepted in Asian medical system as well as traditional Chinese medicine. The temperature requirement is between 20 to 35 degrees Celsius (68-to-95-degree Fahrenheit). An annual rainfall of 1500 mm or more is needed for growing or cultivating Turmeric. The pH of turmeric is 5.9.



Figure 1: Turmeric and Its Preparation.

In the last 50 years it has been confirmed that the most of the medicinal effects of turmeric are mainly due to curcumin, which is a natural polyphenolic compound

present in the rhizome of *Curcuma longa* and other various species of *Curcuma*.^[2]

Generally turmeric have potential effect on various diseases such as cancer, bacterial and viral infection, antifungal property, skin treatment, heart disease, indigestion, diabetes, arthritis, management of obesity, asthma, allergies etc.

Turmeric is widely used in traditional Indian and ayurvedic medicine due to its potential health benefits. Researchers suggest that curcumin possesses anti-inflammatory, antioxidant properties which help in managing various health conditions. It is also alleviating symptoms of osteoarthritis, provide supportive care of digestive health and contribute a healthy condition of health by reducing cholesterol level and improving blood pressure. Moreover, it has ability to support immune system of body and upgrade health condition. In South Asia, it is readily accessible as antiseptic for cuts, burns and bruises.

Turmeric offers a promising health outcome in different aspects. So, the objective of this study is to provide a review on Turmeric and its different health outcomes.^[3]

Traditional Medicine - Turmeric which is derived from the *Curcuma longa* has been a cornerstone of Ayurvedic system of medicine. It is believed that turmeric contains various health benefits. In ayurveda turmeric is believed to establish the balance between tri - doshas in human body, which are vata, pitta and kapha.^[4] Traditionally turmeric is dried and polished then cut into pieces and forward them into mortar and pestle or manual chakki for grinding well. Basically, in ayurvedic medicine system turmeric is taken into internally in the form of fresh juice, tinctures, powders and topically it is used as cream, paste, lotion and ointments. Turmeric has authentic use in ayurvedic medicine in various aspects of human health condition. Traditionally describe as that turmeric has bitter taste (rasa) and possess astringent energetic effect and it's post digestive (vipaka) is pungent and heating.^[5]

Turmeric has potentially advantageous effect on rasa dhatu and rakta dhatu, the tissues of blood, plasma, and lymph. It provides a calm and cooling effect on these tissues but at the same time they stimulating their healthy flow and functions.

Turmeric also helps to lowering the excess kapha and any cumulation of ama (toxicity). It's heating nature allows it to possess mobilizing and cleansing energy, which generally lights agni (digestion). Traditionally it is also used for supporting the liver, muscles, bones, immune system, and skin diseases. In ayurvedic system of medicine the ayurvedic practitioners believed that turmeric has wide medicinal activities in detoxification, hair health by promoting scalp health and hair growth,

anti-parasitic effect by treating parasitic infection, promoting eye health by preventing age related macular degeneration, gastrointestinal health by managing indigestion and irritable bowel syndrome, reducing stress and act as aphrodisiac by enhancing sexual vitality and desire.^[6]

Chemical Constituents – Turmeric has various chemical constituents for performing wide medicinal and pharmacological applications. According to safety evaluation study, a high dose of turmeric (0.5 g/day/person) is well tolerated by human without demonstrating any kind of toxic effects.^[7] Turmeric has 3-6% polyphenolic compounds, which are together known as curcuminoids, which is generally a mixture of curcumin, demethoxycurcumin and biemethoxycurcumin. Curcumin is responsible for color of turmeric as well as most abundant and liable for most of turmeric's health benefits.

Turmeric also contains several aromatic compounds like turmerone (alpha- turmerone, beta- turmerone), terpinolene, alpha- phellandrene, atlantone etc. contribute the characteristic aroma and flavor of turmeric.^[8]

Turmeric also possesses various carbohydrate compounds such as L-arabinose, L- rhamnose, D- galactose, D- glucose, D- xylose and dietary fiber which provide a healthy gut microbiome and promote regular bowel movement.^[9]

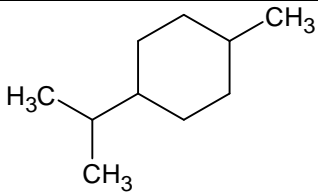
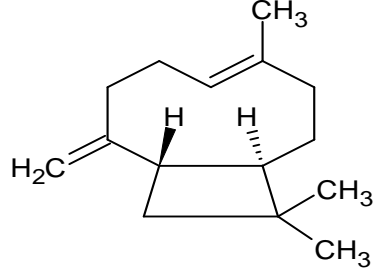
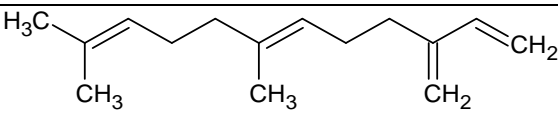
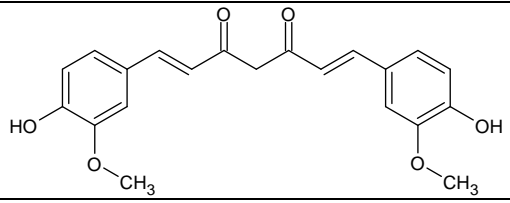
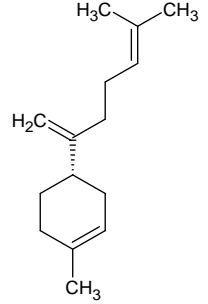
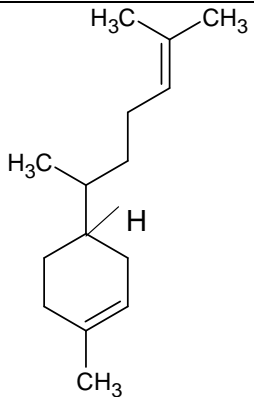
Turmeric has small amount of essential fatty acids in its constituents for contributing a source of energy and supporting various bodily functions. It also has anti-inflammatory properties that provide overall health benefits of turmeric.

