WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 7.523
Volume 6, Issue 8, 2489-2503. Review Article ISSN 2277– 7105

PHARMACOLOGICAL PROPERTIES OF TURMERIC – A REVIEW

***J. Nisha[1] and N. Anbu[2]**

[1]PG Scholar, Government Siddha Medical College, Arumbakkam, Chennai – 600106.

[2]Head of the Department, Dept of Maruthuvam, Government Siddha Medical College, Arumbakkam, Chennai.

Article Received on
21 June 2017,

Revised on 11 July 2017,
Accepted on 31 July 2017

DOI: 10.20959/wjpr20178-9218

***Corresponding Author**
J. Nisha
PG Scholar, Government Siddha Medical College, Arumbakkam, Chennai – 600106.

ABSTRACT

Turmeric (Curcuma longa Linn), a nature's precious and most popular Indian spice belonging to the family zingiberaceae is cultivated throughout the Indian sub continent because of its excellent medicinal properties. The rhizomes of the plant have medicinal values. The active constituents of the turmeric are the flavonoids, curcumin (Diferulo Methane) and various volatile oils, which includes zingiberone, tumerone, water and fat soluble extracts of turmeric. The component Curcumin exhibits strong anti-oxidant properties resulting in enhanced cellular resistance to oxidative damage. Extensive research over last fifty years has revealed several important functions of curcumin. Turmeric has been shown with wide spectrum of biological action which includes Anti-mutagenic, Anti-oxidant, Anti-inflammatory, Anti-diabetic, Anti bacterial, Anti viral, Hepatoprotective, Anti-fungal, Anti-protozoal, Anti-ulcer and Analgesic actions. Curcumin has the ability to inhibit carcinogenesis at three stages, namely tumour promotion, angiogenesis and tumour growth. Curcumin is also used topically to counteract inflammation and irritation associated with inflammatory skin conditions and allergies. This review focuses on the medicinal and pharmacological treatment of diseases with the medicinal values of turmeric.

KEYWORDS: Turmeric, Curcuma longa, Manjal, Hepatoprotective action, Anti-inflammatory action, Anti-diabetic, Anti tumour action.

INTRODUCTION

The Almighty, prior to the creation of mankind had beforehand created the base for all lives the "herb". This beautiful word 'The Herb' has been derived from the Latin word, "herba"

and an old French word “herbe”. These herbs are none but medicinal plants that are used in variety of ways such as food, flavonoid, medicine or perfume and also in certain spiritual activities.

Right from the genesis of mankind plants have always proved to be a life sustainer and had been used for medicinal purposes and life saving purposes. The vitalness of herbs have been vividly depicted even in ancient Siddha, Unani manuscripts and Chinese writings. It is corroborated that for over 4000 years herbs were used as medicine for various healing purposes by Siddha, Indian Vaids, European and Mediterranean cultures.

India has known to be as one of the richest repository of medicinal plants. India’s forests are the greatest resources of a large number of medicinal herbs that are widely used in variety of medicinal fields for the production of medicines and drugs. Of late, WHO (World Health Organization) had reported that all over the globe more than 80 percent of people are totally dependent on natural medicines. The ancient Indian medicine was totally dependent on herbal medicines and true to its reliability the herbal plants exerted their 100% safety. On the whole medicinal plants exhibit a very safe and efficacious treatment with very less or no side effects.

Turmeric (*Curcuma longa)*

Turmeric is a product of Curcuma longa, a rhizomatous herbaceous perennial plant belonging to the ginger family Zingiberaceae, which is native to tropical South Asia. As many as 133 species of Curcuma has been identified worldwide. Almost in all parts of India, where food is greatly respected and rendered importance for its therapeutic properties as for its richness and flavour, every recipe is made successfully completed only with the addition of the fresh roots of this wonderful herb “turmeric”. Right from the head to feet including stomach ailments to cardiovascular problems, this herb individually or grouped together with other herbs has a remedy. This review throws much light on the mysterious healing properties of Turmeric.

Scientific Classification of Turmeric

Kingdom	:	Plantae
Order	:	Zingiberales
Family	:	Zingiberaceae
Genus	:	*Curcuma*
Species	:	*C. longa*
Binomial Name	:	*Curcuma longa*

Geographical Distribution of Turmeric

The native habitat of Turmeric is South and South East Asia. Turmeric is widely distributed in the western coasts of southern parts of India. It is also distributed in Southeast Asia, Malay, China and northern parts of Australia, West Indies and South America. Comparatively India is the largest cultivator of the *C.longa* among all the other countries in the world except for the two countries in Asia i.e., China and Indonesia. From India nearly 50% of the total cultivation is from Andhra Pradesh and Maharastra followed by Tamil Nadu and Kerala.

