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TURMERIC: THE GOLDEN SPICE OF LIFE

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ABSTRACT

Turmeric is an ancient spice derived from the rhizomes of *Curcuma longa*, which is a member of the ginger family (*Zingiberaceae*). Also known as 'Golden Spice of India' turmeric has been used in India for medicinal purposes for centuries. It has been used in traditional medicine as a household remedy for various diseases, including biliary disorders, anorexia, cough, diabetic wounds, hepatic disorders, rheumatism and sinusitis. In addition to its use as a spice and pigment, turmeric and its constituents mainly curcumin and essential oils shows a wide spectrum of biological actions. These include its anti-inflammatory, antioxidant, anti-carcinogenic, anti-mutagenic, anticoagulant, antifertility, anti-diabetic, antibacterial, antifungal, antiprotozoal, antiviral, anti-fibrotic, anti-venom, antiulcer, hypotensive and hypocholesteremic activities. Modern interest on turmeric started in 1970's when researchers found that the herb may possess anti-inflammatory and antioxidant properties. Safety evaluation studies indicate that both turmeric and curcumin are well tolerated at a very high dose without any toxic effects. Thus, turmeric and its constituents have the potential for the development of modern medicine for the treatment of various diseases.

INTRODUCTION: Turmeric has also been used for centuries in Ayurvedic medicine, which integrates the medicinal properties of herbs with food. This extraordinary herb has found its way into the spotlight in the west and rest of globe, because of its wide range of medicinal benefits. Use of turmeric dates back nearly 4000 years to the Vedic culture in India. It is extensively used in Ayurveda, Unani and Siddha medicine as home remedy for various diseases [1, 2]. Turmeric, derived from the rhizomes of *Curcuma longa*, (family- Zingiberaceae) is a perennial plant having short stem with large oblong leaves, and bears ovate, pyriform or oblong rhizomes, which are often branched and brownish-yellow in colour.

Turmeric a native of South-East Asia, is used as a food additive (spice), preservative and colouring agent in Asian countries including China, Bangladesh and South East Asia. It is primarily cultivated in China, Taiwan, Sri Lanka, Bangladesh, Burma (Myanmar), Nigeria, Australia, West Indies, Peru, Jamaica and some other Caribbean and Latin American countries.

Accounting for about 78 percent of world turmeric production, India is the largest producer of turmeric [3]. It is also the biggest consumer and exporter of turmeric. Turmeric is considered as auspicious and is a part of religious rituals. In old Hindu medicine, it is extensively used for the treatment of sprain and swelling caused by injury.

In recent times, traditional India medicine uses turmeric powder for the treatment of biliary disorders, anorexia, coryza, cough, diabetes, wounds, hepatic disorders, rheumatism and sinusitis etc [4].

Chemical Composition of Turmeric: Also known as 'Haridra' or 'Haldi', turmeric contains protein (6.3%), fat (5.1%), minerals (3.5%), carbohydrates (69.4%) and moisture (23.1%) The essential oil (5-8%) obtained by steam distillation of rhizomes has α-phellanderene (1%), sabiene (0.6%), cineol (1%), borneol (0.5%), zingiberene (25%) and sesquiterpines (53%) [5]. Curcumin is the principal curcuminoid of turmeric. The other two are desmethoxycurcumin and bis-desmethoxycurcumin. Curcumin gives yellow colour to turmeric and is now recognized as being responsible for most of the therapeutic effects. It is estimated that 2-5% of turmeric is curcumin. Curcumin was first isolated from turmeric in 1815 and the structure was delineated in 1910 as diferuloylmethane [6].

Most currently available preparation of curcumin contains approximately 77% diferuloylmethane, 18% desmethoxycurcumin and 5% bis-desmethoxy curcumin. Curcumin is hydrophobic in nature and frequently soluble in dismethylsulfoxide, acetone, ethanol and oils. It has absorption maxima around 425nm. When exposed to acidic conditions, the colour of turmeric/curcumin turns from yellow to deep red, and the form in which it is used in various religious ceremonies [7].

A World of Turmeric: Turmeric, a golden spice, had been used by the people of the Indian subcontinent for centuries with no known side effects, not only as a component of food but also to treat a wide variety of ailments. As far as documented evidence, it is used daily in India for at least 6000 years as a medicine, beauty aid, cooking spice, a dye and a lot more.