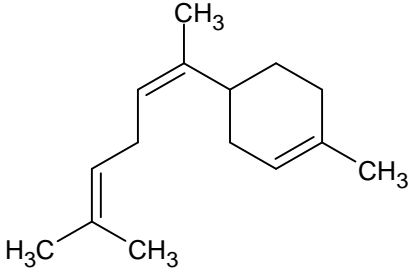
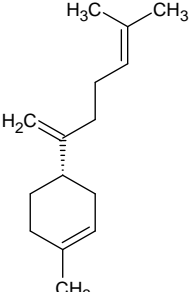
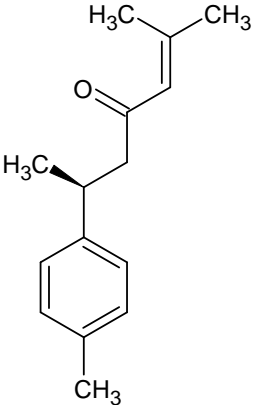
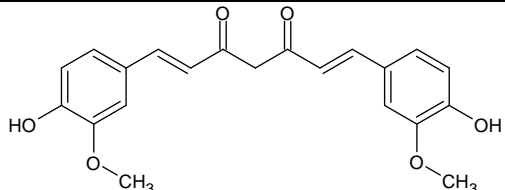
Turmeric contains a number of mono and sesquiterpene. These sesquiterpenes are also known as curcumenones. It is found that a pale yellow to orange yellow volatile oil (4-6%) is acquired from turmeric which contain these mono and sesquiterpenes. Some of them are dehydrocurdione, bisabolol, bisacumol, biscurone, curcumenol, procurcumenol, isoprocumenol etc.

Turmeric provides essential minerals like calcium, potassium, magnesium, phosphorus, iron, copper, zinc etc. for contributing supportive function of overall health benefits.

Turmeric also contain vitamin C and vitamin B6. Vitamin C is an antioxidant that protect cells from oxidative damage and assist immune system. Vitamin B6 is involved in brain development, immune function and metabolism of proteins.^[10]

TABLE – Some Components of Turmeric Along with Their Chemical Nature, Structure and Use.

Sr. No	Components	Chemical Nature	Structure	Use
1	Alpha-Phellandrene	Cyclic monoterpene		Used in fragrances due to its pleasant aroma. ^[11]
2	Beta-caryophyllene	Bicyclic sesquiterpene		Used as a non-steroidal anti-inflammatory agent to reduce pain. ^[12]
3	Trans- beta-furnesene	Acyclic sesquiterpene		Used as free radical scavenger, antibacterial and antifungal agent. ^[13]
4	Curcumin	Diarylheptanoid		Used in antifungal, antibacterial, antianxiety, anti-inflammatory, anti-aging agent. ^[14]
5	Beta- Bisabolene	Sesquiterpene		Used as flavors in beverage industry and also act as a food additive. ^[14]
6	Beta- Sesquiphellandrene	Cycloalkane sesquiterpene		Used as anti-viral and anti-cancer agent. ^[15]

7	Cis- Alpha-Bisabolene	Sesquiterpenoid		Used as flavors in beverage industry and also act as a food additive.
8	Beta- Bisabolene	Sesquiterpene		Used as flavors in beverage industry and also act as a food additive
9	Ar- Turmerone	Sesquiterpenoid		Used as anti-inflammatory, anticonvulsant as well as anti-fungal agent. ^[17]
10	Gama- Curcumin	Diarylheptanoid		Used as anti-inflammatory and management of oxidative stress. ^[18]

Turmeric possesses some proportion of resin those contribute to the herb's healing properties.

Other chemical constituents are curcumin derivatives which provide potential health benefits in human body. These metabolites may have unique biological activities and health benefits associated with curcumin consumption.

These components along with other compounds in turmeric work synergistically to provide its diverse range of potential health benefits, including anti-inflammatory, antioxidant, immune-supportive and other therapeutic and pharmacological effects. Additionally, the bioavailability of curcumin is limited, which is led researchers to explore ways to improve its absorption and effectiveness in the body.