India produces nearly the world's entire turmeric crop and consumes 80% of it. With its inherent qualities and high content of the important bioactive compound curcumin, Indian turmeric is considered to be the best in the world. Erode, a city in the South Indian state of Tamil Nadu, is the world's largest producer of and the most important trading center for turmeric. It is also known as "Yellow City," "Turmeric City," or "Textile City." Sangli, a city of Maharashtra, is second only to Erode in size and importance as a production and trading site for turmeric.

The predominant habitat for medicinal herb "Turmeric" (Curcuma longa) are the forest regions, in clearings, or on riverbanks and it is also imbibed with a natural feature that is to adapt itself to withstand even during unfavourable drought conditions. It loses its leafy parts and has the adaptability to survive in the dry season as underground rhizomes. Some Curcuma species also produce tuberous roots, which act as an additional store of food and water.

Thus the fruits of turmeric ripen underneath the ground. The leafy shoots may grow high in the air from three to five metres height. The flowers are brightly coloured and the slender flower tubes are compacted with nectar. The butterflies aids in the pollination process of this plant. The life span of the flowers are too short, may be lasting only a few hours.

The turmeric plant needs temperatures between 20°C and 30°C and a considerable amount of annual rainfall to thrive. Individual plants grow to a height of 1 m, and have long, oblong leaves. Plants are gathered annually for their rhizomes, and are reseeded from some of those rhizomes in the following season. The rhizome, from which the turmeric is derived, is tuberous, with a rough and segmented skin. The rhizomes mature beneath the foliage in the ground. They are yellowish brown with a dull orange interior. The main rhizome is pointed or

tapered at the distal end and measures 2.5–7.0 cm (1–3 inches) in length and 2.5 cm (1 inch) in diameter, with smaller tubers branching off. When the turmeric rhizome is dried, it can be ground to a yellow powder with a bitter, slightly acrid, yet sweet, taste.

Medicinal value

Turmeric (*Curcuma longa*) 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. For the last few decades, endeavoured labour has been exercised to make a deep impact about the manifold biological activities and pharmacological effects of turmeric and its extracts in the society. It is found that a wide spectrum of biological present is available in Curcumin (diferuloylmethane), the main yellow bioactive component of turmeric. The pharmacological properties such as antivenom, antiulcer anticarcinogenic, antimutagenic, anticoagulant, hypotensive and hypocholesteremic activities, antifertility, antidiabetic, antibacterial, antifungal, antiprotozoal, antiviral, anti inflammatory, antioxidant, antifibrotic are observed. Turmeric aggrevates the anticancer effect by mediating through apoptosis induction.[1] Its antiinflammatory, anticancer and antioxidant roles may be clinically exploited to control rheumatism, carcinogenesis and oxidative stress-related pathogenesis. Clinically, curcumin 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, both turmeric and curcumin have the potential for the development of modern medicine for the treatment of various diseases.[2]

Anti inflammatory property of Turmeric

Tumor promotion being intertwined to proinflammatory states is a well known and vividly understood fact.[3],[4] Consequently, phytochemicals like curcumin that exert a strong anti inflammatory effect are anticipated to have some degree of chemopreventive activity. Preclinical cancer research using curcumin has shown it inhibits carcinogenesis in a number of cancer types, including colorectal, pancreatic, gastric, prostate, hepatic, breast and oral cancers and leukemia and at various stages of carcinogenesis.[5] The anticarcinogenic potential of curcumin are triggered by the few factors: (1) inhibition of NF-κB and COX-2 (increased levels of COX-2 are associated with many cancer types)[6],[7] (2) inhibition of arachidonic acid metabolism via lipoxygenase and scavenging of free radicals generated in this pathway; (3) decreased expression of inflammatory cytokines IL- 1b, IL-6 and TNF-a,

resulting in growth inhibition of cancer cell lines.[8] and (4) down-regulation of enzymes, such as protein kinase C, that mediate inflammation and tumor-cell proliferation.[9]