Turmeric was mentioned in the writings of Marco Polo concerning his 1280 journey to China and India and it was first introduced to Europe in the 13th century by Arab traders. Vasco de Gama, a Portuguese sailor during 15th century, after his visit to India, truly introduced spices to the West [8]. For at least 1000 years Chinese Medicine has used Turmeric especially for the Spleen, Stomach, and Liver Meridians.

They use it to stimulate and strengthen the blood, to purify, to decrease blood pressure, to reduce abdominal pain, anti-biotic, anti-viral and an analgesic. Because of its colour and taste, turmeric was named "Indian saffron" in Europe. Today, India is the primary exporter of turmeric (known as "haldi" in India).

Although its ability to preserve food through its antioxidant mechanism, to give colour to food and to add taste to the food is well known, its health promoting effects are less well recognized or appreciated. It was once considered a cure for jaundice, an appetite suppressant and a digestive [9]. In Indian and Chinese medicines, turmeric was used as anti-inflammatory agents to treat gas, colic, toothaches, chest pains, and menstrual difficulties. This spice was also used to help with stomach and liver problems, to heal wounds and lighten scars and as a cosmetic.

Healing Properties Overview: Besides flavouring food, turmeric, affectionately called as "Kitchen Queen", has been used in traditional medicine as a household remedy for various diseases, including biliary disorders, anorexia, cough, diabetic wounds, hepatic disorders, rheumatism and sinusitis etc. Turmeric has been shown to have a wide spectrum of biological actions. These include its anti-inflammatory, antioxidant, ant carcinogenic, ant mutagenic, anticoagulant, anti-fertility, anti- diabetic, antibacterial, antifungal, anti-protozoal, antiviral, anti-fibrotic, antivenin, antiulcer, hypotensive and hypocholesteremic activities [10, 11, 12].

Its anticancer effect is mainly mediated through induction of apoptosis. It's anti-inflammatory, anticancer and antioxidant roles may be clinically exploited to control rheumatism, carcinogenesis and oxidative stress-related pathogenesis. Therapeutic uses include: AIDS/HIV, anaemia, cancer, diabetes, digestion, food poisoning, gall stones etc. It reduces fevers, diarrhoea, urinary disorders, insanity, poisoning, cough and lactation problems in general [11]. Clinically, turmeric has already been used to reduce post-operative inflammation. Safety evaluation studies indicate that both turmeric and curcumin are well tolerated at a very high dose without any toxic effects. Thus, turmeric has the potential for the development of modern medicine for the treatment of various diseases.

Turmeric as First Aid: Researches has shown turmeric as haemostatic, able to stop the bleeding of wound and a vulnerary, a great healer of wounds due to being both anti-inflammatory and anti-microbial [12, 13]. Turmeric powder has healing effect on both aseptic and septic wounds in rats and rabbits [14].

The Skin's Beautician: Turmeric is a skin's food: it purifies and nourishes the blood and results in healthy and glowing skin. Due to its anti-bacterial and anti-septic properties it is excellent for skin diseases like eczema, acne, skin cancers etc. and helps in preventing premature ageing. Turmeric is used in the formulation of cosmetics and sunscreens [15, 16].

Pain and Inflammation: Inflammation is generally regarded as a source of many health challenges. Turmeric is an excellent anti-inflammatory herb; easing conditions such as bursitis, arthritis, back pain etc and plays an important role in inflammation [17]. The anti-inflammatory action of turmeric includes lowering histamine levels and increasing the production of natural cortisone by adrenal glands. It inhibits release of the pro-inflammatory cytokine TNF-α and the gene that makes inflammatory COX-2 enzymes.

Perhaps Turmeric's most important anti-inflammatory mechanism is its effects on the Prostaglandins (PGs), a large family of potent lipids produced by the body. PG1 and PG3 calm the body while PG2 inflames the body. Turmeric is a potent inhibitor of cyclooxygenase 5-lipoxygenase and also 5-HETE production in neutrophils. Reducing these enzymes means less arachidonic acid metabolism, which means less PG2, which means less pain and inflammation [18]. In patients, undergoing surgery, oral application of turmeric reduces post-operative inflammation [19].

