ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES
Knowledge to Innovation

Vol 6, Issue 3, 2013

ISSN - 0974-2441

Review Article

TURMERIC: NATURE'S PRECIOUS MEDICINE

DUGGI SHRISHAIL[1], HANDRAL HARISH K[2], HANDRAL RAVICHANDRA[3], G.TULSIANAND[4] AND S.D. SHRUTHI [5]

[1]Department of Plant Breeding and Genetics, College of Agriculture, Vellayani Thiruvananthapuram, Kerala, India. [2] Discipline of Oral Sciences, Faculty of Dentistry, National University of Singapore, Singapore. [3]Department of Orthodontics and Dentofacial Othropaedics, P.M.N.M Dental College and Hospital, Bagalkot, Karnataka, India. [4]Department of Biochemistry, A M C college, Bangalore, Karnataka, India. [5]Department of Biotechnology, The Oxford college of Science, Bangalore, Karnataka, India. Email- hkhandral@gmail.com

Received: 23 January 2013, Revised and Accepted: 18 February 2013

ABSTRACT

Ethanobotany is a recent branch of natural science dealing with various aspects such as anthropology, archeology, botany, ecology, economics and medicine, religious, cultural and several other disciplines. Recently, great interest is given to studies of herbal drugs and traditional remedies are indicated worldwide and there has been an upsurge in the scientific investigations in area. Although turmeric (Curcuma longa and *Curcuma aromatica* Salisb.) has been described in Ayurveda, as treatment inflammatory diseases and is referred by different names in different cultures, active principle called Curcumin or diferuloylmethane, a yellow pigment present in turmeric (curry powder) has been shown to exhibit numerous activities. Extensive research over last fifty years has revealed several important functions of curcumin. The present study was aimed to review the ethanobotanical properties, pharmacognostic, phytochemical and pharmacological properties of turmeric plant. Root part of the plant are widely used by different tribal communities as turmeric have been shown to have wide spectrum of biological actions, which include anti-inflammatory, anti-diabetic, analgesic, antibacterial, anti-fungal, anti-protozoal, anti-ulcer, hypocholesteremic activities. Its anti-cancer effect induced mainly mediated through induction of apoptosis and many more medicinal values.

Keywords: Curcuma aromatica Salisb. Ethanobotany, kasthuri turmeric, Pharmacognosy, Phytochemistry, Pharmacology.

INTRODUCTION

Kasthuri turmeric (Curcuma aromatica Salisb.) belonging to the family Zingiberaceae is a medicinal and aromatic plant with multiple uses. Turmeric is known as the "golden spice" as well as the "spice of life." It has been used in India as a medicinal plant, and held sacred from time immemorial. Turmeric has strong associations with the socio-cultural life of the people of the Indian subcontinent. This "earthy herb of the Sun" with the orange-yellow rhizome was regarded as the "herb of the Sun" by the people of the vedic period. No wonder the ancients regarded turmeric as the Oushadhi , the healing herb, the most outstanding herb, the one herb above all others (Jager P de, 1997). Turmeric has at least 6000 years of documented history of its use as medicine and in many socio-religious practices. Turmeric is probably a native of South East Asia, where many related species of curcuma occur wildly, though turmeric itself is not known to occur in the wild. Turmeric is cultivated most extensively in India, followed by Bangladesh, China, Thailand, Cambodia, Malaysia, Indonesia, and Philippines. On a small scale, it is also grown in most tropical regions in Africa, America, and Pacific Ocean Islands. India is the largest producer, consumer and exporter of turmeric. Several commercially produced cosmetics and ayurvedic preparations contain kasthuri turmeric. Skin care is the major domain of application of this aromatic plant. Rhizome of Curcuma aromatica is also used in medicines as a stomachic, carminative and emmenogogue for skin diseases and recently as a health food in Japan (Kojima et al. 1998). Considering the world demand for organic food, the improvement of soil health and productivity and the availability of local resources, the organic farming practice can be encouraged. Our farmers can take advantage of this opportunity presently available in the international market by offering organically produced spice, aromatic and medicinal products. Use of bio-fertilizers for crop production is gaining momentum as they are environmentally safe when compared to chemical fertilizers. Though organic manures have beneficial effects on soil health and crop productivity, their limited nutrient content and requirement in large quantity is a constraint for their wider usage. Dwindling availability and huge cost of bulky chemical manures warrants the need for reducing their quantity through appropriate substitutes. As a cost effective supplement to chemical fertilizers and as a renewable energy source, microbial inoculants can economize the high investment needed for fertilizer usage of N and P (Pandey and Kumar, 2002). Microbial inoculants like Azospirillum, Phosphobacteria and Arbuscular Mycorrhizal Fungi (AMF) are capable of enhancing the fertilizer use efficiently, soil fertility status and thus help in improving the yield and quality of crops.

Taxonomy

Kingdom- Plantae
Class- Liliospida
Sub class- Commelinids
Order- Zingiberales
Family- Zingiberaceae
Genus- Curcuma
Species- Curcuma longa

The wild turmeric is called C.aromatica and domestic species is called C.longa.

Various names

Name in international language	Name in regional language
Spanish- Curcuma	English- Turmeric
French- Curcuma, Saffron des Indes	Hindi- Haldi
German- Kurkuma gelbwruzel	Bengali- Holud
Swedish- Gurkmeja	Gujarathi- Haldi
Burmese- fanwin	Kannada- Arishina
Arabic- Kurkum	Malayalam- Halad
Dutch- Geelwortel	Sindhi- Halda
Thai- Kamin	Punjabi- Haldhor, Haldhar
Indonesian- Kunjit, Kunyit	Tamil- Manjal
Italian- Curcuma	Telugu- Pasupu
Chinese- Yu.chin	Sanskrit-Haladi,Haridra, Harita