Turmeric possess a huge variety of molecular targets that renders it great potential as a therapeutic agent for a variety of inflammatory conditions and cancer types. Consequently, there is extensive interest in its therapeutic potential. In the recent past extensive research works are done regarding the anti-inflammatory property of turmeric in which several ongoing phases II and III clinical trials stands as evidences. Due to the limited systemic bioavailability of curcumin which acts a small hurdle in using *curcumin longa* for its anti-inflammatory property researchers have fixed their minds in investigating a number of different curcumin compounds and analogs that may be more effective and better absorbed. Successful and promising results from the so far accomplished clinical trials are revitalizing and forthwith trials being conducted for both inflammatory conditions and cancer vividly renders curcumin's value as a therapeutic agent and confirms some of the mechanisms responsible for its efficacy.[10]

Composition of Turmeric

Nearly, 100 components have been isolated from turmeric till date. The prime component of the root is a volatile oil, containing turmerone, and there are other coloring agents called curcuminoids in turmeric. Curcumin was first isolated in 1815 and its chemical structure was determined by.[11] It has a melting point at 176–177°C; forms a reddish-brown salt with alkali and is soluble in ethanol, alkali, ketone, acetic acid and chloroform. Curcuminoids consist of natural antioxidants curcumin demethoxycurcumin, 5'-methoxycurcumin and dihydrocurcumin.[12][13] Curcuminoids belong to the group of diarylheptanoids (or diphenylheptanoids) having an aryl-C7-aryl skeleton.[14] Turmeric contains protein (6.3%), fat (5.1%), minerals (3.5%), carbohydrates (69.4%) and moisture (13.1%). The essential oil (5.8%) obtained by steam distillation of rhizomes has a-phellandrene (1%), sabinene (0.6%), cineol (1%), borneol (0.5%), zingiberene (25%) and sesquiterpines (53%).[15] Curcumin (diferuloylmethane) (3–4%) is responsible for the yellow colour, and comprises curcumin I (94%), curcumin II (6%) and curcumin III (0.3%).[16] Demethoxy and bisdemethoxy derivatives of curcumin have also been isolated].[17]

In a standard form, turmeric contains moisture (>8%), curcumin (5–6.9%), extraneous matter (<0.5% by weight), mould (<3.5%) and volatile oils (<3.8%). Volatile oils include d-α-phellandrene, d-sabinene, cinol, borneol, zingiberene and sesquiterpenes (Ohshiro,

Kuroyanag, and Keno 1990.[18] There are a variety of sesquiterpenes, like germacrone; termerone; ar-(+)-, α- and β-termerones; β-bisabolene; α-curcumene; zingiberene; β-sesquiphellanderene; bisacurone; curcumenone; dehydrocurdione; procurcumadiol; bis-acumol; curcumenol; isoprocurcumenol; epiprocurcumenol; procurcumenol; zedoaronediol; and curlone, many of which are specific for a species. The components responsible for the aroma of turmeric are turmerone, arturmerone and zingiberene. The rhizomes are also reported to contain four new polysaccharides-ukonans along with stigmasterole, β-sitosterole, cholesterol and 2-hydroxymethyl anthraquinone.[19], [20] Nutritional analysis showed that 100 g of turmeric contains 390 kcal, 10 g total fat, 3 g saturated fat, 0 mg cholesterol, 0.2 g calcium, 0.26 g phosphorous, 10 mg sodium, 2500 mg potassium, 47.5 mg iron, 0.9 mg thiamine, 0.19 mg riboflavin, 4.8 mg niacin, 50 mg ascorbic acid, 69.9 g total carbohydrates, 21 g dietary fiber, 3 g sugars and 8 g protein.[21]

Antimicrobial properties of Turmeric

Right from the time of old many medicinal plants have stood as a proof of an excellent source of antimicrobial agents.[23] In the countryside regions many plant components are used as a traditional medicine which are readily available and relatively cheaper than modern medicine.[24] Plants generally produce many Secondary metabolites (compound related to groups like phenol, alkaloid, terpenoids, glycosides, etc.) are the usual compounds produced by the plants which constitute an important source of microbicides, pesticides, fungicides and many pharmaceutical drugs. Plant products still remain the principle source of pharmaceutical agents used in traditional medicine.[25] Member of Zingiberaceae family are found to be a rich source of substances of phytochemical interest. They are rich in curcuminoids, and recognized for their broad spectrum of biological activities, curcuminoids vary in chemical structures, physico-chemical characteristics as well as the functional properties.[26] Numbers of plants from this family are used in traditional system of medicine because of its wide spectrum of pharmacological activities.[27] Many species of Curcuma longa are traditionally used for their medicinal properties. In many literatures antifungal, antibacterial and anti inflammatory activity has been reported for species such as *Curcuma longa*, *Curcuma zedoaria*, *Curcuma aromatica* and *Curcuma amada*.[28] [29] From ancient time most people use the rhizome of these plants use as a traditional medicine due to their medicinal effect.[30] Fungi and bacteria are significant destroyers of food stuffs and produced various types of diseases in human. The Gram-positive bacteria such as Staphylococcus aureus and Bacillus subtilis are mainly responsible for post-operative wound infection, toxic

shock syndrome and food poisoning. The Gram-negative bacterium such as Pseudomonas aeruginosa is present in human lung, urinary track and kidney; causes lower urinary tract infection, inflammation and sepsis.[31]