The study focuses on observing essential constituents in turmeric by collecting, drying, and grinding rhizomes

into powder. The seeds are then subcritically extracted using n-pentane. The extraction process is completed using two solvents, NaCl in a saturated solution, and centrifuged. The resulting essential oil is then dissolved in hexane for quantitative analysis. The process ensures accurate and reliable results.

The result of gas chromatography analysis of turmeric oil shows the presence of 10 major elements.^[19]

Anti-inflammatory Agent – Turmeric contain curcumin which can act as an anti-inflammatory agent in various aspects of inflammation. Oxidative stress has been connected in many chronic diseases, and its pathological processes are closely related to those of inflammation and that can easily instigate by another several factors also.

Generally, curcumin helps to inhibit the activation of different enzymes and molecules, which are involved in

the inflammation process. Curcumin blocks the activity of NF- κ B (Nuclear factor kappa B), which is an ancient protein transcription factor that helps to initiate inflammation. By doing so, it retards the production of pro-inflammatory cytokines, which act as a signalling molecule for initiating and assisting inflammatory processes.^[20]

Curcumin also possesses strong anti-oxidant properties that help to neutralize dangerous and harmful free radicals and decrease oxidative stress. As we know oxidative stress is highly responsible incident for conducting inflammation and various diseases. Thus, curcumin mitigating oxidative stress and indirectly reduces inflammation.

Moreover, curcumin activate body's natural immune system which instigate the production of IL-10 (Interleukin-10), which helps to suppress the activity of COX-2 (Cyclooxygenase-2) and LOX (Lipoxygenase). This COX-2 and LOX acts as an inflammatory enzyme that help to induce inflammatory processes.

Turmeric's active compound curcumin acts as a potent anti-inflammatory agent as its ability to retard inflammatory signalling pathways, neutralize oxidative stress a support body's inherent immune system. These multiple approaches of turmeric make it as a promising natural remedy for inflammatory conditions.^[21]

As Antibacterial and Antifungal – Turmeric contains a bioactive compound called curcumin, which is primarily responsible for its antibacterial property. Curcumin has been extensively studied for its ability to inhibit the growth and proliferation of various bacteria.^[22] One notable example of turmeric's antibacterial activity is its effectiveness against *Helicobacter pylori*, a bacterium known to cause gastritis and ulcers.

In a study published in the "Journal of Applied Microbiology", researchers found that curcumin extracted from turmeric demonstrated strong inhibitory effects against *H. pylori*. It is not only preventing the bacterium growth but also reduce its adherence to gastric epithelial cells, which is crucial for its pathogenicity. This suggest that turmeric could be a potential remedy for gastrointestinal infections caused by *H. pylori*.

Turmeric's antifungal properties are attributed to its curcumin content as well. Fungal infections can affect various body parts, including skin, nail and mucus membranes. One remarkable example of antifungal activity of turmeric is its role in *Candida albicans* infections. *Candida albicans* is a common fungus responsible for oral thrush, vaginal yeast infections and other candidiasis related conditions. Researchers have found that curcumin can disrupt the cell wall of *Candida albicans*, leading to its inhibition and eventual death.^[23]

Moreover, turmeric has been investigated for its potential to combat dermatophytes fungi responsible for skin and nail infections, such as athlete's foot and onychomycosis. A study published in the "Journal of Ethnopharmacology" reported that turmeric extracts displayed significant antifungal activity against various dermatophytes and highlights its potential as a natural remedy for these infections.^[24]

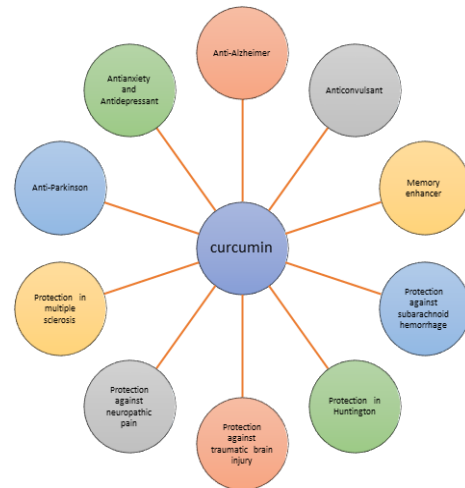


Figure 2: Curcumin and Its Biological Aspects.

As Antioxidant Agent – The important active constituent of turmeric is curcumin, which is renowned for its potent antioxidant properties and its probable positive effect on cellular health. In general antioxidants are those molecules which helps to neutralize dangerous and harmful free radicals present in our body. These harmful radicals are susceptible to damage cells in our body and potentiate to conduct several chronic diseases, including aging, cancer etc.