Ethanobotany

The genus *Curcuma* L.(Zingiberaceace) contains many taxa of economic, medicinal, ornamental and cultural importance. Throughout the world India stands as largest producer of turmeric (93.3% of the total world production) and its cultivation is done in 150000 hectares in India. (Satishkumar B, 2005). Turmeric covers 6% of the total area under the spices in the country, which are mainly used for domestic purpose as condiment and occupies. Only 8% of the total production is exported annually and the rest is consumed in the domestic market. Maximum area under turmeric is in Andhra Pradesh followed by Maharashtra, Tamil Nadu, Orissa, Karnataka and Kerala. The genus *Curcuma L*. (Zingiberaceace) contains many taxa which are economically important as food, condiment and as coloring, medicinal and ornamental materials (Skorniekova J, *et al.* 2004). It is found throughout the South and South East Asia with a few species extending to China, Australia and South Pacific. The highest diversity is concentrated in India and Thailand, with atleast 40 species in each area, followed by Myanmar, Bangladesh, Indonesia and Vietnam. Due to lack of a comprehensive taxonomic revision, still there is little consensus on the number of species that should be recognized. Recent species may vary from 503 to 80 species. (Larsen K. *et al*. 1998). Their number will probably reach 120 in the near future due to ongoing detailed botanical exploration of India and South East Asia. (Skorniekova J, *et al.* 2004). The genus exhibit wide variations at intra and inter-specific levels. Turmeric having anti-inflammatory, hypocholestraemic, choleratic, anti-microbial, insect repellent, anti-rheumatic, anti-fibrotic, anti-venomous, anti-diabetic, anti-viral, anti-hepatotoxic as well as anti-cancerous properties in day to day domestic use as a folk lore medicine from time immemorial. With curcumin, oleoresin oil and other complex compounds it is lately gaining importance as potential source of drugs for various ailments. Turmeric oil is used as aromatherapy and in perfume industry apart from religious, cultural uses. (Sopher DE, 1964).It is being as an inseparable part of Ayurvedic system of medicine in India and China. (Satishkumar B, 2005). Many authors are attempting to collect the information to provide a comprehensive ethanobotanic treatment on turmeric in India with special reference to its use in medication based on the information available in literatures along with those collected by the authors. The first evidences of the use of turmeric, known as *Haridra,* are found in *Atharvaveda* (a collection of Vedas and mantras) and it was considered a curative drug for skin disease, graying of hair, and for charming away jaundice. In Tibetan medicine also, the term "Haridra" is given for turmeric. Turmeric is bitter in taste and its action is "pungent-like" after digestion and metabolism. Being hot, light, acrid, and irritant, it is able to reduce corpulence; stimulate all functions, and clear channels. The use of turmeric as a spice, a dye, or a cosmetic is well known the world over. Turmeric has got a wide range of activities, properties, and uses as per the ancient traditional medicine texts, some of which are as aromatic, stimulant, tonic, carminative, and anthelmintic. It is effective in treating liver obstruction and dropsy, is externally used for ulcers and inflammation, cures flatulence, dyspepsia, anorexia, intermittent fevers, prurigo, eczema, sprain, bruises, wounds, inflammatory troubles of joints, small pox, chicken pox, catarrhal and purulent ophthalmia, conjunctivitis, cough, ring worm and other parasitic skin diseases, piles, common cold, catarrh, coryza, hysterical fits, relieves pain in scorpion sting, chronic otorrhoea, reduces indolent swellings, and is used in the treatment of urinary diseases, leucoderma, diseases of blood, bad taste in mouth, elephantiasis, diarrhea, bronchitis, vertigo, and gonorrhea, (Nadkarni 1976; Kritikar and Basu 1984). It is intellect-promoting (*Sayana*), antidote for snake venom (*Kausika Sutra)*, in cardiac complaints and jaundice (*Atharvaveda samhita*). has made an exhaustive list of the known and reported uses of turmeric in the treatment of illnesses. Turmeric is indicated against a variety of health problems and pathological conditions and used traditionally by a large number of ethnic communities in a variety of conditions. Some of the properties are well documented and validated by pharmacological and clinical trials, while many remain to be validated. (Duke JA. 2003) It was compiled that 114 biological properties of turmeric from the USDA database. (Jager P de, 1997) In Chinese medicine, turmeric rhizomes and tubers (root tubers) are used for different purposes. Turmeric rhizome is said to be a "blood" and *Qi* (vital energy) stimulant, with analgesic properties. It is used to treat chest and abdominal pain and distention, jaundice, frozen shoulder, amenorrhea due to blood stasis, and postpartum abdominal pain due to stasis. It is also used for injuries (Chang and But, 1987). The "tuber" has properties more or less similar, but is used in hot conditions as it is more cooling and has been used to treat viral hepatitis (Bensky and Gamble, 1986).

Other uses of turmeric in traditional system

- It is an essential substance to purify the gum resin of *Commiphora mukul* (Guggul) before it is made use of in ayurvedic formulations.
- Turmeric powder is mixed with the latex of *Snuhi* (*Euphorbia nerifolia*) plant and is then coated over the surgical thread repeatedly. This thread is known as *Ksharasoothra* , which is tied on piles and fistula to cure them effectively.
- In veterinary medicine, turmeric is used to heal wounds or ulcers of animals.
- In "leech therapy," turmeric powder is sprinkled over the leech to detach it from the biting site. Again turmeric powder is added to the water, in which the leech is kept, to make it vomit the sucked blood.
- Turmeric powder is used as an insect and ant repellant and sprinkled around the vessels to be protected.
- Turmeric is included in the group of yellow substances (*Peethavarga*) in *Rasa sastra* (Alchemy), used in the processing of mercury.

PHYTOCHEMISTRY

The phytochemical screening of petroleum ether extract, benzene extract, chloroform extract, acetone extract, methanol extract, ethanol extract and water extract was performed. Among which ethanolic extract yield (2.35%) was investigated for its anti-fertility activity. Presence of alkaloids, carbohydrates, glycosides, phytosterols, saponins, gums and mucilage in various extracts were observed. Some tests were conducted to confirm the presence of phyto-constituents in the plant extracts. Test for alkaloids was conducted by using Mayer's reagent, upon which addition to petroleum ether, chloroform, ethyl acetate, alcohol and water extracts separately showed the formation of white or cream colored precipitates which confirms the presence of alkaloids. No phenolic compounds were found which was confirmed by adding few drops of 5% lead acetate solution to alcoholic extracts. Flavonoids were absent which was confirmed by no change in color of filter paper upon dipping in ammoniated alcoholic and aqueous extracts. Saponins were considered to present when petroleum extracts and benzene extracts showed honey comb like frothing after giving a shake with sodium bi-carbonate. After performing the Millon's, Biuret's and Ninhydrin's test showed the absence of proteins and amino acids. When the petroleum extracts, benzene extracts , methanol extracts, ethanol extracts and water extracts were given a shake with chloroform and few drops of acetic anhydride along with few drops of sulphuric acid from the side tube forms the blue to brick red color formation confirms the presence of Phytosterols. (Trishna D *et al.* 2010). The major constituents, curcumin (diferulolmethane) is in the most important faction of *Curcuma longa,* which melts at 1760 C to 1770C and forms red-brown salts with alkalis. Curcumin is soluble in ethanol, alkalis, ketone, acetic acid and chloroform; and insoluble in water. In the molecule of curcumin, main chain is aliphatic chain, unsaturated and aryl group can be substituted or not. The main chemical components are Curcumin (60%), desmethoxycurcumin, monodemethoxycurcumin, bisdemethoxycurcumin, dihydrocurcumin andcyclocurcumin. By the oxidation of curcumins vanillin can be yielded. The essential oil (5.8%) obtained by steam distillation of rhizomes has a- phelladrene (1%), sabinene (0.6%), Cineol (1%), borneol (0.5%), Zingiberene (25%) and sesquiterpines (53%) (Ishita C, *et al.* 2004). (Song EK, 2001). Curcumin (diferuloylmethane) (3-4%) is responsible for yellow color and comprises of curcumin I (94%), curcumin II (6%) and curcumin III (0.3%). Demethoxy and bis-demethoxy derivatives of curcumin have also been isolated (Kotwal GJ, 2005).