Also the toxic effects produced by Aspergillus includes carcinogenicity, genotoxicity, terratogenicity, nephrotoxicity, hepatotoxicity, reproductive disorders and immune suppression[32] Candida albicans is a diploid fungus that grows both as yeast and filamentous cells and a causal agent of opportunistic oral and genital infections in human.[33],[34]

Other Medicinal properties of Turmeric

Curcumin has exhibited a powerful scavenger of oxygen free radicals. Its antioxidant activity is comparable to vitamins C and E.[35] It can protect lipids or hemoglobin from oxidation. It can significantly inhibit the generation of reactive oxygen species (ROS) such as H2O2, superoxide anions and nitrite radical generation by activated macrophages. Its derivatives, bisdemethoxycurcumin and demethoxycurcumin also have antioxidant activities.[4]

Curcumin pre-treatment has been shown to decrease ischemia-induced oxidative stress and changes in the heart.[36] An in vitro study measuring the effect of curcumin on an inducible stress protein, resulted in enhanced cellular resistance to oxidative damage.[37]

Cardioprotective effects

Turmeric exerts cardio-protective effects mainly by antioxidant activity, lowering lipid peroxidation, antidiabetic activity and inhibiting platelet aggregation. A study of 18 atherosclerotic rabbits given 1.6-3.2 mg/kg/day of turmeric extract demonstrated decreased susceptibility of LDL to lipid peroxidation, in addition to lower plasma cholesterol and triglyceride levels. Turmeric effect on cholesterol levels may be due to decreased cholesterol uptake in the intestines and increased conversion of cholesterol to bile acids in the liver. Inhibition of platelet aggregation by turmeric constituents is thought to be via potentiation of prostacyclins synthesis and inhibition of thromboxane synthesis.[38]

Gastrointestinal effects

Turmeric exerts several protective effects on the gastrointestinal tract. Turmeric also inhibits ulcer formation caused by stress, alcohol, Indomethacin, reserpine, pyloric ligation, increasing gastric wall mucus in rats subjected to these gastrointestinal insults. It also inhibits intestinal spasm and increases bicarbonate, gastrin, secretin and pancreatic enzyme secretion.

An open, phase II trial performed on 25 patients with endoscopically-diagnosed gastric ulcer, given 600 mg powdered turmeric five times daily, showed complete recovery in 48 percent of patients. No adverse reactions or blood abnormalities were recorded.[39] Curcumin reduced mucosal injury in mice with experimentally induced colitis. Ten days prior to induction of colitis, with 1, 4, 6-trinitrobenzene sulphonic acid, administration of 50 mg/kg curcumin resulted in a significant reduction of diarrhea, neutrophil infiltration and lipid peroxidation in colonic tissue. Also all indicators inflammation were reduced and the symptoms improved.[40] In rat models of experimentally-induced pancreatitis, curcumin was able to decrease inflammation. In cerulean or ethanol induced pancreatitis, curcumin was also able to inhibit the inflammatory mediators, resulted in amelioration in disease severity as measured by histology, pancreatic trypsin, serum amylase, and neutrophil infiltration.[41]

Anti-cancer effect

Numerous animal studies have explored turmeric influence on the carcinogenesis. Several studies have demonstrated that curcumin is able to inhibit carcinogenesis at three stages: angiogenesis, tumor promotion, and tumor growth. In two studies of colon and prostate cancer, curcumin was shown to inhibit cell proliferation and tumor growth. Turmeric and curcumin are also able to suppress the activity of several common mutagens and carcinogens. The anticarcinogenic effects of turmeric and curcumin have been related to direct antioxidant and free-radical scavenging effects, as well as their ability toindirectly increase glutathione levels, thereby aiding in hepatic detoxification of mutagens and carcinogens and inhibiting nitrosamine formation. Curcumin has also been shown to inhibit the mutagenic induction effect of UV rays.[42-46]