Curcumin has potential anti-oxidant activity that helps to donate electron and neutralize free radicals present in our cellular organization as well as body. Thereby, it decreases oxidative stress. Thus, by scavenging free radicals' curcumin can potentially reduce oxidative stress and uphold overall cellular health. Curcumin has strong antioxidative effects and supports the cells against protein carbonylation, lipid peroxidation, and also mitochondrial permeability transition. Several research papers suggests that curcumin's antioxidant properties not only give protection against oxidative stress or oxidative damage but also it gives a potential benefit on health condition.^[25] A recent systematic review has shown that the supplementation of purified curcuminoids have beneficial effect on several oxidative stress parameters such as plasma activities of SOD and catalase enzymes and also serum concentration of Glutathione peroxidase (GSH) and lipid peroxidase. Being a potential lipophilic compound, curcumin can breakdown of peroxy radicals, thus curcumin can be considered as chain breaking antioxidant as vitamin E. Curcumin also retards oxidative stress by reducing different form of free

radicals such as ROS (Reactive oxygen species) as well as RNS (Reactive nitrogen species).

Thus, curcumin's potential antioxidant properties make it a promising beneficial compound for supporting and managing cellular health by combatting oxidative stress, its associate damage as well as prevent chronic diseases in the manner of great interest and exploration.^[26]

Role in Osteoarthritis and Joint Health – Curcumin has gained attention in managing osteoarthritis and promoting joint health. Curcumins have potential therapeutic benefits in joint mobility and osteoarthritis treatment. A recent study involved 102 patients of poor joint health, where 51 patients were given by curcumin treatment and others mean another 51 patients were receiving ibuprofen drug, a no steroidal anti-inflammatory drug (NSAIDs).^[27] In this comparative study, curcumin group showed better joint motility and good upgradation of joint health as well as reduce inflammation. In vitro study demonstrate that curcumin can lower the apoptosis rate of chondrocytes (a cell responsible for cartilage formation) and reduce inflammation factors. Thus, the study exhibit that the curcumin is a safe and effective therapeutic remedial option for managing symptoms of osteoarthritis.

Curcumin helps to decrease the symptoms of osteoarthritis by decrease in systemic oxidative stress, as measured via serum activities of SOD and concentrations of reduced GSH and malondialdehyde (MDA), which induce osteoarthritis. Curcumin can block inflammatory cytokines and enzymes, including cyclooxygenase-2 (COX-2), the target pain reliever celecoxib (Celebrex).^[28] Inflammation plays a significant role in the induction of symptoms of osteoarthritis which contribute cartilage degradation and pain. Curcumin can inhibit those certain inflammatory molecules and potentially reduce inflammatory responses in the joints. By modulating these several kinds of pathways curcumin might help to mitigate pain and slow down this degenerative disease, osteoarthritis. That's why studies have been shown that it can be helpful for people with osteoarthritis (OA).

Additionally, curcumin possess antioxidant property which counteract the oxidative stress within joint tissues. This oxidative stress can aggravate the damage of cartilage and joint structures, which leads to further degeneration. Now curcumin neutralize those free radicals and helps to protect joint cells from oxidative damage.

A comparison study comparing curcumin and diclofenac for treating knee osteoarthritis found that curcumin has nearly identical therapeutic effects to diclofenac. Curcumin's similar effect to phenylbutazone improves joint condition, reducing swelling and improving walking time, making it a potential therapeutic option for those unable to tolerate NSAIDs.^[29]

Impact on Gastrointestinal Health – As we know that the gastrointestinal tract (GI) plays a crucial role in the various process of digestion, absorption of nutrients and overall, well – being for gut health. Turmeric has potential benefit to cure, prevent and try to mitigate different kinds of complexation in gut.

Turmeric has potent anti-inflammatory activity that helps to alleviate any inflammation in gastrointestinal tract. Chronic infection in gut can led to Inflammatory bowel disease (IBD), Crohn's disease, ulcerative colitis etc, in which curcumin is thought to be modulate inflammation by inhibiting different pro-inflammatory enzymes. Eighteen years ago, the Canadian Society of Intestinal Research, the Gastrointestinal Society's sister charity, provided funding for Dr. Baljinder Sahl's research into the benefits of curcumin in colon cancer. Sahl and his Vancouver team contributed to a building body of evidence that this flavourful spice can help prevent cancerous cells from developing in the colon.

Turmeric is also been traditionally used to support digestion. It is believed that turmeric has capability to stimulate bile production, which generally helps in breakdown of fat in the digestive process and maintain gut health. Thus, the improvement of bile flow can improve digestion and prevent the uneasiness after consuming fatty meals.^[30]

Various clinical trials support that turmeric as well as curcumin has potential therapeutic activity in different Gi tract disorders such as Ulcerative colitis, colon cancer, pancreatic cancer, familial adenomatous polyposis, inflammatory bowel disease, hypercholesteremia, atherosclerosis, pancreatitis, psoriasis, chronic anterior uveitis, and arthritis.

Some individuals with irritable bowel syndrome (IBS) experience relief from manifestations after consuming turmeric. A clinical study occurred in the UK, which involve 207 irritable bowel syndrome patients. Researchers are shown an exceptional improvement of their disease state after giving them turmeric tablet. The researcher further recommends larger placebo-controlled study.

Emerging research studies suggest that turmeric might positively influence the gut microbiota. An efficiently balanced gut microbiome is essential for overall GI health. Curcumin's potential probiotic effect may promote the growth of beneficial gut bacteria and while inhibiting the harmful ones. Thus, turmeric provides a healthier gut environment.