PHARMCOLOGICAL ACTIVITIES

In vitro studies

Healing property, skin care

Oil of turmeric and its ether and chloroform extracts have proved to be antifungal, anti-protozoan, antiviral, and antibacterial (Chattopadhyaya *et al.* 2004). In a screening for antibiotic property, turmeric showed broad-spectrum antibacterial activity (Omoloso and Vagi, 2001). Turmeric oil obtained as a by-product from curcumin manufacture was subjected to antibacterial study and found effective against *Bacillus cereus*, *Bacillus coagulans, Bacillus subtilis, Staphylococcus aureus, Escherichia coli,* and *Pseudomonas aeruginosa*. (Negi *et al.* 1999).

Anti-helminthic Property

Alcoholic extract of rhizomes was found to have anti-protozoal activity against *Entamoeba histolytica* (Dhar et al. 1968). Curcumin has anti-leishmania activity. (Koide et al. 2002)

Anti-cancerous

It is now proved that the antioxidants present in turmeric neutralize carcinogenic free radicals. It is evaluated and proved the anticancer activity of turmeric. (Kuttan *et al*. 1985). The antioxidant and antitumor-promoting effects of curcumin were shown to be due to the induction of apoptosis in human leukemia cells, and this aspect was studied and positively proved (Kuo *et al.* 1996). Supporting investigation on the specific inhibitory effect of cyclooxygenase (cox) - 2 by dietary curcumin in human colon cancer cells. (Goel *et al.* 2001). Curcumin has showed a suppressive effect on human breast carcinoma cells.(Shao *et al.*2002 and Choudhari *et al.* 2002).

Biomedical applications of Turmeric

Curcumin (diferuloylmethane), a polyphenol, is a low molecular-weight active principle of the perennial herb *Curcuma longa* (commonly known as turmeric). Recent evidence suggests that curcumin is a highly pleotropic molecule that interacts physically with its diverse range of molecular targets including transcription factors, growth factors and their receptors, cytokines, enzymes, and genes regulating cell proliferation and apoptosis. Curcumin possesses antioxidant, anti-inflammatory, anticarcinogenic, and antimicrobial properties, and suppresses proliferation of a wide variety of tumor cells. Several clinical trials dealing with cancer have addressed the pharmacokinetics, safety, and efficacy of curcumin in humans. (Ammon HP and Wahl MA, 1999). Despite extensive research and development, poor solubility of curcumin in aqueous solution remains a major barrier in its bioavailability and clinical efficacy. Being hydrophobic in nature, it is insoluble in water but soluble in ethanol, dimethylsulfoxide, and acetone. To increase its solubility and bioavailability, attempts have been made through encapsulation in liposomes, polymeric and lipo-NPs, biodegradable microspheres, cyclodextrin, and hydrogels. (Ratul Kumar D, *et al.* 2010). In recent years, various controlled delivery forms, such as polymeric micro/nanospheres, liposomes, micelles, parenteral emulsion, and prodrugs have been investigated to increase its solubility, to minimize the side effects as well as to avoid the use of toxic adjuvant (Gang R, 2003). Recent studies suggested preparation of a novel nanocomposites formulation, i.e. biodegradable chitosan-alginate (CS-ALG) nanocomposites incorporated with medical clay, Cloisite 30B called CS-ALG/ C 30 B nanocomposites, for oral chemotherapy by using curcumin as a prototype drug due to its excellent therapeutic effects against a wide spectrum of cancers and its great commercial success as the best seller among various anticancer agents. The composites have been characterized using XRD, FTIR and SEM techniques. The kinetics of the drug delivery system has been reported. (Vijay Kumar M, *et al.* 2011). The cancer stem cell hypothesis asserts that malignancies arise in tissue stem and/or progenitor cells through the dysregulation or acquisition of self-renewal. (Al-Hajj M, *et al.* 2004). If the cancer stem cell hypothesis is valid, then strategies aimed at targeting stem cell self-

renewal pathways represent rational approaches for cancer prevention. One such pathway is the Wnt signaling pathway which is dysregulated in breast cancer, as well as many other malignancies. This suggests that the protective effects of curcumin might be due to Wnt inhibition of self-renewal in breast stem/progenitor cells (Lindvall C, et al, 2007). Although the development of specific pharmacologic Wnt inhibitors has proved a challenge, there is evidence that curcumin, a dietary phenol found in spices, is able to down regulate the Wnt signaling pathway. (Park CH, *et al*, 2006). Interestingly, there is substantial evidence in preclinical models that curcumin is a potent chemopreventive dietary agent. (Bachmeier B, *et al*. 2007)

In vivo studies

Analgesic action

The powdered rhizome is effective in the treatment of sprain and inflammation (Khare, 2000) Turmeric paste mixed with a little lime and saltpeter and applied hot is a popular application to sprains (Nadkarni, 1976).

