STM JOURNALS

Research & Reviews: A Journal of Pharmacology
ISSN: 2230-9861 (Online), ISSN: 2349-1299 (Print)
Volume 9, Issue 1
www.stmjournals.com

Phytochemical and Pharmacological Importance of Turmeric (*Curcuma longa*): A Review

Sayantani Chanda*, T.V. Ramachandra
Energy and Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore, Karnataka, India

Abstract

Curcuma longa L. is a member of the ginger family (Zingiberaceae) and used widely by the traditional medical practitioners for the treatment of various ailments. Due to high curcumin content Indian turmeric is very popular as compared to other countries. Rhizomes derived from Curcuma longa is commonly known as Haldi or Turmeric. Rhizomes are horizontal underground stems that send out shoot as well as roots. Turmeric constitutes of fat-soluble, polyphenolic pigments known as curcuminoids which include mainly curcumin (deferulolyl methane) responsible for yellow colour for Indian curries, others are demethoxy curcumin and bisdemethoxy curcumin. Turmeric is sometimes also called the 'Indian saffron' and it is a natural antiseptic. Turmeric has high nutritive and medicinal values. Turmeric contains phytochemical constituents so it is considered as medicinal plant. The presence of non-nutritive plant chemical (phytochemical constituents) possesses disease preventive properties. In the form of root powder, turmeric is used for its flavouring properties as a spice, food medicine as it is associated with a variety of important beneficial properties. Many studies have been carried out in respect of various aspects such as morphology, phytochemical profiles of the entire parts of the plant and other features have also been recorded and documented. In this paper effort has been made to review the uses, botanical description, taxonomical classification, phytochemical constituents, and pharmacological activities along with the current trends in research on turmeric.

Keywords*: Curcuma longa, Taxonomical Classification, Phytochemical, Uses Pharmacological, Description*

****Author for Correspondence*** E-mail: isayantani.chanda@gmail.com

INTRODUCTION

Human being used plants parts as a phytomedicine since ancient times. Plants are important for bioactive constituents as primary and secondary compounds. It has been found that secondary metabolites both chemically and taxonomically are exceptionally different compound. This metabolites used in many areas like human therapy, agriculture, scientific research, veterinary and many other areas. They are largely used in the human therapy, agriculture, scientific research, veterinary and many other areas. According to the World Health Organization (WHO), about 80% of individuals from developed countries use the traditional medicine as a source of potential and powerful drugs that are derived from medicinal plants [1]. *Curcuma longa* is a perennial herb erect, leafy, belongs to the Zingiberaceae family, that measures up to 1 m high with a short stem, having oblong, pointed leaves and funnel-shaped yellow flowers. It is spread throughout tropical and subtropical regions of the world that are generally cultivated in Asiatic countries, mainly in India and China. 'Haldi' traditionally known in India whose rhizomes are oblong, ovate, pyriform and often short branched [2, 3, 4]. Current research shows that curcumin has a new magnitude about its potentiality and have anti-inflammatory and anticancer activities [5]. The yellow powder known as curcumin extracted from rhizome is used medicinally. Dried *Curcuma longa* which is the source of the spice turmeric gives curry powder whose colour is yellow. Turmeric used in traditional Indian medicine as well as Hindu religious ceremonies and also used widely in foods for

its flavour and colour. The old Hindu texts have described that turmeric is as aromatic stimulant and carminative [3, 4]. Recently powder of turmeric used as traditional medicine against gastrointestinal diseases, especially for biliary and hepatic disorder, diabetic wounds, rheumatism, inflammation, sinusitis, anorexia, coryza and cough. Turmeric which act as anticancer, anti-diabetic, antioxidant, hypolipidemic, anti-inflammatory, antimicrobial, anti-fertility, anti-venom, hepatoprotective, nephroprotective, anticoagulant and possess anti HIV activity to combat AIDS [4, 6, 7].

TAXONOMICAL CLASSIFICATION

Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Subclass: Zingiberidae
Order: Zingiberales
Family: Zingiberaceae
Genus: Curcuma
Species: longa
Scientific name: Curcuma longa

DESCRIPTION

Stemless herb with root stock. Leaves broadly lanceolate or oblong, with a deep ferruginous purple. Petiole and sheath as long as the blade. Spike appearing rather before the leaves. Flowering bract green with ferruginous tinge, flower pale yellow, reddish at outer boarder.

MEDICINAL USES

Rhizome: Purifies blood, used as tonic to brain and heart, used to treat leucoderma, piles, bronchitis, asthma, tumours, tuberculous glands on the neck, enlargement of spleen, to check leucorrhal and gonorrhoeal discharge.