Nowadays, turmeric as well as curcumin is a sharply and keenly studied compound. Particularly in combination with black pepper, it provides healthier gut environment. As always, it's important to consult with a healthcare provider before making significant dietary changes, especially if you have underlying health condition. A

systematic review of curcumin and turmeric supplementation's effect on gastrointestinal diseases was conducted in Iran. Curcumin, a plant-derived product, has been used for treating abdominal pain and poor digestion. The review aimed to investigate the effects of curcumin or turmeric supplementation alone or in combination with other herbs or nutrients on GI diseases.^[31]

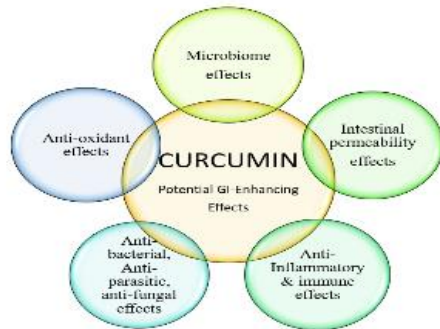


Figure 3: Curcumin and Its Potential Effects on GI.

Role on Cardiovascular Health - Turmeric, a popular spice and traditional remedy, has gained attention for its potential impact on cardiovascular health. The active constituent of turmeric is curcumin which has been studied for its various potential benefits in relation to heart health. While research is ongoing and more study reports are needed to establish a definitive conclusion.

Atherosclerosis thickening or hardening of the arteries. The formation of plaque in the inner line of blood vessel by deposited of fatty substances, cholesterol, cellular waste products, calcium, and fibrin. This plaque formation can disturb blood flow and an increase in reactive oxygen species (ROS). ROS are produced by various systems, including NADPH oxidases and the mitochondria, in endothelial as well as in smooth muscle cells. Under homeostatic conditions, excessive ROS production is prevented by anti-oxidative systems such as Glutathione (GSH), Superoxide dismutase (SODs), and Catalase, which are downregulated by different risk factors for CVDs. Now curcumins antioxidant properties help to neutralize dangerous, harmful free radicals and decrease oxidative stress. This action may help to protect the arterial walls from damage and reduce the plaque formation.^[32] The endothelium, the inner lining of the blood vessels plays an important role in the maintenance of the healthier vascular health as well as cardiac health. Dysfunction of the endothelium is the early warning of the atherosclerosis. Curcumin can improve the health of the endothelium by vasodilation, decreasing inflammation and increase production of nitric oxide can provide a healthier vascular environment that is less conduct to plaque formation.^[33]

Turmeric also helps to manage and regulate high level of cholesterol. High levels of Low-density lipoprotein (LDL) contribute to the build-up of the plaque in the

arteries. Curcumin has potential role in regulation of cholesterol levels by reducing the formation of cholesterol in liver and helps to increase the expression of LDL receptors. This incident can help to remove the traces of LDL from the blood stream and prevent formation of plaque in the arterial wall. Research has also found that seasoning foods with turmeric can help reduce your body's bad cholesterol (LDL). Also, preliminary studies show that curcumin may reduce the number of heart attacks bypass patients had after surgery.

Turmeric also shows anti-platelet activity by inhibiting the platelet aggregation and reduce the chances of clot formation. This action can contribute to prevent the complications associated with atherosclerosis.^[34]

Curcumin may have positive effect on cardiovascular health according to a few studies as well as clinical trials. In one study, 121 people are participated in the study who had coronary artery bypass surgery. A few days before and after the surgery, one group had taken 4 grams curcumin in a day and others are given to placebo. The group that takes 4 grams of curcumin a day saw a 65% decreased risk of having a heart attack in the hospital.

It's important to note that research suggest that curcumin may have a positive effect on different aspects on plaque formation and atherosclerosis, the evidence is not yet conclusive.^[35] Curcumin's potential benefits in this context are part of a complex interplay of factors, and its efficacy can be influenced by factors such as dosage, bioavailability, and individual health conditions.

It is also important to remember that if there is any kind of evidence for using curcumin on reducing blood pressure and have a positive impact on blood pressure, then more intriguing research on this aspect is needed for confirming and realizing its correct application and appropriate dosage form. It's also noteworthy that turmeric as well as curcumin should not be used as a sole treatment material for atherosclerosis and high cholesterol without any proper and impactful medical supervision. Soit's recommended to discuss a professional healthcare provider for guidance on your curcumin intake in daily.^[36]

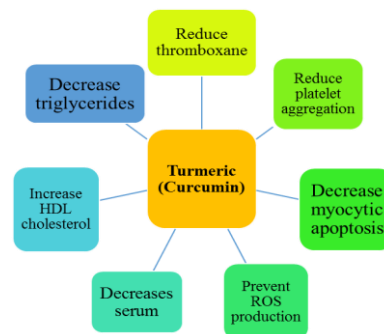


Figure 4: Effect of Curcumin on Cardiovascular Health.