Among various mechanisms, induction of apoptosis plays an important role in its anticarcinogenic effect. It induces apoptosis and inhibits cell-cycle progression, both of which are instrumental in preventing cancerous cell growth in rat aortic smooth muscle cells.[47] The antiproliferative effect is mediated partly through inhibition of protein tyrosine kinase and c-myc mRNA expression and the apoptotic effect may partly be mediated through inhibition of protein tyrosine kinase, protein kinase C, c-myc mRNA expression and bcl-2 mRNA expression91. Curcumin induces apoptotic cell death by DNA-damage in human cancer cell lines, TK-10, MCF-7 and UACC-62 by acting as topoisomerase II poison.[48] In an animal study, rheumatoid arthritis induced by streptococcal cell wall, intraperitoneal injection of turmeric extract containing 4 mg total curcuminoids/kg/day for four days prior to

induction of arthritis, inhibited joint inflammation in both acute (75%) and chronic (68%) phases. To test the efficacy of an oral preparation, a 30-fold higher dose of the curcuminoid preparation, given to rats four days prior to arthritis induction, reduced joint inflammation by 48%.[49]

Curcumin suppresses human breast carcinoma through multiple pathways. Its antiproliferative effect is estrogendependent in ER (estrogen receptor)-positive MCF-7 cells and estrogen-independent in ER-negative MDA-MB-231 cells.[50] Curcumin also downregulates matrix metalloproteinase (MMP)-2 and upregulates tissue inhibitor of metalloproteinase (TIMP)-1, two common effector molecules involved in cell invasion It also induces apoptosis through P53-dependent Bax induction in human breast cancer cells[52] However, curcumin affects different cell lines differently. Whereas leukaemia, breast, colon, hepatocellular and ovarian carcinoma cells undergo apoptosis in the presence of curcumin.[51]

Curcumin also suppresses tumour growth through various pathways. Nitric oxide (NO) and its derivatives play a major role in tumour promotion. Curcumin inhibits iNOS and COX-2 production[53] by suppression of NFkB activation[54] Curcumin also increases NO production in NK cells after prolonged treatment, culminating in a stronger tumouricidal effect[55] Curcumin also induces apoptosis in AK-5 tumour cells through upregulation103 of caspase-3. Reports also exist indicating that curcumin blocks dexamethasone induced apoptosis of rat thymocytes[56] [57] Recently, in Jurkat cells, curcumin has been shown to prevent glutathione depletion, thus protecting cells from caspase-3 activation and oligonucleosomal DNA fragmentation.[58]

Anti-diabetic potential

In a research study conducted by Lekshmi *et al*, the turmeric extracts were screened for their inhibitory activity against α-glucosidase and α-amylase enzymes and the Turmeric rhizome extracts showed high potential to inhibit glucosidase activities and glycation reactions. Ethyl acetate, methanol and water extracts of Turmeric inhibited α-glucosidase activity in dose dependent manner with IC50 values 0.4, 3.1 and 12.6 µg/mL. IC50 values obtained for α-amylase inhibitory potential of ethyl acetate, methanol and water extracts were respectively 71.6, 90.3 and 498.3 µg/mL. Under the experimental conditions, the standard glucosidase inhibiting drug acarbose inhibited α-glucosidase and α-amylase enzymes with IC50 values 17.1 and 290.6 µg/mL respectively. Ethyl acetate extract of turmeric had the highest α-glucosidase and α-amylase inhibitory potential among the extracts. Glucose inhibitory

potential of both ethyl acetate and methanol extracts was significantly ($p < 0.05$) higher than those of acarbose. The extracts were also effective in scavenging free radicals and inhibiting LDL and cellular oxidations and ACE activity. The high antidiabetic, Antioxidant and antihypertensive capacities of turmeric rhizome revealed in this research highlighted its potential to serve as a source for preventive and therapeutic agents for the management of diabetes and related disorders.[59]

CONCLUSION

Through this review the pharmacological properties of the single herb Turmeric (Curcuma longa) has been scientifically analyzed and it has proved it to be a golden spice with multimodal action that can be therapeutically used for various ailments. Thus the scientific analysis also confirms the traditional claims of the medicinal value of Turmeric.

ACKNOWLEDGEMENT

The author thankfully acknowledge Dr.K.kanakavalli, M.D.(S), Principal, Government Siddha Medical College, Arumbakkam, Chennai – 600106 for her valuable guidance and support.