Blood, Liver, Heart and Respiratory System: Turmeric is a potent blood purifier and helps to create new blood. Turmeric also protects liver from toxins and pathogens. It is known to destroy major hepatoxins, like aflatoxin and to rebuild the liver. Turmeric increases the secretion of bile promotes bilification and may prevent cholehithiasis. Turmeric also removes cholesterol from the liver and inhibits its assimilation. Turmeric's protective effect on the heart (cardiovascular system) include lowering cholesterol and triglyceride levels decreasing susceptibility of low density lipoproteins (LDL) to lipid peroxidation and inhibiting platelet aggregation. Turmeric protects against heart diseases by lowering high blood cholesterol level and by preventing blood clotting which can lead to heart attack and stroke [20, 21].

Inhibition of platelets aggregation by *C. longa* constituents is thought to be via potentiation of prostacyclin synthesis and inhibition of thrombin synthesis. Besides these, support of the respiratory system is one of the main traditional uses of Turmeric. As an anti-oxidant it protects the lungs from pollution and toxins. It also helps the oxygen transfer from the lungs to the blood.

The Awesome Anti-Oxidant: The antioxidant activity of turmeric was reported [22] as early as 1975. It acts as a scavenger of oxygen free radicals [23]. It can protect haemoglobin from oxidation [24]. Water- and fat-soluble extracts of turmeric and curcumin, its main active constituent, exhibits strong antioxidant activity, comparable to vitamins C, E and Beta-Carotene. Oxidation by free radicals is linked with accelerated aging and virtually every major chronic disease including atherosclerosis, cancer, cardiovascular diseases, cataracts, and rheumatoid arthritis. *In vitro*, curcumin can significantly inhibit the generation of reactive oxygen species (ROS) like superoxide anions, H_2O_2 and nitrite radical generation by activated macrophages [25].

An *in vitro* study measuring the effect of curcumin on endothelial heme oxygenase-1, an inducible stress protein, was conducted utilizing bovine aortic endothelial cells [26]. Incubation (18 hours) with curcumin resulted in enhanced cellular resistance to oxidative damage. Reactive oxygen species (ROS) also play an important role in cell mediated cytotoxicity (CMC) of the immune system. Numerous reports indicate that turmeric could mediate both pro-oxidant and antioxidant roles, making turmeric usage a consumer choice for feeling and looking young; preventing premature ageing; cancer and tumours prevention, liver protection, removing oxidized cholesterol thereby preventing heart attacks; reducing pain and acute (injuries) and chronic inflammations (arthritis) [27, 28].

Turmeric for Stomach and Intestine: And pathogens Constituents of *Curcuma longa* exert several protective effects on the Gastro-Intestinal (GI) system. Sodium curcuminate inhibited intestinal spasm and p-tolymethylcarbinol, a turmeric component, increased gastrin, secretin, bicarbonate, and pancreatic enzyme secretion. Turmeric has also been shown to inhibit ulcer formation caused by stress, alcohol, indomethacin, pyloric ligation, and reserpine, significantly increasing gastric wall mucus in rats subjected to these gastrointestinal insults. Research has also confirmed the digestive benefits of turmeric [29].

Turmeric acts as a cholagogue, stimulating bile production, thus, increasing the bodies' ability to digest fats, improving digestion and eliminating toxins from the liver. Turmeric powder has beneficial effect on the stomach. It increases mucin secretion in rabbits and may thus act as gastro-protectant against irritants. Curcumin has some good effects on the intestine also. Antispasmodic activity of sodium curcuminate was observed in isolated guinea pig ileum [30].

Curcumin also enhances intestinal lipase, sucrase and maltase activity [31]. Turmeric is traditionally used for weak stomachs, poor digestion, dyspepsia, to normalize metabolism, to help digest protein, and to increase the bio-availability of food and the ability of the stomach to withstand digestive acids. Turmeric reduces the intensity of cysteamine-induced duodenal ulcers, increases the gastric wall mucus, and also normalizes gastric juices [32].

Ears, Eyes, Nose and Mouth: Due to its astringent, anti-biotic and anti-inflammatory properties, turmeric is excellent for the toothaches or tooth decay and is used in preparations of toothpastes. It tones the gums and destroys bacteria whose acidic wastes cause cavities. One of the main causes of eye disease, especially cataracts, is the oxidation of lens in your eyes. Turmeric taken internally decreases the oxidation of the lens by causing a significant induction of glutathione-S-transferase isozyme rGST8-8 in the lens epithelium [33]. Turmeric also works efficiently for stopping nosebleeds, helps to clear the sinuses, restore a more acute sense of smell, and helps to purify the mind and brain.

