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A review on phytochemical and medical properties of turmeric

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Abstract
Turmeric is a spice that has good medical properties and it has different health benefits for the human body, the major source of polyphenol is curcumin. Turmeric is derived from Curcuma longa, a rhizomatous herbaceous perennial plant native to tropical South Asia and a member of the ginger family Zingiberaceae. It is used as a pungent compound in food items which gives colour and good flavour to foods a cocking spice. Turmeric helps to manage oxidative and inflammatory conditions. Thus, this review aims to offer a discussion of turmeric its Nutritional, Phytochemical Properties, Biological and Therapeutically Properties, and health promotion and disease prevention, with a focus on its antioxidant, anti-inflammatory, neuroprotective, anticancer and anti-diabetic.

Keywords: Turmeric, curcumin, antioxidant, anti-inflammatory, phytochemical

1. Introduction
Turmeric is now widely grown in the tropics and is known by various names in different cultures and countries. Turmeric is popularly known in North India as "haldi," a Sanskrit term, and in the south as "manjal," a word that frequently appears in ancient Tamil literature. Curcuma has been identified in 133 different species all over the world. Temperatures between 20 °C to 30 °C are required for the turmeric plant to thrive, as well as a significant amount of annual rainfall (F. Benzie & Wachtel-Galor, 2011) [18]. Turmeric is a spice that has attracted the interest of both the medical and scientific communities, as well as the culinary community (Priyadarsini, 2014) [38]. Turmeric is a rhizomatous herbaceous perennial plant in the ginger family (Curcuma longa). The therapeutic benefits of turmeric, the source of curcumin, have been known for thousands of years, then later has it been possible to pinpoint the specific mechanism of action and identify the bioactive components (Gupta *et al.*, 2013) [22]. Curcumin (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione), also known as diferuloylmethane, is the major natural polyphenol found in Curcuma longa (turmeric) rhizomes and other Curcuma specious (Aggarwal *et al.*, 2003) [2]. Turmeric is a plant that used for medicinal purposes for approximately 4000 years. Turmeric is used not just as a spice in Southeast Asia, but also as a component in religious ceremonies. Turmeric is sometimes known as "Indian saffron" due to its beautiful yellow hue. Over 3000 publications on turmeric have been published in the previous 25 years, indicating that modern medicine has come to realise its relevance (F. Benzie & Wachtel-Galor 2011) [18]. Turmeric is used as a traditional medicinal plant for centuries due to its antioxidant, anti-inflammatory, antimutagenic, antibacterial, and anticancer characteristics (Hewlings, 2017) [24]. Curcumin is a lipophilic polyphenol compound that makes up 2-5 percent of turmeric powder (Deogade and Ghate 2015) [14].
Curcumin is well-known and frequently utilized for its potential health benefits in a number of methods all over the world. Turmeric, which contains curcumin s used in curries in India; in Japan, it has served in tea; in Thailand, used in cosmetics; in China, it is used as a colourant; in Korea, it is served in drinks; in Malaysia, it is used as an antiseptic; in Pakistan, it is used as an anti-inflammatory agent; and in the United States, it is used as a preservative and a colouring agent in mustard sauce, cheese, butter, and chips, Curcumin is available in capsules, tablets, ointments, energy drinks, soaps, and cosmetics, among other forms (Gupta *et al.*, 2013) [22]. Curcuminoids have been labelled as "Generally Recognized as Safe" (GRAS) (Gupta *et al.*, 2013) [22] by the clinical experiment and US Food and Drug Administration (FDA) have demonstrated good characteristics of acceptability and safety profiles at doses ranging from

4000 to 8000 mg/day (Basnet and Skalko-Basnet 2011) [8] and about 12,000 mg/day of 95 per cent concentration of three curcuminoids: Curcumin, bisdemethoxycurcumin, and demethoxycurcumin (Lao *et al.*, 2006) [30].

2. Turmeric

2.1 Nutritional And Phytochemical Properties

The Curcuma genus, which has roughly 120 species, has a long history of medical usage (Akarchariya *et al.*, 2017) [4], (Dosoky and Setzer, 2018) [16]. *Curcuma longa* L. (Curcuma; Turmeric) is the most well-known Curcuma species; it is a cultivated plant growing in many regions of the world in warm climates (Wu, 2015) [48]. However, determining the taxonomic identification of this genus is challenging due to its exceptionally brief flowering time and herbarium preparation due to the flashiness of tubers, rhizomes, and inflorescences (Jadhao and Bhuktar, 2018) [27].