Impact On Neurological Health – Curcumin has potential positive affect on neurological health by boosting the brain neurotransmitters serotonin and dopamine.^[37] It can reduce spinal neuroinflammation by adjusting diverse astroglia mediated cascades. Eventually it has different evidence that curcumin has therapeutic aspect on a renown neurological disorder, such as depression. In a clinical study, a group of 60 depressed people was given with turmeric which shows the effectiveness of Prozac in alleviating symptoms of the condition. Curcumin may also increase levels of serotonin and dopamine, which are chemicals in your brain that regulate mood and other body function.

Turmeric has an important therapeutic aspect on Alzheimer's disease, as it is a progressive neurodegenerative disease.^[38] According to WHO 5% male and 6% female above age 60 is prone to affect with Alzheimer disease with dementia type in India. It is believed that Alzheimer disease can degrade nerve cells by inflammation, oxidative damage as well as formation of beta amyloid plaques and metal toxicity.^[39] So, curcumin has antioxidant and anti-inflammatory activity by it can reduce oxidative stress and incidence as well as prevalence of Alzheimer disease.^[40]

Role on Skin Health – Turmeric has considerable attention in promoting the skin health. It's active compound, curcumin show antioxidant and anti-inflammatory effect and making it popular ingredient in various skincare products.^[41]

Antioxidant properties of curcumin helps to combat against oxidative strength and suppress premature aging as well as prevent skin damage. Curcumin can neutralize free radicals which may help to decrease the appearance of fine lines and wrinkles.^[42]

The anti-inflammatory activities of curcumin can provide beneficial role to fight against different inflammatory skin conditions such as acne, eczema and psoriasis. It also alleviates redness, swelling, itching and discomfort associated with these conditions.^[43]

Turmeric also inhibits the potential excess production of melatonin and provide a promising beneficial role in management of Hyperpigmentation. It can reduce dark spots and wrinkles and led more even skin tone.

As with any skincare product, it's important to read the caution due to individual skin hypersensitivity as well as itching and seeking professional device when necessary.^[44]

Studies show that skincare products formulated with turmeric and curcumin can help improve the appearance of skin tone irregularities, like blotchiness, redness, and unevenness. Curcumin has powerful anti-inflammatory as well as antioxidant properties, so it can reduce redness of skin as well as blemishes on skin, thus it provides a

soothing, calmness condition on skin. Some evidence even suggests that using turmeric topically can help improve the appearance of dark spots and discolorations.^[45]

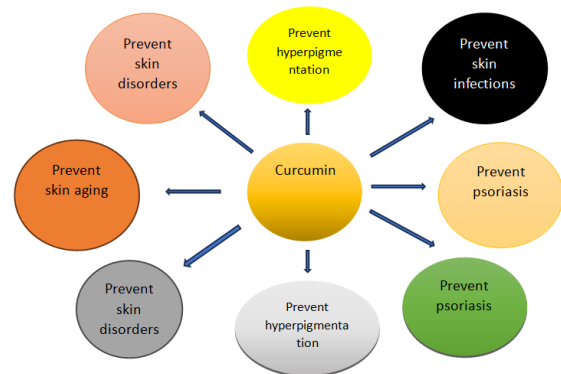


Figure 5: Impact of Curcumin on Skin Health.

Role in Managing Metabolic Syndrome – Curcumin, the activated compound of turmeric has been investigated for its beneficial role in addressing different aspects of metabolic syndromes.^[46] Metabolic syndrome is a cluster of condition including high blood pressure, high blood sugar, obesity, abnormal cholesterol level, that together can arise the potential risk of heart disease, stroke and type 2 diabetes.

Insulin resistivity is an important feature of metabolic syndrome, in this case cell becomes less responsive to the effect of insulin. Different study report suggest that curcumin can improve insulin sensitivity by translocating the glucose transporter proteins (GLUT4) to the cell membrane, allowing cells to take up glucose from the blood stream and drastically improve response to insulin.

Curcumin can produce an impact in lipid metabolism by regulating cholesterol level. It can potentially lower bad low-density lipoprotein (LDL), which is prone to accumulation of cholesterol level in our body and raising good high-density lipoprotein (HDL), Thus leading to a mor favourable lipid profile.

Curcumin can also normalize the blood pressure level in our body by modulating different mechanism in our physiological system. The dysfunction of endothelial lining or inner lining of blood vessel can cause high blood pressure. Now curcumin improve endothelial function by enhancing the availability of nitric oxide (NO) and regulate blood vessel tone.^[47]

Curcumin may promote the widening as well as relaxation of blood vessel by increasing production of nitric oxide (NO), thus lowering the pressure of blood-on-blood vessels and reduce BP level.^[48]