Data are also available showing that turmeric powder is used in Indian and Chinese medicines for treating cough, sputum, sinusitis, dyspnoea, toothaches, ear and eye pains etc [34].

Antifertility activity and Female Reproductive System: Petroleum ether and aqueous extracts of turmeric rhizomes show 100% antifertility effect in rats when fed orally [35]. Implantation is completely inhibited by these extracts [36]. Curcumin inhibits 5*a*-reductase, which converts testosterone to 5*a*-dihydrotesto-sterone, thereby inhibiting the growth of flank organs in hamster [37].

Curcumin also inhibits human sperm motility and has the potential for the development of a novel intravaginal contraceptive [38]. Turmeric regulates menses, decreases intensity and pain of periods, decreases amenorrhea and decreases uterine tumors. Turmeric is a mild and supportive uterine stimulant.

Antimicrobial activity of Turmeric: Turmeric extract and the essential oil of *Curcuma longa* inhibit the growth of a variety of bacteria, parasites, and pathogenic fungi. The aqueous extract of turmeric rhizomes has antibacterial effects [39]. Both curcumin and the oil fraction suppress growth of several bacteria like *Streptococcus*, *Staphylococcus*, *Lactobacillus*, etc.[40]. Ether and chloroform extracts and oil of *C. longa* have antifungal effects [41]. Crude ethanol extract also possesses antifungal activity [41].

Turmeric oil is also active against *Aspergillus flavus*, *A. parasiticus*, *Fusarium moniliforme*. The ethanol extract of the rhizomes has anti-*Entamoeba histolytica* activity. Curcumin has anti-*Leishmania* activity *in vitro* [42]. Several synthetic derivatives of curcumin have anti-*L. amazonensis* effect [43]. Anti-*Plasmodium falciparum* and anti-*L. major* effects of curcumin have also been reported [42]. Turmeric has been shown to have antiviral activity [10, 44]. It acts as an efficient inhibitor of Epstein-Barr virus (EBV) key activator Bam H fragment z left frame 1 (BZLF1) protein transcription in Raji DR-LUC cells [44].

EBV inducers such as 12-0-tetradecanoylphorbol-13-acetate, sodium butyrate and transforming growth factor-beta increase the level of BZLF1 m-RNA at 12–48 h after treatment in these cells, which is effectively blocked by curcumin [45].

Most importantly, curcumin also shows anti-HIV (human immunodeficiency virus) activity by inhibiting the HIV-1 integrase needed for viral replication [46]. It also inhibits UV light induced HIV gene expression [47]. Thus curcumin and its analogues may have the potential for novel drug development against HIV.

Turmeric for Nervous disorders, Detox and Immunity: Curcumin, active constituent of turmeric, can bind with heavy metals such as cadmium and lead, thereby reducing the toxicity of these heavy metals. This property of curcumin explains its protective action to the brain. Curcumin acts as an inhibitor for cyclooxygenase, 5-lipoxygenase and glutathione S-transferase. Curcumin and manganese complex of curcumin offer protective action against vascular dementia by exerting antioxidant activity [48].

Turmeric is one of the 10 best herbs used to treat poisoning and to purify blood. It detoxifies the body and mind, helping the body to cure itself. One sure sign of this is that it increases the level of the enzyme glutathione S-transferase (GST), which is essential to detoxification. In addition it helps beautify the skin and improve the complexion, promoting circulation and nutrition to the surface of the body. It vitalizes the body's own natural healing energy through its action of strengthening digestion and circulation, and aiding in the regulation of all bodily systems.

Turmeric with its potent anti-microbial and anti-oxidant activities interferes with the ability of microbes and viruses to replicate them and it increases body's Immune system's ability to fight the infection and ultimately helps in enhancing the immunity of body. Curcumin can also help the body fight off cancer should some cells escape apoptosis. When researchers looked at the lining of the intestine after ingestion of curcumin, they found that CD4+ T-helper and B type immune cells were greater in number [49].

In addition to this localized immune stimulation, curcumin also enhances immunity in general. Researchers in India have documented increased antibodies and more immune action in mice given regular turmeric dosages.

Turmeric for Diabetes: Turmeric is an important herb in most Ayurvedic treatments of diabetes as it lowers blood sugar, increases glucose metabolism and potentate's insulin activity more than three-fold. Part of the action might be due to its chromium content. Curcumin prevents galactose-induced cataract formation at very low doses [50]. Both turmeric and curcumin decrease blood sugar level in alloxan-induced diabetes in rat [51]. Curcumin also decreases advanced glycation end products induced complications in diabetes mellitus [52].