Curcumin is also known as "curcumin I" and is made up of 1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione and 1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione. Curcumin is a diferuloylmethane with the chemical formula C21H20O6 with a crystalline yellow-orange colour. It has a molecular weight of 368.39 g/mol, a melting temperature of 183 °C, and a molecular weight of 368.39 g/mol. It has keto-enol tautomerism chemically, which means it has a dominating keto form in neutral and acidic solutions, while its more stable enol form dominates in the solid-state and in an alkaline solution (Anand *et al.*, 2007). Curcumin II [Desmethoxycurcumin, 1-(4-hydroxy-3-methoxyphenyl)-7-(4-hydroxyphenyl)-1,6-heptadiene-3,5-dione] and curcumin III [bisdemethoxycurcumin, 1,7-bis(4-hydroxyphenyl)-1,6-heptadiene3,5-dione] are two more curcumin molecules (Buckingham, 2018). Curcumin is an orange-yellow dye that is almost insoluble in water and has been approved as a food ingredient by the European Union (EU). Other names for it include CI 75300, Natural Yellow 3 or diferuloylmethane, as well as the E code E100. Curcumin stability in an aqueous solution is pH-dependent, having an optimal cut-off point between pH 1 and 6. In the charged state its hue changes to red, (pH 1 or pH>7) and sunshine increases curcumin breakdown (Goel *et al.*, 2008) [20], (Priyadarsini, 2009) [37].

Curcumin is usually given at a level of 5-500 mg/kg for nutritional purposes, depending on the food type. Dairy foods, beverages, cereals, mustard, food concentrates, pickles, sausages, confectionery, ice cream, and meat, fish, eggs, and bread products are the most common uses (Lakshmi, 2014) [29], (Solymosi *et al.*, 2015) [44]. It's also used in seasonal sauces, mayonnaise sauces, and butter when mixed with annatto (Satyanarayana *et al.*, 2010) [42].

Table 1: Composition of Turmeric

Nutritional Composition (%)	**Moisture**	**89.12**
	Protein	10.07
	Ash	2.76
	Crude Fibre	4.87
	Either extract	6.64
	Nitrogen free extract	66.76
Minerals (PPM)	Calcium	1.67
	Magnesium	0.92
	Potassium	1.29
	Phosphorus	1.07
	Sulphur	0.73
	Copper	0.04
	Selenium	0.04
	Iron	0.06
Phytochemicals (mg/g)	Saponin	1.36
	Tannin	1.87
	Flavonoid	0.68
	Steroid	0.99
	Terpenoid	0.54
	Alkaloid (%)	10.04
	Phytate	10.30