Anti-inflammatory action

Inflammatory changes of joints are often associated with rheumatic complaints. Turmeric is attributed with hot potency and anti-inflammatory action. It cures the etiological factors and pathological changes of inflammation. The anti-inflammatory activity of curcumin was first reported in 1971 (Srimal et al. 1971). It was further reported that oral doses of curcumin possess significant anti-inflammatory action in both acute and chronic animal models. Curcumin had been proved to be safe in human trials and had demonstrated anti-inflammatory activity. (Chandra and Gupta 1972). In clinical trials, curcumin was reported to be effective in rheumatoid arthritis. (Deodhar, *et al.* 1980). A clinical trial in eight patients with definite rheumatoid arthritis showed significant improvement in morning stiffness and joint swelling after two week-therapy (Chattopadhyaya *et al.* 2004)

Healing property, skin care

According to Ayurveda, turmeric is *Vranahara* (ulcer healing),*Varnya* (improve complexion), *Tvakdoshahara* (cure skin diseases), and *Kandoohara* (cure itching). Till recently, before the onslaught of synthetic and herbal skin care products in the market, womenfolk were dependent more on turmeric, and they used to smear their bodies with a mixture of turmeric–sandal paste for gaining a golden glow to their skin, (Remadevi and Ravindran, 2005). Turmeric helps to remove hairs and impart colour and improve complexion of skin. Several Sanskrit synonyms of turmeric indicate its color-improving property (such as: *varna-datri* — one who gives color, indicates its use as enhancer of body complexion; *hemaragi* and *hemaragini* — both indicate golden color, meaning that it is used by womenfolk to get a golden complexion; *yoshti priya*, meaning favorite of young women, indicating its use for enhancing beauty; *hridayavilasini*, meaning giving delight to heart, charming; etc.). It is considered as an effective wound-healing medicine and is strongly related to the social customs of India. If a wound occurs as a part of a ritual, only turmeric powder is used for healing. The fresh juice of turmeric is believed to have anti-parasitic property in many skin afflictions. Turmeric powder with cow's urine is given internally also in prurigo and eczema. Turmeric mixed with gingili oil is applied over the body to prevent skin eruptions. A coating of turmeric powder or a thin paste is applied on small pox and chicken pox patients to facilitate the process of scabbing (Nadkarni, 1976). Experimental studies proved that curcumin enhances cutaneous wound healing in rats and guinea pigs by increasing the formation of granulation tissue and biosynthesis of extracellular matrix proteins. Systemic treatment with curcumin in local muscle injury led to faster restoration. (Joe et al. 2004) The bactericidal properties of turmeric have been proved by clinical testing (Khanna, 1999). In an experimental study it is proved significant anti-ulcerogenic activity of the ethanol extract of turmeric in rats. (Rafatullah, *et al.*. 1990). The wound-healing property of turmeric was investigated and observed that turmeric decreased the nitric oxide synthetase (NOS) levels and proved effective in chronic and acute wounds. (Cohly, *et al*. 1999).

Antidiabetic property

From the *Samhita* period itself (ca. 4000 yrs), turmeric was famous for its antidiabetic property. Experimental study reports also prove the efficacy of turmeric in diabetes. (Arun and Nalini 2002). Experimental study on the efficacy of turmeric on blood sugar and polyol pathway in albino rats and found that both turmeric and curcumin decreased blood sugar level in alloxan-induced diabetes. Curcumin was found to be capable of decreasing the complications in diabetes mellitus (Sajithlal et al. 1998). The report suggests that the antidiabetic action of turmeric may be mainly through the vitalization of pancreatic cells and by stimulation of insulin production. The ethanolic extract of turmeric was found to lower blood glucose level when given as injection to experimental rats. The lowering effect was 37.2% after 3 hours and 59.5% after 6 hours.

Anthelmintic property

Turmeric is said to be *Krimihara* (anthelmintic) and *Krimighn*a (destroyer of worms) in Ayurvedic lexicons. The juice of turmeric has anti-helminthic property on internal use. In the rural areas of Nepal, turmeric powder or paste boiled in water with a little common salt is taken as an anti-helminthic (Nadkarni, 1976).

Turmeric in respiratory diseases

Turmeric is well accepted as a *Kaphahara* drug (phlegmatic conditions are termed as "Kapha" and that which cures it is *Kaphahara*). Turmeric is anti-inflammatory and anti-purulent in nature. It is reported that volatile oil of turmeric as oral drug in a clinical trial was found very effective in the treatment of bronchial asthma (Jain JP *et al.* 1990). Fresh rhizome proved effective against whooping cough and other coughs and in dyspnea (Khare, 2000). In catarrh and coryza, the inhalation of burning turmeric fumes causes copious mucous discharge and gives instant relief (Nadkarni, 1976). The root, parched and powdered, is given in bronchitis (Kirtikar and Basu, 1984). A report of clinical trials in respiratory diseases such as bronchial asthma, bronchitis, bronchiectasis, and tropical eosinophilia revealed that turmeric could play a vital role as an adjuvant in improving the airway resistance. Anti-asthmatic property of Curcumin had been tested in guinea pig model. (Ram *et al*. 2003).

Turmeric in urinary disorders

Some recent experimental studies suggested that the administration of Curcumin is a promising approach in the treatment of renal disorders. In Brunes (Darussalam), turmeric rhizome is used to cure urinary infection, as a traditional method. Vangasena (an ancient Ayurvedic expert, who had written his own treatise) that turmeric is good for calculus. (Kolammal, 1979). Curcumin and curcumioids as oral drug to prevent the formation of urinary calculi. The nephroprotective effect of curcumin was analyzed in rats. They studied the effect of curcumin on Adriamycin (ADR)-induced nephrosis in rats and found that the injury was prevented by curcumin treatment. Curcumin protected ADR induced proteinuria, albuminuria, hypoalbuminaemia, hyperlipemia, and urinary excretion. Curcumin restored renal function.

Turmeric in liver diseases

For curing jaundice, turmeric paste was applied over the body of the patient, and the sorcerer carried out magical expulsion of the disease. After that, the turmeric was washed off and the people believed that the disease also got washed off together with the turmeric (Remadevi and Ravindran, 2005). Turmeric is considered good for afflictions of the liver (Chopra et al. 1958; Kirtikar and Basu 1984). Turmeric is effective in treating jaundice and is recommended in the diet of patients suffering from jaundice or even infective hepatitis. Clinical trial with turmeric and *Phyllanthus fraternus* for treating infective hepatitis has proved very effective, without any side effects. In Japan, crude turmeric rhizomes were tested in experimental animals against CC14-induced hepatotoxicity. The curcuminoids showed significant anti-hepatotoxic action. Ethanolic extract of turmeric showed significant hepatoprotective effect. Curcumin in combination with *Eclipta alba* and *P. fraternus* was a promising combination against liver injuries, which normalized the level of lipid accumulated in the liver and brought down the level of serum bilirubin in CC14-induced hepatotoxicity in experimental rats. The level of serum triglycerides, pre-β-lipoproteins and cholesterol improved and that of glycogen normalized after treatment. (Anonymous, 2001).