Turmeric vs. Cancer: Turmeric/ curcumin act as a potent anti-carcinogenic compound and were recently nominated by the National Cancer Institute for study. Induction of apoptosis plays an important role in its anti-carcinogenic properties. Curcumin induces apoptosis, inhibits cell cycle progression and finally prevents cancerous cell growth. The mechanism responsible for apoptosis (programmed cell death) involves inhibition of cell signaling pathway genes like Akt, NF-kB, AP 1 and DNA damage.

Turmeric inhibits the Topoisomerase enzyme, which is required for the replication of cancer and parasite cells. It strongly inhibits DNA and RNA synthesis and increases mitochondrial membrane permeability; a very significant property in the apoptosis of proliferating cells. It can also prevent proliferation by cell cycle arrest in the G2/M phase in a variety of malignant tumors.

G2/M arrest renders cells more susceptible to the cytotoxic effects of radiation, suggesting that curcumin may find significance as a radio sensitizer [53]. The ability to inhibit COX-2 gene overexpression, which is implicated in the carcinogenesis of many different tumors, has suggested a plausible role of curcumin to protect children against leukaemia. Curcumin was shown to induce apoptosis among leukaemia B lymphoma cells and inhibits the multiplication of leukaemia cells in laboratory studies [54].

Earlier research conducted at the University of Texas, M.D. Anderson Cancer Centre has shown that curcumin an active compound of turmeric can also inhibit Cytochrome P450, a phase I metabolizing iso-enzyme which is required for toxic chemicals such as heterocyclic amines to induce DNA adduct formation leading to carcinogenesis [55] and on the other hand to activate phase II metabolizing enzymes generally regarded as favourable detoxifiers, implies its strong

promise as a possible safe and nontoxic chemo preventive and/or treatment agent for colon, skin, stomach, liver, lung, duodenum, soft palate and breasts cancers [56]. Furthermore, curcumin can enhance cancer cells' sensitivity to certain drugs commonly used to combat cancer and can potentially improve the effectiveness of radiation treatment.

For example, IFN-Gamma chemotherapy was found to be effective against non-small cell lung cancer, which was relatively insensitive in the absence of curcumin. Another study reported that curcumin could protect animals from the tumour-producing effects of deadly gamma radiation and it protects against damaging ultraviolet light, which is known to play a role in the development of skin cancer. Ayurveda especially recommends turmeric for cancers of the female reproductive system, namely breast and uterine cancer.

Even if one was going the allopathic route to treat their cancer, they can still use turmeric to increase the effectiveness and decrease some of the side effects of cancer treatments. The efficacy of turmeric to decrease cell viability, cell cycle arrest and induction of apoptosis is encouraging to the development of a natural drug with known Nuke-B inhibitory activity[57]. In short, turmeric is an example of a natural dietary agent capable of acting at multi levels in cellular pathway for the prevention or treatment of diseases with multifactorial etiologies such as colon, skin, stomach, liver, lung duodenum, soft palate and breast cancer [58].

CONCLUSION: It is a wonder that a natural yellow pigment, turmeric, which has been consuming in India since the second millennium BC in both medicine and food has become one of the most cited natural molecule in terms of its capacity to deliver a multitude of health guarding effects as studied and established by modern scientific community around the globe. For the last few decades, extensive work has been done to establish the biological activities and pharmacological actions of turmeric and its extracts. It has been used in ayurvedic medicine since ancient times, with various biological applications. Various studies are in progress for using turmeric in drug-development. Although the crude extract has numerous medicinal applications, clinical applications can be made only after extensive research on its bioactivity, mechanism of action, pharmacotherapeutics and toxicity studies.

However, as turmeric and its compounds show a wide spectrum of biological activities, it would be easier to develop new drugs from turmeric after extensive studies on its mechanism of action and pharmacological effects. Recent years have seen an increased enthusiasm in treating various diseases with natural products.

Turmeric/Curcumin is a non-toxic, highly promising natural antioxidant, spice having a wide spectrum of biological functions. It is expected that turmeric and its constituents specially curcumin and essential oils may find application as a novel drug in the near future to control various diseases, including inflammatory disorders, carcinogenesis, HIV/AIDS, diabetes, oxidative stress-induced pathogenesis and a lot more.