***Source*:** Imoru *et al.*, (2018) [26]; Mane *et al.*, (2018) [32]

2.2 Biological and Therapeutical Properties

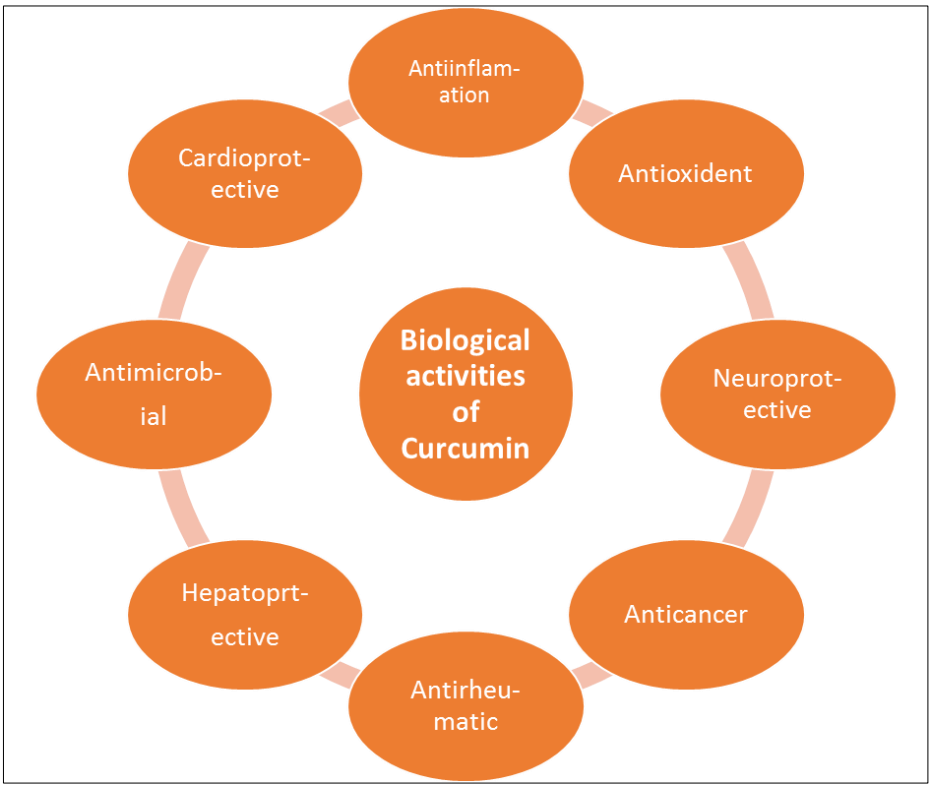
Surprisingly, this natural polyphenol is referred to as the "wonder drug of life" by everyone (Gera *et al.*, 2017) [19]. Turmeric was utilized to treat inflammatory disorders of numerous organs, liver and digestive tract problems, and wound healing in ancient times in the Far East. The first studies on curcumin's health effects were conducted in the 1970s. Curcumin has been proven to have many therapeutic potentialities in these and subsequent investigations (Yanpanitch *et al.*, 2015) [50], (Gera *et al.*, 2017) [19], (Salehi *et al.*, 2019) [41].

Curcumin, a polyphenol, has been demonstrated to target several signalling molecules while also displaying cellular activity, supporting its multiple health advantages (Gupta *et al.*, 2013) [22]. Inflammatory disorders (Vera-Ramirez *et al.*, 2013), metabolic syndrome (Panahi *et al.*, 2016) [35], pain (Kuptniratsaikul *et al.*, 2014) [28], and the management of inflammatory and degenerative eye conditions (Allegri *et al.*, 2010) [6], (Mazzolani and Togni, 2013) [33] have all been demonstrated to benefit from it. It has also been demonstrated to be beneficial to the kidneys (Trujillo *et al.*, 2013). While curcumin supplementation appears to have a plethora of therapeutic benefits, the majority of these are related to its antioxidant and anti-inflammatory properties (Gupta *et al.*, 2013) [22], Vera-Ramirez *et al.*, (2013).

Curcumin is widely known and used for its possible health benefits in a variety of ways around the world. Turmeric, which contains curcumin, is used in curries in India; in Japan,

it is used in tea; in Thailand, it is consumed in cosmetics; in China, it is used as a colourant; in Korea, it is served in drinks; in Malaysia, it is used as an antiseptic; in Pakistan, it is used as an anti-inflammatory agent; and in the United States, it is used as a preservative and a colouring agent in mustard sauce, cheese, butter, and chips, Curcumin is available in capsules, tablets, ointments, energy drinks, soaps, and cosmetics, among other forms (Gupta *et al.*, 2013) [22]

Curcuminoids have been designated as "Generally Recognized As Safe" (GRAS) by the US Food and Drug Administration (FDA), and clinical trials have demonstrated good tolerability and safety profiles at doses ranging from 4000 to 8000 mg/day and up to 12,000 mg/day of 95 percent concentration of three curcuminoids: curcumin, bisdemethoxycurcumin, and demethoxycurcumin (Lao *et al.*, 2006) [30], (Basnet and Skalko-Basnet, 2011) [8].



2.3 Antioxidant activity

The antioxidant benefits of curcumin have been studied the most in the literature. Curcumin's antioxidant capacity has been related to its chemical structure, which includes carbon double bonds, b-diketo group, phenyl rings with hydroxyl, and o-methoxy groups, according to many *in vitro* and in vivo investigations. Antioxidant activity can be explained by a variety of processes, including the binding of free radicals, hydrogen atom donors, and electron donors to neutralise free radicals. The mechanism of action of curcumin's antioxidant activity has been elucidated using laser flash photolysis and pulse radiolysis (Javad *et al.*, 2020) [43].