Turmeric in digestive system

Turmeric is a traditionally used spice and has formed an essential ingredient in Indian recipes from time immemorial. In the digestive system, turmeric acts as a carminative and protective against intestinal gas formation. The hot potency of turmeric (as per Ayurveda) enables it as a digestive and stimulant. Turmeric is an important constituent of the group of drugs indicated for diarrhea, in *Ashtanga hridaya* and *Susruta samhita*, two of the most respected lexicons in *Ayurveda.* Turmeric is anti-flatulent, digestive, and stimulant due to its hot potency. It is reported to have anti-spasmodic activity, inhibiting excessive peristaltic movements of the intestine (Chopra et al. 1958; Anonymous, 2001). Anti-flatulent activity of turmeric/curcumin in experimental animals. (Bhavanisankar and Srinivasa Murthy 1979). Curcumin enhanced intestinal lipase, sucrase, and maltase activity (Patel and Srinivasan, 1996). Turmeric powder increased mucin secretion in rabbits and thus acted as a protecting agent against irritants (Lee et al. 2003). In experimental studies, curcumin showed protective effects from ulcerogenic effects of phenylbutazone. (Dasgupta et al. 1969; Sinha et al.1974) but 0.5% curcumin failed to protect, and at higher doses of 50 mg or 100 mg/kg it produced ulcers (Gupta et al. 1980). Curcumin blocked indomethacin; ethanol and stress-induced gastric ulcers in experimental rats (Chattopadhyaya et al. 2004).

Turmeric in ophthalmic care

Turmeric is indicated in traditional medicine in catarrahal and purulent ophthalmia, conjunctivitis, etc. Central Food Technological Research Institute, Mysore, isolated a water-soluble peptide (0.1% of dry weight) from turmeric, having antioxidant activity. It inhibited deoxyribonucleic acid (DNA) damage, especially produced by wood smoke, and reported that it can reduce the opacity on eye lens, produced by smoke condensate and thereby prevent loss of vision (Anon., 2001) .Efficacy of curcumin in the management of chronic anterior uveitis (CAU) was investigated clinically.(Lal et al. 1999). Curcumin was administered orally to patients suffering from CAU at a dose of 375 mg tds for 12 weeks and found that the efficacy of curcumin in curing CAU, and the recurrences following treatment were comparable to that of corticosteroid therapy. The lack of side effects with curcumin forms the greatest advantage, compared to corticosteroids. Screening of some indigenous plants for their lens aldose reductase (LAR) - inhibiting potential. Turmeric and three other indigenous plants were found effective in inhibiting LAR activity. (Halder et al. 2003)

Antitumor, anticancerous activity

Dietary turmeric could be effectively used as a chemopreventive agent in benzo- (alpha)-pyrene-induced forestomach tumors in Swiss mice. An ethanolic extract of turmeric, as well as an ointment containing curcumin, is reported to produce remarkable symptomatic relief in patients with external cancerous lesions (Anonymous, 2001). It is now proved that the antioxidants present in turmeric neutralize carcinogenic free radicals. Curcuminoids possess anti-carcinogenic property due to their oxygen radical-scavenging property (Kohli. *et al.* 2005). In a comparative study of curcuminoids for their free radical-scavenging activity. It is found turmeric to be the most potent free radical scavenger, followed by dimethoxycurcumin and bis-demethoxy curcumin. Acetyl curcumin was found inactive. (Nair and Rao 1996). Reports showed the use of turmeric preparations in the treatment of cancer. In the course of a search for antitumor agents, the extract of turmeric was found to be effective in inducing apoptosis or programmed cell death (PCD) in human myeloid leukaemia cells (HL — 60). (Sang Hyun *et al*. 1996). Curcuminoids protect the normal human keratinocytes from hypoxanthine/xanthine oxidase injury. Further, they proposed that since curcuminoids synergistically inhibited nitrobluetetrazolium reduction, a decrease in superoxide radical formation, leading to lower levels of cytotoxic hydrogen peroxide, might explain the protective effect. Bonte *et al*. (1997). The chemopreventive effect of curcumin was assayed during the promotion/progression stages of

colon cancer. The inhibition of adenocarcinomas of the colon was reported as dose dependent. Curcumin treatment during the initiation and postinitiation stages as well as throughout the promotion/progression stage increased apoptosis in colon tumors, compared with groups receiving azoxymethane (AOM) and the control diet. (Kawamori et al. 1999). It is revealed that the antitumor activity of curcumin is mediated through the induction of apoptosis in AK -5 tumor cells. (Khar et al. 1999). Reports showed that turmeric inhibited tumor necrosis factor (TNF)-α-induced expression of adhesion molecules on human umbilical vein endothelial cells. Curcumin was the most potent among the three compounds tested, as inhibiting TNF-α induced expression of intercellular adhesion molecule-1(ICAM-1), vascular cell adhesion molecule-1 (VCAM-1), and E-selectin by human umbilical vein endothelial cells. (Gupta et al. 1999). Curcumin-I, II, and III from turmeric were assayed by for their cytotoxicity and antioxidant, and anti-inflammatory activities. These compounds were reported to have potent activity against leukemia and colon, central nervous system (CNS), melanoma, renal, and breast cancer cell lines. (Ramsewak et al. 2000). Evaluation of the anticancer potential of curcumin was performed. Human clinical trials indicated no dose-limiting toxicity when administered at doses up to 10 g/d. The available evidences indicate that turmeric and curcumin can inhibit cancer at the initiation, promotion, and progression stages of TPA (12-O-tetradecanoylphorbol-13-acetate)- induced tumor promotion in mouse skin. (Aggarwal, et al. 2003). All the studies thus suggest that curcumin has enormous potential in the prevention and therapy of cancer.