Curcumin has potentially positive impact on complex hormone system, Renin-Angiotensin Aldosterone system (RAAS) by modulating certain component of system as well as it can maintain proper balance of sodium and

water, which can contribute to blood pressure control. Its effect on brain and nervous system may contribute to stress reduction and relaxation, which can indirectly influence blood pressure. In a randomized double-blind placebo-controlled crossover trial, a study involving 36 obese adults was conducted, where they were given either some amount of curcumin and some amount of piperine or a placebo for 30 days, followed by a two-week washout period. A significant reduction in serum triglyceride concentrations was observed, but the treatment did not have a significant influence on serum total cholesterol, LDL-C, HDL-C, and high-sensitivity C-reactive protein (hs-CRP) concentrations, nor on body mass index (BMI) and body fat. According to a study, which is conducted on Tufts University in the year 2009, curcumin can actually reduce fat tissue growth by shrink and contract the fat cells and suppressing blood vessels that needed to form fat tissue.^[49]

Potential Role on Covid 19 – COVID 19, short for “Coronavirus Disease 2019” is a very high contagious respiratory disease, which is caused by novel coronavirus SRS-coV-2. It was first identified in December 2019 at Wuhan in China, after that it has spread globally and became pandemic.^[50]

Some study suggest that it might have a role in modulating as well as supporting the immune system in our body. In the first study, the research group investigated the modulation of pro-inflammatory cytokines by nanocurcumin. Patients with COVID-19 showed high mRNA expression and secretion of cytokines, IL-1 β , IL-6, TNF-, and IL-18, but showed a significant reduction in IL-6 and IL-1 after treatment with nanocurcumin.

The COVID-19 pandemic, characterized by respiratory symptoms and severe cardiovascular and renal complications has led to an urgent need to understand the virus's mechanisms and development treatment options. Curcumin, a natural polyphenolic compound, has potential effects on gastrointestinal disorders, such as inhibiting virus entry, encapsulation, and viral protease and modulating cellular signalling pathways. A systematic review of clinical trials conducted to investigate the effect of curcumin or turmeric supplementation on GI diseases.^[51]

As Anticancer Agent -Curcumin, a natural compound found in turmeric has gained significant attention in potential role of cancer prevention and treatment due to its antioxidant, anti-inflammatory, as well as anti-cancer properties. However, it's important to note that while there is prominent research, curcumin is not a substitute for conventional cancer treatments.

Chronic inflammation is linked to cancer development, so curcumin's anti-inflammatory effect can reduce the potential risk of development of tumour growth and its progression.^[52]

Curcumin is an antioxidant, which means it can neutralize harmful free radicals that damage DNA and helps to contribute cancer development. By reducing oxidative stresses curcumin might lower the risk of cancer. It enhances apoptosis of cancerous cell through an overexpression of p53 and intonation of Bax and Bcl-2 molecules in a well dose-dependent manner.

Curcumin may trigger the process of apoptosis in our physiological system, which is generally programmed cell death. In cancer cells, apoptosis is when suppressed allowing them to survive and proliferate. So, its ability to induce apoptosis can help eliminate these abnormal cells from body. It also has been shown to inhibit the proliferation of cancer cells by interfering different signalling pathways that uncontrolled cell division and growth.

Tumours require to blood supply for its own growth. Curcumin may inhibit angiogenesis, the process by which tumours develop new blood vessels to nourish themselves and thereby slowing the growth.^[53]

Curcumin may also provide obstacles in the spread of cancer cells to other parts of the body from the source. Curcumin may modulate the immune system as well as response by promoting the activity of immune cells that target and destroy cancer cells.

A total of 21 clinical trials were selected, reviewed, and included in this study. Sixteen out of 21 clinical trials were associated with the effectiveness of curcumin or turmeric on various types of cancer, and the other five clinical trials were related to the evaluation of the efficacy of curcumin or turmeric in relieving the side effects of cancer chemotherapy and radiotherapy. All the results of these clinical trials have shown that turmeric has a role in prevention and intervention on cancerous cells.^[54]

Adverse Effects – Turmeric is generally considered safe when used in moderation as a spice in cooking or as dietary supplement. In some cases, excess consumption of turmeric can lead to certain side effects.

Taking large amount of turmeric may cause different gastrointestinal side effects such as nausea, vomiting, diarrhoea. Some people may also experience stomach upset or indigestion.^[55]

For example, according to JECFA (The Joint United Nations and World Health Organization Expert Committee on Food Additives) and EFSA (European Food Safety Authority) reports, the Allowable Daily Intake (ADI) value of curcumin is 0–3 mg/kg body weight.

Turmeric can interact certain medicines, particularly those medications that affect blood clotting or are metabolized by the liver. Turmeric is high in oxidates, so

that can contribute to the formation of kidney stones is susceptible individuals.

Turmeric, despite its potential therapeutic benefits, has been linked to negative side effects such as diarrhea, headache, rash, and yellow stool in clinical trials. Limited research exists on its safety during pregnancy and breastfeeding.^[56]

Nutritional Value of Turmeric- Doctors generally recommend to take 500 milligrams turmeric in twice daily with food. However, it has been suggested that this

dose of turmeric utterly depends on overall person’s health.