All of these studies should further add to the usefulness of turmeric and its constituents specially curcumin and essential oil. Overall, due to its usage, biological safety, combined with its cost and efficacy, and thousands of years of experimentation justify calling turmeric "The Golden Spice of Life".

REFERENCES:

1. Chattopadhyay I, Biswas K, Bandyopadhyay U, and Banerjee RK: Turmeric and curcumin: Biological actions and medicinal applications. *Curr* Sci. 2004; 87: 44–50.
2. Abas F, Lajis NH, Shaari K, Israf DA, Stanslas J, Yusuf UK, and Raof SM: A labdane diterpene glucoside from the rhizomes of *Curcuma longa*. *J Nat Prod*.; 2005; 68: 1090-1093.
3. Deepa KM: The Golden Spice. Market Survey, Facts for You; 2007; 51: 45-46.
4. Syu WJ, Shen CC, Don MJ, Ou JC, Lee GH and Sun CM: Cytotoxicity of curcuminoids and some novel compounds from *Curcuma zedoaria*. *J Nat* Prod.; 1998; 61: 1531–1534.
5. Tohda C, Nakayama N, Hatanaka F, and Komatsu K: Comparison of anti-inflammatory activities of six curcuma rhizomes:Apossible curcuminoid-independent pathway mediated by *Curcuma phaeocaulis* extract. *Evid Based Complement Alternat* Med.; 2006; 3: 255–260.
6. Mohammad M, Lajis NH, Abas F, Ali AM, Sukari MA, Kikuzaki H and Nakatani N: Antioxidative constituents of *Etlingera elatior*. *J Nat Prod*.; 2005; 68:285–288.
7. Dechatowongse T: Isolation of constituents from the rhizome of plai (*Zingiber cassumunar* Rpxb.). *Bull Dept Med Sci.;* 1976; 18: 75-79.
8. Akram M, Shahab-Uddin, Khan AA, Chani U, Hanan A, Mohiuddin E and Asif M: *Curcuma longa* and Curcumin- A review article. Rom. J. Biol- Plant Biol; 2010; 55: 65-72.
9. Aggarwal BB, Sundram C, Malani N and Ichikawa H: Curcumin-The Indian Solid Gold. Current Science; 2010; 332: 16-34

10. Araujo AC and Leon LL: Biological activities of *Curcuma longa* L. *Mem*. *Inst*. *Oswaldo Cruz*.; 2001; 96: 723–728.