Curcumin's antioxidant activity is enhanced by scavenging reactive oxygen species (ROS) such as superoxide radicals, hydrogen peroxide, and nitric oxide (NO) radicals, as well as preventing lipid peroxidation (Ak and Gulcin, 2008) [3]. Many antioxidant enzymes, including as SOD, CAT, GPx, and OH-1, are activated, resulting in this latter action. Curcumin can also boost GSH levels by boosting glutathione transferase and its mRNAs. Curcumin can also block the production of reactive oxygen species (ROS) by enzymes such LOX, COX, and xanthine oxidase. Because of its lipophilic nature, curcumin is also thought to be a chain-breaking antioxidant, possibly working as a peroxyl radical scavenger (Priyadarsini *et al.*, 2003) [36].

2.4 Anti-cancer activity

Curcumin has been demonstrated to be beneficial in suppressing transformation, tumour development and invasion, angiogenesis, and metastasis in several stages of cancer development. Curcumin has been shown to inhibit tumour cell growth via the cell proliferation pathway (cyclin D1, c-myc), cell survival pathway (Bcl-2, Bcl-xL, cFLIP, XIAP, and cIAP1), caspase activation pathway (caspase 8, 3, and 9), tumour suppressor pathway (p53, p21), death receptor pathway (DR4, DR5), and many cell signal pathways that contain protein kinase pathway (c (AMPK) (Ravindran *et al.*, 2009) [39]. Curcumin is said to be useful in reducing or preventing different cancer types, including multiple myeloma, due to these effects (Devassy *et al.*, 2015) [15]. Curcumin is also said to improve the effectiveness of radiotherapy, potentially allowing for a faster treatment time (Akpolat *et al.*, 2010) [5]. In a study on colon cancer cells, a monocarbonyl analogue of B63 obtained through chemical changes of curcumin's structure was found to have a stronger antiproliferative impact than curcumin. Simultaneously, tumour development has been suppressed with less B63 (50 mg/kg B63, 100 mg/kg curcumin) (Zheng *et al.*, 2014) [52].

2.5 Neuroprotectivity activity

Neuroinflammation is a type of persistent inflammation that causes alterations in neuronal metabolism, which leads to neuronal degeneration. The activation of microglia and astrocytes increases neuronal death in neuroinflammatory conditions. The latter are in charge of the production of pro-inflammatory cytokines including TNFα and IL-1. Curcumin

has been proposed as a potential therapeutic agent for a variety of neurological disorders, including dementia, Alzheimer's disease, Parkinson's disease, multiple sclerosis, and Huntington's disease (HD), based on existing research. It has antioxidant, anti-inflammatory, and anti-protein aggregating properties (Ye and Zhang, 2012) [51], (Teter *et al.*, 2019) [45]. Curcumin inhibits the generation of inflammatory cytokines and prostaglandins by activated microglia and astrocytes (Zhu *et al.*, 2014) [53], (Cianciulli *et al.*, 2016) [12]. In microglial and astrocyte cells, it also reduces the synthesis of TNFa, IL-1β, macrophage inflammatory protein (MIP-1β), monocyte chemoattractant protein (MCP-1), and IL-8 (Chen *et al.*, 2015) [23].

2.6 Antidiabetic activity

Study of curcumin found that treating human adipocytes with curcumin (15 µM) for 24 hours reduced reactive oxygen species (ROS) production evaluated by the 2′,7′-dichlorohydrofluorescin diacetate assay, whereas ROS production measured by the nitroblue tetrazolium assay remained unaltered (Hirzel *et al.*, 2013). These findings imply that curcumin inhibits the generation of reactive oxygen species (ROS). Curcumin (20 M) treatment of primary rat adipocytes for 45 minutes significantly decreased both baseline and insulin-stimulated glucose transport. This suppression of glucose uptake was observed in cells that had been pre-treated with curcumin as well as cells that had been treated with curcumin shortly before glucose transport was assessed. Furthermore, curcumin administration had no influence on the protein level of phospho-protein kinase B/Akt, implying that these effects on glucose transport are not caused by insulin signalling suppression (Green *et al.*, 2014) [21].