The risk of side effects is quite low and drug interactions with turmeric is unlikely to happen. If it shows any ill effects that taking of turmeric can be stop. Turmeric may cause bloating, and there is a theoretical and documental concern that it can show drug interaction with concomitant use of blood clotting medications. Turmeric may help supplement in conventional care, but it’s not a substitute for medicine.^[57]

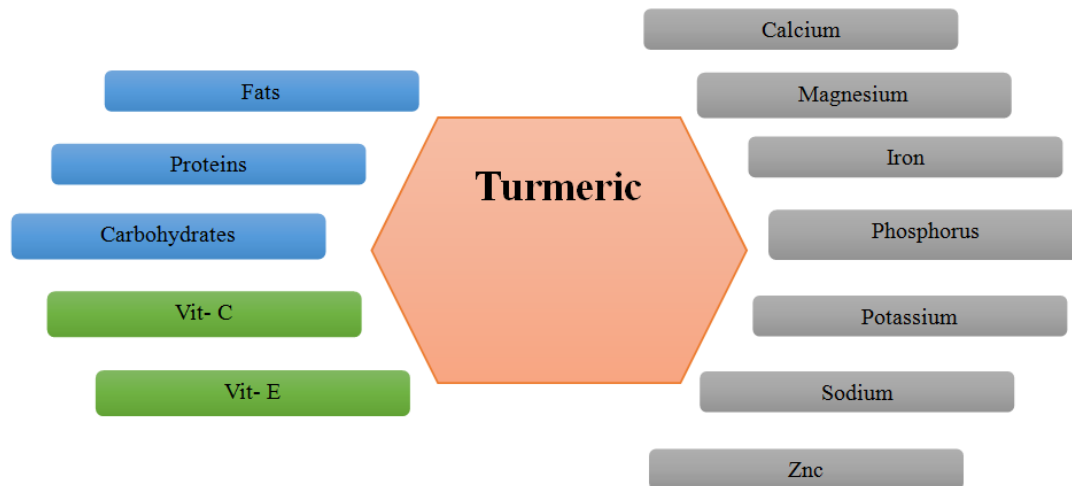


Figure 6: Nutritional Constituents in Present in Turmeric.

Future Emerging Areas and Innovations– The future directions of turmeric, a popular spice and medicinal herb, encompasses a range of exciting developments and innovations. These areas are driven by increasing awareness of its health benefits and the desire for sustainable agriculture.

Biotechnology can play a pivotal role in enhancing turmeric varieties. Researchers are working on genetically modifying turmeric to increase its curcumin content, the compound responsible for many of its health benefits. For instance, a genetically modifies “high curcumin” turmeric variety could provide more potent anti-inflammatory and anti-oxidant properties.^[58]

The demand for organic turmeric on the rise due to health-conscious consumers. Innovation in sustainable farming practices, such as regenerative agriculture and intercropping with other beneficial plants, are being explored to ensure a consistent supply of high-quality organic turmeric.

Turmeric is increasingly being incorporated into functional foods and nutraceuticals. Products like turmeric infused beverages, snacks and dietary supplements are emerging as convenient ways to consume turmeric for its health benefits.

Its potent medicinal properties are being harnessed by pharmaceutical companies. Innovations include the development of curcumin-based drugs for various health conditions, such as anti-inflammatory drugs and potential treatments for neurodegenerative treatments.

Artificial intelligence is being applied to turmeric farming to optimize crop management. Artificial intelligence driven systems can monitor soil conditions, predict disease outbreaks and optimize irrigation that leading to increased yields and reduced environmental impact.^[59]

Its anti-inflammatory and antioxidant properties are finding their way into the cosmetic and skincare products are being formulated to address various skin concerns, such as acne, eczema and aging.

The vibrant yellow colour makes it a promising natural dye alternative. Innovations in textile and fabric industries are exploring the use of turmeric as a sustainable and eco-friendly dye option.

Its compounds can be used in the development of biodegradable plastics. This aligns with the increasing demand for eco-friendly materials.^[60]

Thus, turmeric become a golden species for these various aspect in healthcare system.

Regulatory And Legal Considerations – Regulatory and legal considerations for turmeric supplements typically fall under the purview of dietary supplement regulations in various countries.^[61]

FDA Regulations (United States) – The United States, turmeric supplements are regulated as dietary supplements by the Food and Drug Administration (FDA). Manufacturers must adhere to regulations outlined in the Dietary Supplement Health and Education Act (DSHEA). They are responsible for ensuring the safety and labelling accuracy of their products.

Labelling Requirements – Turmeric supplement labels must accurately represent the ingredients and their quantities. Make sure any health care substantiated and comply with local regulations.

Good Manufacturing Practices (GMP) – Manufacturers should adhere to GMP guidelines to ensure the quantity, quality and consistency of turmeric supplements. This includes proper handling of raw materials and quality control during production.

Safety Testing – Turmeric supplements should undergo safety assessments should undergo to identify potential risks or side effects. Toxicological studies and clinical trials may be necessary to support safety claims.

Claims and Advertising – In some regions, you may need scientific evidence to support claims about the health benefits of turmeric. Misleading or false claims can lead to legal issues.

Intellectual Property – It is notified to ensure that you are not interfering on any patents or trademarks related to turmeric or it's active constituents.^[61]

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