Anticholesterol action

Turmeric, as well as curcumin, is reported to reduce the uptake of cholesterol from the gut and increase the high-density lipids (HDL) cholesterol and decrease low-density lipids (LDL) type. It can also inhibit the peroxidation of serum LDL, which can lead to atherosclerotic lesions. Thus, turmeric can prevent coronary problems and heart diseases (Anon, 2001). It is reported that the levels of serum cholesterol and liver cholesterol decreased to one-half, while cholesterol-fed rats were treated with curcumin. Deposition of cholesterol was found to be high in liver sections of rats fed with cholesterol and least in specimens from animals concurrently fed with curcumin. Curcumin increased fecal excretion of bile acids and cholesterol, in normal and hypercholesterolemic rats. This biliary drainage explains the reduction of tissue cholesterol (Patil TN and Srinivasan M, 1971). Investigation showed the possible hypolipidemic effect of curcumin in rats fed on a high cholesterol diet (HCD). He found an obvious hypocholesterolemic effect that is supposed to be due to an effect on cholesterol absorption, degradation, or elimination, but not due to an antioxidant mechanism. The report suggests that the ingestion of curcumin-containing spices in diet, especially rich in fat, could have a lipid-lowering effect. (Arafa HM, 2005).

Antifertility

Turmeric is reported to possess anti-fertility activity, as observed in experimental animals. Petroleum ether and aqueous extracts produced 100% anti-implantation effects in rats at a dose of 200 mg/kg body weight fed orally on the first to seventh day of pregnancy. (Garg SK et al. 1978) Studies showed the effect of curcumin as a potential vaginal contraceptive and found that it inhibited human sperm motility and had the potential for the development of novel intravaginal contraceptive. The test results indicated that curcumin had a selective sperm-immobilizing effect in addition to a previously studied antihuman immunodeficiency virus (HIV) property. Investigation showed the contraceptive effect of turmeric in male albino rats and observed a reduction in sperm motility and density in treated group. Turmeric is supposed to have affected the androgen synthesis, either by inhibiting the Ley dig cell function or hypothalamus pituitary axis, thereby inhibiting the spermatogenesis (Purohit A and Meenakshi B, 2004).

Biomedical applications of Turmeric

If systemic bioavailability of curcumin can be improved to allow bioactive concentrations of curcumin and piperine in vivo, then this combination may serve as an effective cancer preventive intervention to limit stem cell self-renewal, since these cells, and dysregulation of self-renewal pathways, may be involved in carcinogenesis. Strategies aimed at reducing stem cell number and inhibiting their self-renewal could be an effective approach in cancer prevention. If this is the case, then assays such as mammosphere formation and ALDH expression may serve as biomarkers for cancer prevention studies in clinical trials. Curcumin, even at large doses, has been demonstrated to be non-toxic in clinical trials. Piperine has been shown in a small, phase I clinical trial to enhance the systemic bioavailability of curcumin. However, a more systematic phase I trial with pharmacokinetic, pharmacodynamic and toxicity endpoints of repeated dosing of these agents in combination is still needed. If proven safe and efficacious, dietary polyphenols could be an acceptable non-toxic long-term cancer risk reduction strategy (Madhuri K *et al,* 2011).

Table 1: Components and their medicinal importance

Component Name	Medicinal Property
Curcumin	Anti-HIV, anti-EBV, antiadenoma – carcinogenic, antiaflatoxin, antiatherosclerotic,antiaggregant, antiangiogenic,antiarachidonate, anticancer, antiedemic, anti-ischemic, antiinflammatory,antileukemic, antileukotrene, antilymphomic, antimelanomic, antimetastatic, antimutagenic, antinitrososaminic, antioxidant, antiperoxidant, antiprostaglandin, antisarcomic, metal chelator, antithromboxane, antitumor agent, antiviral, apoptotic, cox-2inhibitor, fibrinolytic, hepatoprotective, immunostimulant, ornithine decarboxylase inhibitor, protease inhibitor, protein kinase inhibitor.
Bis-desmethoxycurcumin	Antiangiogenic, anti-flammatory, cytotoxic, anticancer
Desmethoxy Curcumin	Antiangiogenic, anti-nflammatory, anticancer
Tetrahydro Curcumin	Antioxidant and anti-inflammatory
Alpha Curcumene	Antitumor and anti-inflammatory
Ar- turmerone	Anti-inflammatory, antitumor, cox-2 inhibitor, choleretic, hepatotonic.
Curcumol	Anticancer, antitumor(cervix) and anti-sarcomic
Curdione	Anti-leukopenic, antisarcomic, antitumour, anti X-radiation.
Dehydro Curdione	Analgesic, antiarthritic, antiedemic, anti-inflammatory, anti-oxidant, antipyretic and calcium channel blocker.
Zingiberene	Antirhinoviral, antiulcer and carminative.

CONCLUSION

Turmeric is one of the most precious and powerful plant on earth and is being used as a natural wonder by the ancient people of India. Turmeric is proving beneficial in the treatment of many different health conditions from cancer to Alzheimer's disease. Studies at Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore, India shown that turmeric may play a vital role in fighting HIV/AIDS, particularly HIV, Type 1 10. Consequently, agents that can modulate multiple cellular targets are now attractive objects of research. As this review has shown Curcumin is one such agent and has potential to treat various diseases. More extensively well controlled clinical trials are now needed to fully investigate its potential. Regardless of all these Curcumin has established as a foodstuff and also a natural medicine because of its low cost, proven chemopreventive and therapeutic potential and potent pharmacological activities of turmeric at in-vivo and in-vitro which made it a nature's precious drug. Curcumin is rapidly moving from kitchen shelf toward the clinic.