11. Kapoor LD: *Handbook of Ayurvedic Medicinal Plants*, CRC Press, Boca Raton, Florida; 1990; 2: 185-187.
12. Gujral ML, Chowdhury NK and Saxena PN: The effect of certain indigenous remedies on the healing of wounds and ulcers. J. Indian State Med. Assoc.; 1953; 22: 273-276.
13. Gopinath D, Ahmed MR, Gomathi K, Chitra K, Sehgal PK and Jayakumar R: Dermal wound healing processes with curcumin incorporated collagen films. *Biomaterials*; 2004; 25: 1911-1917.
14. Sidhu GS, Mani H, Gaddipati JP, Singh AK, Seth P, Banaudha KK, Patnaik GK and Maheshwari SK: Curcumin enhances wound healing in streptozotocin induced diabetic rats and genetically diabetic mice. Wound Repair Regen*;* 1999; 7**:** 362–374.
15. Saikia AP, Ryakala VK, Sharma P, Goswami P and Bora U: Ethnobotany of medicinal plants used by Assamese people for various skin ailments and cosmetics. J Ethnopharmacol; 2006; 106: 149–157.
16. Phan TT, See P, Lee ST, and Chan SY: Protective effects of curcumin against oxidative damage on skin cells in vitro: its implication for wound healing. J Trauma; 2001; 51: 927–931.
17. Surh YJ, Chun KS, Han HH, Keum SS, Park YS, and Lee SS: Molecular mechanism underlying chemopreventive activities of anti-inflammatory phytochemicals: down regulation of COX-2 and iNOS through suppression of NF-*k*B activation. Mutat. Res.; 2001; 48: 243–268.
18. Chainani-Wu N: Safety and anti-inflammatory activity of curcumin: a component of turmeric (*Curcuma longa*). J. Altern.Complement Med.; 2003; 9: 161–168.
19. Brouet I and Ohshima H: Curcumin, an antitumor promoter and anti-inflammatory agent, inhibits induction of nitric oxide synthase in activated macrophages. Biochem. Biophys. Res. Commun.; 1995; 206: 533–540.
20. Chan AT, Manson JE, Albert CM, Chae CU, Rexrode KM, Curhan GC, Rimm EB, Willett WC and Fuchs CS: Nonsteroidal anti-inflammatory drugs, acetaminophen, and the risk of cardiovascular events. Circulation; 2006; 113: 1578–1587.
21. Dogne JM, Hanson J, Supuran C and Pratico D: Cardiovascular side effects: from light to shadow. Curr Pharm Des; 2006; 12: 971–975.
22. Vajragupta O, Boonchoong P, Watanabe H, Tohda M, Kummasud N and Sumanont Y: Manganese complexes of curcumin and its derivatives: evaluation for the radical scavenging ability and neuroprotective activity. Free Radic. Biol. Med.; 2003; 35: 1632– 1644.
23. Ruby AJ, Kuttan G, Dinesh BK, Rajasekharan KN and Kuttan R: Antitumor and antioxidant activity of natural curcuminoids. Cancer Lett.; 1995; 94: 79–83.
24. Akrishnan VR and Menon VP: Potential role of antioxidants during ethanol-induced changes in the fatty acid composition and arachidonic acid metabolites in male Wistar rats. Cell Biol. Toxicol.; 2001; 17: 11–22.
25. Mahakunakorn P, Tohda M, Murakami Y, Matsumoto K, Watanabe H and Vajragupta O: Cytoprotective and cytotoxic effects of curcumin: dual action on H2O2 induced oxidative cell damage in NG108-15 cells. Biol. Pharm. Bull.; 2003; 26: 725–728.
26. Lim GP, Chu T, Yang F, Beech W, Frantschy SA and Cole GM: The curry spice curcumin reduces oxidative damage and amyloid pathology in an Alzheimer transgenic mouse. J. Neurosci.; 2001; 21: 8370–8377.
27. Ammon HPT and Wahl MA: Pharmacology of *Curcuma longa*. Planta Med.; 1991; 57: 1–7.
28. Biswas TK and Mukherjee B: Plant medicines of Indian origin for wound healing activity: A review. Int J Low Extrem Wounds; 2003; 2: 25-39.
29. Bhavani Shankar TN and Sreenivasa MV: Effect of turmeric (Curcuma longa) fractions on the growth of some intestinal and pathogenic bacteria in vitro. Indian J. Exp. Biol.; 1979; 17: 1363–1366.
30. Platel K and Srinivasan K: Influence of dietary spices or their active principles on digestive enzymes of small intestinal mucosa in rats. Int. J. Food Sci. Nutr.; 1996; 47: 55–59.
31. Cream GP; Shearman DJ and Small WP: Diseases of the digestive system. In Davidsons Principles and Practice of Medicine (ed. Macleod, J.) The English Language Book Society and Churchill Livingstone, Edinburgh; 11; 1974: 456.
32. Pulla RA and Lokesh BR: Effect of dietary turmeric (*Curcuma longa*) on iron-induced lipid peroxidation in the rat liver. Food Chem. Toxicol.; 1994; 32: 279–283.
33. Chaudhri KR: Turmeric, haldi or haridra, in eye diseases. Antiseptic; 1950; 47: 67-68.
34. Suryanarayana P, Krishnaswamy K and Reddy GB: Effect of curcumin on galactose-induced cataractogenesis in rats*. Mol. Vis.;* 2003; 9: 223–230.
35. Garg SK: Effect of Curcuma longa (rhizomes) on fertility in experimental animals. Planta Med.; 1974; 26: 225–227.
36. Garg SK, Mathur VS and Chaudhury RR: Screening of Indian plants for antifertility activity. Indian J. Exp. Biol.; 1978; 16: 1077–1079.
37. Rithaporn T, Monga M and Rajasekharan M: Curcumin: a potential vaginal contraceptive. Contraception; 2003; 68: 219–223.
38. Liao S, Lin J, Dang MT, Zhang H, Kao YH, Fukuchi J and Hiipakka RA: Growth suppression of hamster flank organs by topical application of catechins, alizarin, curcumin and myristoleic acid. Arch. Dermatol. Res.; 2001; 293: 200–205.
39. Banerjee A and Nigam SS: Antimicrobial efficacy of the essential oil *of Curcuma longa*. Indian J. Med. Res.; 1978; 68: 864–866.
40. Kumar S, Narain U, Tripathi S and Misra K: Synthesis of curcumin bioconjugates and study of their antibacterial activities against beta-lactamase-producing microorganisms. Bioconjug. Chem.; 2001; 12: 464–469.
41. Jayaprakasha GK, Negi PS, Anandharamakrishnan C and Sakariah KK: Chemical composition of turmeric oil – a by-product from turmeric oleoresin industry and its inhibitory activity against different fungi. *Z*. Naturforsch.; 2001; 56: 40–44.
42. Koide T, Nose M, Ogihara Y, Yabu Y and Ohta N: Leishmanicidal effect of curcumin *in vitro*. Biol. Pharm. Bull.; 2002; 25: 131–133.
43. Gomes DC; Alegrio LV, Lima ML, Leon LL and Araujo CS: Synthetic derivatives of curcumin and their activity against *Leishmania amazonensis*. Arzneimittelforschung; 2002; 52: 120–124.
44. De Clercq E: Current lead natural products for the chemotherapy of human immunodeficiency virus (HIV) infection. Med. Res. Rev; 2000; 20: 323–349.
45. Taher MM, Lammering G, Hershey C and Valerie K: Curcumin inhibits ultraviolet light induced human immunodeficiency virus gene expression. Mol. Cell Biochem; 2003; 254: 289–297.
46. Hergenhahn M, Soto U, Weninger A, Polack A, Hsu CH, Cheng AL and Rosl F: The chemopreventive compound curcumin is an efficient inhibitor of Epstein-Barr virus BLZF1 transcription in Raji DR-LUC cells. Mol. Carcinogen; 2002; 33: 137– 145.
47. Mazumdar A, Raghavan K, Weinstein J, Kohn KW and Pommer Y: Inhibition of human immunodeficiency virus type-1 integrase by curcumin. Biochem. Pharmacol; 1995; 49: 1165–1170.