REFERENCES

1. Kwon Y, Magnuson BA. Age-related differential responses to curcumin-induced apoptosis during the initiation of colon cancer in rats. Food Chem Toxicol, 2009; 47: 377-385.
2. Chattopadhyay I, Biswas K, Bandyopadhyay U, Banerjee RK. Turmeric and curcumin: Biological actions and medicinal applications. Current science-Bangalore-. 2004; 87: 44-53.
3. Bennett A. The production of prostanoids in human cancers, and their implications for tumor progression. Prog Lipid Res., 1986; 25: 539-542.
4. Qiao L, Kozoni V, Tsioulias GJ, et al. Selected eicosanoids increase the proliferation rate of human colon carcinoma cell lines and mouse colonocytes in vivo. Biochim Biophys Acta, 1995; 1258: 215-223.
5. Aggarwal BB, Kumar A, Bharti AC. Anticancer potential of curcumin: preclinical and clinical studies. Anticancer Res., 2003; 23: 363-398.
6. Surh YJ, Chun KS, Cha HH, et al. Molecular mechanisms underlying chemopreventive activities of anti-inflammatory phytochemicals: down-regulation of COX-2 and iNOS through suppression of NFkappa B activation. Mutat Res., 2001; 480-481: 243- 268.

7. Huang MT, Lysz T, Ferraro T, et al. Inhibitory effects of curcumin on in vitro lipoxygenase and cyclooxygenase activities in mouse epidermis. Cancer Res., 1991; 51: 813-819.
8. Cho JW, Lee KS, Kim CW. Curcumin attenuates the expression of IL-1beta, IL-6 and TNF-alpha as well as cyclin E in TNF-alpha-treated HaCaT cells; NFkappaB and MAPKs as potential upstream targets. Int J Mol Med, 2007; 19: 469-474.
9. Liu JY, Lin SJ, Lin JK. Inhibitory effects of curcumin on protein kinase C activity induced by 12-O-tetradecanoyl-phorbol-13-acetate in NIH 3T3 cells. Carcinogenesis, 1993; 14: 857-861.
10. Jurenka JS. Anti-inflammatory properties of curcumin, a major constituent of Curcuma longa: a review of preclinical and clinical research. Alternative medicine review. 2009; 14: (2). Roughley, P. J. and Whiting, D. A., Experiments in the biosynthesis of curcumin. J. Chem. Soc., 1973; 20: 2379–2388.
11. Ruby, A. J., Kuttan, G., Dinesh Babu, K., Rajasekharan, K. N. and Kuttan, R. Antitumor and antioxidant activity of natural curcuminoids. Cancer Lett., 1995; 94: 79–83.
12. Vopel, G., Gaisbaver, M. and Winkler, W., Phytotherapie in der Praxis. Deutscher Arzteverlag, Kolu, 1990; 74.
13. Remadevi, R.; Surendran, E.; Kimura, T. Turmeric in Traditional medicine. In Turmeric: the genus Curcuma, Ravindran, P. N.; Nirmal Babu, K.; Sivaraman, K., Eds. CRC Press: Boca Raton, London, New York, 2007; 409-436.
14. Kapoor, L. D., Handbook of Ayurvedic Medicinal Plants, CRC Press, Boca Raton, Florida, 1990; 185.
15. Ruby, A. J., Kuttan, G., Dinesh Babu, K., Rajasekharan, K. N. and Kuttan, R. Antitumor and antioxidant activity of natural curcuminoids. Cancer Lett., 1995; 94: 79–83.
16. Vopel, G., Gaisbaver, M. and Winkler, W., Phytotherapie in der Praxis. Deutscher Arzteverlag, Kolu, 1990; 74.
17. Ohshiro M, Kuroyanag M, Keno A. Structures of sesquiterpenes from Curcuma longa. Phytochemistry. 1990; 29: 2201–5.
18. Kapoor L. D. Handbook of Ayurvedic Medicinal Plants. Boca Raton, FL: CRC Press; 1990.
19. Kirtikar K. R, Basu B. D. Blatter E, Caius J. F, Mhaskar K. S. Indian Medicinal Plants. 2nd Ed. Vol II. Lalit Mohan Basu, Allahabad, India: 1993; 1182.