REFERENCES

1. Jager PD. Turmeric. California: Vidyasagar Pub; 1997. p. 67.
2. Kojima H, Yanai T, Toyota A. Essential oil constituents from Japanese and Indian *Curcuma aromatica* rhizomes. Planta Medica 1998; 64: 380-381.
3. Pandey V, Kumar D. Biofertilizers for Sustainable Agriculture. Agric.Today 2002; 5:44-47.
4. Satishkumar B. Genetic Resources of Curcuma: Diversity characterization and utilization, Plant Genetic Research 2005; 3(2):230-251.
5. Skorniekova J, Sabu M, Prasanthkumar MG. *Curcuma mutabilis* (Zingiberaceae): a new species from South India, Gardens' Bull Singapore 2004; 56: 43-54.
6. Larsen K, Lock JM, Maas H, Maas PJM. Zingiberaceae. In: Kubitzki K, editors. The families and genera of vascular plants. Berlin: Springer- Verlag; 1998; 4: 474-495.
7. Sopher DE. Indigenous uses of turmeric (*C. domestica*) in Asia and Oceania. Anthropos 1964; 59: 93-127.
8. Nadkarni KM. Indian Materia Medica 1.3rd ed. Bombay: Popular Prakasan;1976.
9. Kirtikar KR, Basu BD. Indian Medicinal Plants. Dehra Dun, India: Bishensing Mahendrapal Singh, (Reprint);1984.
10. Duke JA. CRC Handbook of Medicinal Spices. Boca Raton: CRC Press; 2003.
11. Chang HM, But PP. Pharmacology and Applications of Chinese Materia Medica 1987; 2: 936-939.
12. Bensky D, Gamble A. *Chinese Herbal Medicine Materia Medica*. Seattle: East land press;1986. p.390-391.
13. Trishna D, Shanthi BM, Mrinmoy B, Mohanty JP, Shildibyendu. Evaluation of phytochemical screening and anti-fertility activity of *curcuma aromatica* salisb. (2010) International Journal of Pharmaceutical Sciences and research 2010; 1(1).
14. Ishita C, Kaushik B, Uday B, Ranajit KB. Turmeric and Curcumin: Biological actions and medical applications. Current sciences 2004; 87(1): 44-53.
15. Song EK. Diarylheptanoids with free radical scavenging and hepato protective activity in-vitro from Curcuma longs. Planta Med 2001; 67: 876- 877.
16. Kotwal GJ : Natural Products and Molecular Therapy. First International Conference, New York: Annal New York Acedamy of Sciences 2005; 1056.
17. Chattopadhyaya I, Biswas K, Bandopadhyay U, Banerjee, RK. Turmeric and curcumin: biological actions and medicinal applications. Current Science 2004; 87:44-53.
18. Omoloso AD, Vagi JK. Broad spectrum antibacterial activity of *Allium cepa*, *Allium roseum*, *Trigonella foenum graecum* and *Curcuma domestica*. Natural Product Sciences 2001; 7:13-16.
19. Negi PS, Jayaprakasha GK, Rao LJM, Sakariah KK. Antibacterial activity of turmeric oil: a byproduct from curcumin manufacture. J. Agricultural and Food Chemistry 1999; 47:4243-4297.
20. Dhar ML, Dhar MM, Dhavan BN, Mehrotra BN, Ray C. Screening of Indian plants for biological activity. Part 1 Ind. J. Exptl. Biol 1969; 6:232
21. Koide T, Nose M, Ogihara Y, Yabu Y, Ohta N. Leishmanicidal effect of curcumin in vitro. Biological & Pharmaceutical Bulletin 2002; 25:131-133.
22. Kuttan R, Bhanumati P, Nirmala K, George MC. Potential anticancer activity of turmeric (*Curcuma longa*). Cancer Lett 1985; 29:197-202.
23. Kuo ML, Huang TS, Lin JK. Curcumin, an antioxidant and antitumor promoter, induces apoptosis in human leukemia cells. Biochim.Biophys. Acta 1996; 1317: 95-100.
24. Goel A, Boland CR, Chauhan DP. Specific inhibition of cyclooxygenase –2(COX-2) expression by dietary curcumin in HT 29 human colon cancer cells. Cancer Lett 2001; 172:111-118.
25. Shao ZM, Shen ZZ, Liu CH, Sartippour MR, Go VL, Hever D, et al. Curcumin exerts multiple suppressive effects on human breast carcinoma cells. Int.J.Cancer 2002; 98: 234–240.
26. Choudhari T, Pal S, Aggarwal ML, Das T, Sa G. Curcumin induces apoptosis in human breast cancer cells through p53-dependent Bax induction. FEBS Lett 2002; 512:334-340.
27. Ammon HP, Wahl MA. Pharmacology of *Curcuma longa*, Planta Med; 1991, 57:1-7.
28. Ratul Kumar D, Naresh K, Utpal B. Encapsulation of Curcumin in alginate- chitosan- pluronic composite nanoparticles for delivery to cancer cells.Nanomedicine: NBM. 2010; 6: 153-160.
29. Gang R, Si-Shen F. Preparation and characterization of poly(lactic acid)-poly(ethylene glycol)- poly(lactic acid) (PLA-PEG-PLA) microspheres for controlled release of paclitaxel. Biomaterials 2003; 24 (27): 5037-5044.
30. Vijay Kumar M, Debasish S, Nayak PL. Chitosan–sodium alginate anocomposites blended with cloisite 30b as a novel drug delivery system for anticancer drug curcumin. Int. J. Appl. Biol. Pharm. Technol. 2011; 2(3): 402-409.
31. Al-Hajj M, Becker MW, Wicha M, Weissman I, Clarke MF. Therapeutic implications of cancer stem cells. Curr Opin Genet Dev 2004; 14:43–7.
32. Lindvall C, Bu W, Williams BO, Li Y. Wnt signaling, stem cells, and the cellular origin of breast cancer. Stem Cell Rev 2010; 3:157–68.
33. Park CH, Hahm ER, Park S, Kim HK, Yang CH. The inhibitory mechanism of curcumin and its derivative against beta-catenin/Tcf signaling. FEBS Lett. 2005;579:2965–2971
34. Bachmeier B, Nerlich AG, Iancu CM, Cilli M, Schleicher E, Vene R et al. (1986) Chinese Herbal Medicine Materia Medica. Seattle: East land press; 1986. p390-391.
35. Sarma PV. Dravyaguna Vijnana, Varanasi, India (Reprint): Chaukhambha Bharati Academy; 2005.
36. Khare CP. Indian Herbal therapies. New Delhi: Vishv vijay Private Ltd; 2000.
37. Srimal RC, Khanna KM, Dhawan BN. A preliminary report on anti inflammatory activity of curcumin. Ind. J. Pharmacol 1971; 3: 10.
38. Chandra D, Gupta SS. Anti- inflammatory and anti-arthritic activity of volatile oil of *Curcuma longa* (Haldi) : Ind. J.Med.Res 1972; 60:131-142.
39. Deodhar SD, Sethi R, Srimal RC. Preliminary study on anti rheumatic activity of Curcumin (diferuloylmethane). Ind .J. Med Res 1980; 71: 632-634.
40. Remadevi R, Ravindran PN. Turmeric : Myths and Traditions. Spice India 2005. 18(8):11-17.
41. Joe B., Vijayakumar, M. and Lokesh B.R. (2004) Biological properties of Curcumin –cellular and molecular mechanisms of action. Critical Reviews in Food Science and Nutrition, 47, 97-111.
42. Khanna NM. Turmeric: Nature's Precious gift. Current Science 1999; 76:1351- 1356.
43. Rafatullah S. Medicinal, Aromatic and Poisonous Plants. Riyadh, Saudi Arabia: King Saud University; 1990.