2.7 Anti-inflammation

Numerous *in vitro* and in vivo investigations have revealed that curcumin has a high potential for treating a variety of inflammatory disorders in the literature (Aggarwal and Sung 2009) [1], (Cianciulli *et al.*, 2016) [12], (Edwards *et al.*, 2017) [17], (Dai *et al.*, 2018) [13]. Many chronic diseases have been linked to oxidative stress, and its pathogenic processes are similar to those of inflammation in that one can readily be caused by the other. In reality, inflammatory cells are known to release a number of reactive species at the site of inflammation, resulting in oxidative stress, demonstrating the link between oxidative stress and inflammation (Biswas *et al.*, 2016) [10]. A variety of reactive oxygen/nitrogen species can also trigger an intracellular signalling cascade that boosts pro-inflammatory gene expression. Inflammation has been linked to the onset of a variety of chronic illnesses and ailments (Recio *et al.*, 2012) [40], (Panahi *et al.*, 2014) [34]. Alzheimer's disease (AD), Parkinson's disease, multiple sclerosis, epilepsy, cerebral injury, cardiovascular disease, metabolic syndrome, cancer, allergy, asthma, bronchitis, colitis, arthritis, renal ischemia, psoriasis, diabetes, obesity, depression, fatigue, and acquired immune deficiency syndromeAIDS are just a few of these diseases (Recio *et al.*, 2012) [40].

Curcumin has been shown to inhibit pro-inflammatory transcription factors (NF-kB and AP-1), reduce pro-inflammatory cytokines such as TNFa, IL-1b, IL-2, IL-6, IL-8, MIP-1a, MCP-1, CRP, and PGE2, down-regulate enzymes such as 5-lipoxygenase and COX-2 and -5, and inhibit mitogen-activated protein kinases (MAPK) and pathways involved (Aggarwal and Sung, 2009) [1], (Panahi *et al.*, 2014) [34], (He *et al.*, 2015) [23], (Machova Urdzikova *et al.*, 2015) [31]. Tumor necrosis factor α(TNF-α) is a significant mediator of inflammation in most disorders, and its action is regulated by the activation of nuclear factor (NF)-κB, a transcription factor. Despite the fact that TNF-α is the most-strong NF-κB activator, TNF-α expression is also regulated by NF-κB. Most inflammatory cytokines, gram-negative bacteria, numerous disease-causing viruses, environmental contaminants, chemical, physical, mechanical, and psychological stress, excessive glucose, fatty acids, UV radiation, cigarette smoke, and other disease-causing factors all activate NF-κB. As a result, medicines that inhibit NF-κB and NF-κB- regulated gene products may be effective against a variety of disorders. Curcumin has been demonstrated to inhibit NF-κB activation, which is triggered by a variety of inflammatory triggers (Recio *et al.*, 2012) [40].

On the other hand, because oxidative stress causes chronic inflammation, a link between antioxidant molecules and their anti-inflammatory properties is becoming more apparent. Curcumin can affect the expression of NF-κB in this way. In fact, activation of the NF-κB pathway results in the generation of proinflammatory cytokines such as interleukin (IL-1, IL-2, IL-6, IL-8) and TNF- α, which are known to activate pro-inflammatory signalling pathways. Curcumin may also reduce oxidative stress and inflammation by activating the Nrf2 pathway. Two COX isoenzymes (COX-1 and COX-2) are involved in the conversion of arachidonic acid into prostaglandins and thromboxanes via the COX pathway. COX-2 is induced by a variety of cytokines and tumour promoters and is thus associated to inflammation and carcinogenesis, with numerous studies suggesting that curcumin can suppress COX-2 gene expression induction (Yang *et al.*, 2017) [49].

3. Future trends

Due to its numerous promising medicinal potentials, many pharmaceutical and cosmetic enterprises create diverse goods such as tablets, colouring agents, ointments, tablets, energy drinks, extracts, gels, soap, cosmetics, nasal sprays and creams utilising curcumin and other turmeric compounds. Curcumin therapy has been shown to be effective in a variety of malignancies, including colon, lung, breast, cervical, pancreatic, colon, and stomach cancers, with few or no adverse effects. Curcumin formulations such as ointment, capsules, pills, and oral supplements were employed in the clinical studies.

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