20. Balakrishnan K. V. Postharvest technology and processing of turmeric. In: Ravindran P. N, Nirmal Babu K, Sivaraman K, editors. Turmeric: The Genus Curcuma. Boca Raton, FL: CRC Press; 2007; 193–256.
21. Goud V. K, Polasa K, Krishnaswamy K. Effect of turmeric on xenobiotic metabolising enzymes. Plant Foods Hum Nutr. 1993; 44: 87–92.
22. Mahesh B and Satish S. Antimicrobial Activity Of Some Important Medicinal Plant Against Plant And Human Pathogens. World Journal of Agricultural Science, 2008; 4(S): 839-843.
23. Rashedul I M, Ahamed R, Rahman M O, Akbar M A, Al-Amin M, Alam K D, Lyzu F. In Vitro Antimicrobial Activities of Four Medicinally Important Plants in Bangladesh", European Journal of Scientific Research, 2010; 39(2): 199-206.
24. Srinivasan D, Nathan S T, Suresh and Perumalsamy P, Lakshmana. ntimicrobial Activity Of Certain Indian Medicinal Plants Used In Folkloric Medicine, Journal of Ethnopharmacology, 2001; 74: 217-220.
25. Revathy S, Elumalai S, Merina B and Benny A. Isolation, Purification and Identification of Curcuminoids from Turmeric (Curcuma longa L.) by Column Chromatography", Journal of Experimental Sciences, 2011; 2(7): 21-25.
26. Anand P, Thomas S G, Kunnumakkara A B et al. Biological Activities of Curcumin And Its Analogues (Congeners) Made by Man And Mother Nature, Biochemical pharmacology, 2008; 76: 1590-1611.
27. Apisariyakul A, Vanittanakom N and Buddhasukh D. Antifungal Activity of Turmeric Oil Extracted from Curcuma longa (Zingiberaceae), Journal of Ethnopharmacology, 1995; 4: 163-169.
28. Yoshioka T E, Fujii M, Endo K, Wada Y, Tokunage N, Shiba H, Hohsho H, Shibuya and Muraki T. Antiflammatory Potency Of Dehydrocurdione, A Zedoaryderived Sesquiterpene, Inflammation Research, 1998; 47: 476-481.
29. Wibowo M, Deasywaty and Tepy U, Antimicrobial and identification of active compound Curcuma xanthorrhiza Roxb. International Journal of Basic & Applied Sciences IJBAS-IJENS, 2012; 12(1): 69-78.
30. Nascimento G F, Locatelli Juliana, Freitas Paulo C and Silva Giuliana L, Antibacterial Activity Of Plant Extracts And Phytochemicals On Antibioticresistant Bacteria. Brazilian Journal of Microbiology, 2008; 31: 247-256.

31. Satish, S, Mohana, D C, Ranhavendra, M P and Raveesha, K A. Antifungal Activity Of Some Plant Extracts Against Important Seed Borne Pathogens of Aspergillus sp., Journal of Agricultural Technology, 2007; 3(1): 109-119.
32. Enfert C and Hube B. (Eds.). Candida: Comparative and Functional Genomics, Caister Academic Press, 2007; ISBN 978-1-904455-13-4.
33. Harit J, Barapatre A, Prajapati M, Aadil KR, Senapati S. Antimicrobial activity of rhizome of selected Curcuma variety. International Journal of Life Sciences Biotechnology and Pharma Research. 2013; 2(3): 183-9.
34. Ammon HP, Anazodo MI, Safayhi H, Dhawan BN, Srimal RC. Curcumin: A potent inhibitor of leukotriene B4 formation in rat peritoneal polymorphonuclear neutrophils (PMNL). Planta Med, 1992; 58: 226.
35. Ammon HP, Wahl MA. Pharmacology of Curcuma longa. Planta Med, 1991; 57: 1-7.
36. Bernard GT, Esteban P, Christopher JS. Turmerones: Isolation from turmeric and their structure determination. Chem Commun, 1982; 6: 363.
37. Nasri H, Shahinfard N, Rafieian M, Rafieian S, Shirzad M, Rafieian M. Turmeric: A spice with multifunctional medicinal properties. Journal of Herb Med Pharmacology. 2014; 3(1).
38. Khajehdehi P. Turmeric: Reemerging of a neglected Asian traditional remedy. J Nephropathol, 2012; 1(1): 17-22.
39. Perkins S, Verschoyle RD, Hill K, Parveen I, Threadgill MD, Sharma RA, et al. Chemopreventive efficacy and pharmacokinetics of curcumin in the min/+ mouse, a model of familial adenomatous polyposis. Cancer Epidemiol Biomarkers Prev, 2002; 11: 535-40.
40. Kwon Y, Magnuson BA. Age-related differential responses to curcumin-induced apoptosis during the initiation of colon cancer in rats. Food Chem Toxicol, 2009; 47: 377-85.
41. Rao CV, Rivenson A, Simi B, Reddy BS.Chemoprevention of colon carcinogenesis by dietary curcumin, a naturally occurring plant phenolic compound. Cancer Res., 1995; 55: 259-66.9.
42. Shpitz B, Giladi N, Sagiv E, Lev-Ari S, Liberman E, Kazanov D, et al. Celecoxib and curcumin additively inhibit the growth of colorectal cancer in a rat model. Digestion, 2006; 74: 140-4. 10.
43. Perkins S, Verschoyle RD, Hill K, Parveen I, Threadgill MD, Sharma RA, et al. Chemopreventive efficacy and pharmacokinetics of curcumin in the min/+ mouse, a

model of familial adenomatous polyposis. Cancer Epidemiol Biomarkers Prev, 2002; 11: 535-40.11.