48. Thiyagarajan M and Sharma SS: Neuroprotective effect of curcumin in middle cerebral artery occlusion induced focal cerebral ischemia in rats. Life Sci.; 2004; 74: 969–985.
49. Sreejayan N and Rao MN: Free radical scavenging activity of curcuminoids. Arzneimittelforschung; 1996; 46: 169-171.
50. Biswas SK, McClure D, Jimenez LA, Megson IL and Rahman I: Curcumin induces glutathione biosynthesis and inhibits NF-kappaB activation and interleukin- 8 release in alveolar epithelial cells: mechanism of free radical scavenging activity. Antioxid Redox Signal; 2005; 7: 32–41.
51. Arun N and Nalini N: Efficacy of turmeric on blood sugar and polyol pathway in diabetic albino rats. Plant Foods Hum. Nutr; 2002; 57: 41–52.
52. Sajithlal GB, Chittra P and Chandrakasan G: Effect of curcumin on the advanced glycation and cross-linking of collagen in diabetic rats. Biochem. Pharmacol; 1998; 56: 1607–1614.
53. Bush JA, Cheung KJ and Lee G: Curcumin induces apoptosis in human melanoma cells through a Fas recep-tor/caspase-8 pathway independent of p53. Exp Cell Res; 2001; 271: 305-314.
54. Cheng AL, Hsu CH and Lin JK: Phase I clinical trial of curcumin, a chemopreventive agent, in patients with high-risk or pre-malignant lesions. Anticancer Res; 2001; 21: 2895-2900.
55. Hour TC, Chen J and Huang CY: Curcumin enhances cytotoxicity of chemotherapeutic agents in prostate cancer cells by inducing p21 (WAF1/CIP1) and C/EBPbeta expressions and suppressing NF-kappa activation. Prostate; 2002; 51: 211-218.
56. Kuttan R, Bhanumathy P, Nirmala K and George MC: Potential anticancer activity of turmeric (*Curcuma longa*). Cancer Lett.; 1985; 29: 197–202.
57. Aggarwal BB, Kumar A and Bharti AC: Anticancer potential of curcumin: preclinical and clinical studies. Anticancer Res.; 2003; 23: 363–398.
58. Jana NR, Dikshit P, Goswami A and Nukina N: Inhibition of proteasomal function by curcumin induces apoptosis through mitochondrial pathway. J. Biol. Chem.; 2004; 279: 11680–11685.

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