44. Cohly HH, Rao P, Kanji MR, Manisundram VK, Taylor D, Wilson A, et al. Effect of turmeric (Chemical Plant Extract) on in-vitro nitric oxide synthetase (NOS) levels in tissues harvested from acute and chronic wounds. Wounds 1999; 11(3):70-76.
45. Arun N, Nalini N. Efficacy of turmeric on blood sugar and polyol pathway in diabetic albino rats. Plant Foods for Human Nutri 2002; 57: 41-52.
46. Sajithlal GB, Chittra P, Chandrakesan G. Effect of Curcumin on the advanced glycation and cross-linking of collagen in diabetic rats. Biochem Pharmacol 1998; 56: 1607 – 1614.
47. Kirtikar KR, Basu BD. Indian Medicinal Plants. Dehra Dun, India: Bishensing Mahendrapal Singh, (Reprint);1984.
48. Ram A, Das M, Ghosh B. Curcumin attenuates allergen induced airway hyperresponsiveness in sensitized guinea pigs. Biological & Pharmaceutical Bulletin 2003; 26: 1021-1024.
49. Kolammal M. Pharmacognosy of Ayurvedic Drugs. Trivandrum; Pharmacognosy unit, Govt Ayurveda College; 1979.
50. Anonymus. Wealth of India. National Institute of Science Communication, Council of Scientific & Industrial Research 2001.
51. Chopra RN, Chopra IC, Handa KL, Kapur LD. Indigenous Drugs of India. Calcutta: Academic Publishers; 1958.
52. Bhavanisankar TN, Srinivasa Murthy V. Effect of turmeric (Curcuma longa) fractions on the growth of some intestinal and pathogenic bacteria in vitro. Ind. J. Exp.Biol 1979; 17:1363-1366.
53. Patel K, 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.
54. Lee CJ, Lee JH, Scok JH, Hur GM, Park YC, Scol IC, et al. Effects of baicalein, berberine, curcumin and hespiridin on mucin release from airway goblet cells. Planta Med 2003; 69:523-526.
55. Dasgupta SR, Sinha M, Sahana CC, Mukherjee BP. A study of the effect of an extract of *Curcuma longa* Linn. on experimental gastric ulcers in animals. Ind. J. Pharmacol 1969; 1:49-54.
56. Sinha M. Mukherjee BP, Muherjee B, Dasgupta SR. Study on the 5-hydroxytryptamine contents in guinea pig stomach with relation to phenylbutazone induced gastric ulcers and the effects of curcumin thereon. Indian J. Pharmacol 1974; 6: 87-96.
57. Gupta B, Kulsreshtha VK, Srivastava RK, Prasad DN. Mechanisms of curcumin induced gastric ulcer in rats. Indian J.Med.Res 1980; 71: 806-814.
58. Lal B, Kapoor AK, Asthana OP, Agrawal PK, Prasad R, Kumar P, et al. Efficacy of curcumin in the management of chronic anterior uveitis. Phytotherapy Research 1999; 13(4):318-322.
59. Halder N, Joshi S, Gupta SK. Lens aldose reductase inhibiting potential of some indigenous plants. J. Ethnopharmacology 2003; 86(1):113-116.
60. Kohli K, Ali J, Ansari MJ, Raheman Z. Curcumin: A natural anti-inflammatory agent. Indian Journal of Pharmacology 2005; 37 (3) :141-147.
61. Nair S, Rao MNA. Free radical scavenging activity of curcuminoids. Arzneimittel Forschung 1996; 46: 169-171.
62. Sang Hyun P, Kim GJ, Jeong, HS, Yum SK. Ar-turmerone and beta-atlantone induce internucleosomal DNA fragmentation associated with programmed cell death in human myeloid leukemia HL-60 cells. Archives of Pharmacal Research 1996; 19:91-94.
63. Bonte F, Noel-Hudson M.S, Wepierre J, Meybeck A. Protective effect of curcuminoids on epidermal skin cells under free oxygen radical stress. Planta Medica 1997; 63:265-266.
64. Kawamori T, Lubet R, Steele VE, Kelloff GJ, Kaskey RB, Rao CV, et al. Chemopreventive effect of curcumin, a naturally occurring anti-inflammatory agent, during the promotion/progression stages of colon cancer. Cancer Research (Baltimore) 1999; 59(3):597-601.
65. Khar A, Ali AM, Pardhasaradhi BVV, Begum Z, Rana Anjum R. Antitumor activity of curcumin is mediated through the induction of apoptosis in AK-5 tumor cells. FEBS Letters 1999; 445(1): 165-168.
66. Gupta B, Ghosh B. *Curcuma longa* inhibits TNF-alpha induced expression of adhesion molecules on human umbilical vein endothelial cells. International J. Immunopharmacology 1999; 21(11):745-757.
67. Ramsewak RS, DeWitt DL, Nair MG. Cytotoxicity, antioxidant and anti-inflammatory activities of curcumins I-III from *Curcuma longa*. Phytomedicine 2000;7(4):303-308.
68. Aggarwal BB, Kumar A, Bharti, AC. Anti-cancer potential of Curcumin: preclinical and clinical studies. Anticancer Research 2003; 231: 363-398.
69. Patil TN, Srinivasan M. Hypo cholesteremic effect of Curcumin in induced-hyper cholesteremic rats. Ind. J. Exp. Biol 1971; 9: 167-169.
70. Arafa HM. Curcumin attenuates diet-induced hypercholesterolemia in rats. Med. Sci. Monit 2005; 11(7): 228-234.
71. Garg SK, Mathur VS, Chaudhury RR. Screening of Indian plants for antiferility activity. Indian J.Exp.Biol 1978; 16:1077-1079.
72. Purohit A, Meenakshi B. Contraceptive effect of *Curcuma longa* (L.) in male albino rat. Asian J. Andrology 2004; 6: 71-74
73. Madhuri K, Dean EB, Hasan K, Connie C, Karim T, Christophe G, et al. Targeting Breast Stem Cells with the Cancer Preventive Compounds Curcumin and Piperine. Breast cancer research treatment 2010;122