44. Kwon Y, Magnuson BA. Age-related differential responses to curcumin-induced apoptosis during the initiation of colon cancer in rats. Food Chem Toxicol, 2009; 47: 377-85.
45. Zeng Y, Qiu F, Takahashi K, Liang J, Qu G, Yao X. New sesquiterpenes and calebin derivatives from Curcumalonga. Chem Pharm Bull (Tokyo), 2007; 55: 940-3.
46. Chen, H. W. and Huang, H. C., Effect of curcumin on cell cycle progression and apoptosis in vascular smooth cells. Br. J. Pharmacol., 1998; 124: 1029–1040.
47. Martin-Cordero, C., Lopez-Lazaro, M., Galvez, M. and Ayuso, M. J. Curcumin as a DNA topoisomerase II poison. J. Enzyme Inhib. Med. Chem., 2003; 18: 505–509.
48. Shpitz B, Giladi N, Sagiv E, Lev-Ari S, Liberman E, Kazanov D, et al. Celecoxib and curcumin additively inhibit the growth of colorectal cancer in a rat model. Digestion, 2006; 74: 140-4. 10.
49. Shao, Z. M., Shen, Z. Z., Liu, C. H., Sartippour, M. R., Go, V. L., Heber, D. and Nguyen, M. Curcumin exerts multiple suppressive effects on human breast carcinoma cells. Int. J. Cancer, 2002; 98: 234–240.
50. Choudhuri, T., Pal, S., Aggarwal, M. L., Das, T. and Sa, G. Curcumin induces apoptosis in human breast cancer cells through p53- dependent Bax induction. FEBS Lett, 2002; 512: 334–340.
51. Choudhuri, T., Pal, S., Aggarwal, M. L., Das, T. and Sa, G. Curcumin induces apoptosis in human breast cancer cells through p53- dependent Bax induction. FEBS Lett., 2002; 512: 334–340.
52. 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.
53. Surh, Y. J., Chun, K. S., Cha, H. H., Han, S. S., Keum, Y. S., Park, K. K. and Lee, S. S. Molecular mechanism underlying chemopreventiveactivities of anti-inflammatory phytochemicals: down regulationof COX-2 and iNOS through suppression of NF-kB activation. Mutat. Res, 2001; 480–481, 243–268.
54. Bhaumik, S., Jyothi, M. D. and Khar, A. Differential modulationof nitric oxide production by curcumin in host macrophages and NK cells. FEBS Lett, 2000; 483: 78–82.

55. Sikora, E., Bielak-Zmijewska, A., Piwocka, K., Skierski, J. and Radziszewska, E. Inhibition of proliferation and apoptosis of human and rat T lymphocytes by curcumin, a curry pigment. Biochem. Pharmacol, 1997; 54: 899–907.
56. Jaruga, E., Bielak-Zmijewska, A., Sikora, E., Skierski, J., Radziszewska, E., Piowcka, K. and Bartosz, G. Glutathione-independent mechanism of apoptosis inhibition by curcumin in rat thymocytes. Biochem. Pharmacol., 1998; 56: 961–965.
57. Piwocka, K., Jaruga, E., Skierski, J., Gradzka, I. and Sikora, E. Effect of glutathione depletion on caspase-3 independent apoptosis pathway induced by curcumin in Jurkat cells. Free Radic. Biol. Med., 2001; 31: 670–678.
58. Piwocka, K., Jaruga, E., Skierski, J., Gradzka, I. and Sikora, E. Effect of glutathione depletion on caspase-3 independent apoptosis pathway induced by curcumin in Jurkat cells. Free Radic. Biol. Med., 2001; 31: 670–678.
59. Lekshmi PC, Arimboor R, Nisha VM, Menon AN, Raghu KG. In vitro antidiabetic and inhibitory potential of turmeric (Curcuma longa L) rhizome against cellular and LDL oxidation and angiotensin converting enzyme. Journal of food science and technology. 2014; 51(12): 3910-7.