PHYTOCONSTITUENTS

(a) 1,8-cineole, 2-bornanol, 2-hydroxy-methyl-anthraquinone, 4-hydroxybisabola-2**.**
(b) 10-diene-9-one; 4-methoxy-5-hydroxybiosabola; 4-hydroxy-cinnamoyl-(Feruloyl)-methane, Alpha-atlantone, Alpha-pinene, Alphaterpineol, Ar-turmerone, Arabinose.
(c) Ascorbic-acid, Ash, Azulene, Beta-carotene, Beta-pinene, Beta-sesquiphellandrene, Bis-(Para-hydroxy-cinnamoyl)-methane.
(d) Bis-desmethoxycurcumin, Bisabolene, Bixin, Borneol, Boron, Caffeic-acid, Calcium, Caprylic-acid, Caryophyllene, Chromium, Cineole, Cinnamic-acid, Cuminyl-alcohol, Curcumene, Curcumenol, Curcumin, Curdione, Cobalt, Copper.
(e) Eugenol, Epiprocurcumenol; Eucalyptol; Eugenol; Feruloyl-p-coumaroyl-methane, Gamma-atlantone, Germacrone, Germacrone-13-al;Guaiacol, Isoborneol, L-alpha-curcumene.
(f) L-beta-curcumene, Limonene, Manganese, Monodesmethoxycurcumin, Niacin, Nickel, norbixin; O-coumaric-acid, P-coumaric-acid, P-methoxycinnamic-acid, Pcymene, P-tolymethylcarbinol, Phosphorus, Protocatechuic-acid, Procurcumadiol.
(g) Acidic polysaccharides: utonan A, B, C, D.
(h) Volatile Oil(4.2%),its main content is turmerone, arturmerone, curcumene, germacrone, ar-curcumene,
(i) The herbal classics CHMM (Chinese Herbal Materia Medica).
(j) Other chemicals: Turmeric contains protein (6.3%), fat (5.1%), minerals (3.5%), carbohydrates (69.4%) and moisture (13.1%). Phenolic diketone, curcumin (diferuloylmethane) (3-4%) is responsible for the yellow colour, and comprises curcumin I (94%), curcumin II (6%) and curcumin III (0.3%).
(k) Other chemicals compound are copper/zinc, campesterol, stigmasterol, beta-sitosterol, cholesterol, fatty acids and metallic elements potassium, sodium, magnesium, calcium, manganese, iron.

PRELIMINARY PHYTOCHEMICAL SCREENING

The chemical evaluation includes qualitative chemical tests which have been used for identification of various phytoconstituents present in the powdered crude drug. The Preliminary phytochemical investigations of aqueous extract, acetone extract, ethanolic extract, chloroform extract and methanolic extract of *Curcuma longa* rhizome using commonly employed precipitation and coloration reactions were performed by

various researchers which reveals the presence such as carbohydrates, proteins, alkaloids, glycosides, terpenes, steroids, flavonoids, tannins and saponins [1, 8, 9]. The corresponding tests performed by various researchers were being compiled from standard published literatures which are described below.

Preparation of the Extract

The rhizomes of *Curcuma longa* were collected and sun dried, cut into small pieces The small piece of dried rhizome was then grinded to get a fine powder, which is ready for use [8, 9].

Test for Alkaloid

The extract was mixed with 3 ml of dilute hydrochloric acid and then filtered thoroughly. The filtrate was tested carefully with following test [9]:

(a) Mayer's Test: To a 1 ml or 2 ml of filtrate, few drops of Mayer's reagent are added by the side of the test tube. The white or creamy precipitate indicated test as positive (presence of alkaloids) [1, 5, 8, 10].
(b) Wagner Test: 1 ml or 2 ml of the filtrate extract was treated with Wagner's reagent; formation of brown reddish precipitate shows positive result of alkaloids [1, 5, 8].
(c) Dragendroff's Test: To a few ml of filtrate, 1–2 ml of Dragendorff's reagent was added formation of prominent yellow precipitate indicates the presence of alkaloids [5, 8].

Test for Glycosides

(a) To 2 ml test solution, added with equal quantity of Fehling's solution A and B and solution was heated gives the positive result of glycoside. A brick red precipitate was observed [8].
(b) Legal's Test: To 2 ml or 1 ml test solution, pyridine and alkaline sodium nitroprusside was added ,get a blood red or pink colour indicate presence of glycoside [1, 8, 9].
(c) Keller-Killani Test*:* To 2 ml glacial acetic acid containing a drop of $FeCl_3$ treated with extract .Formation of a brown colour ring indicates the presence of glycoside [1, 9].
(d) Borntrager's Test: Firstly extract was boiled with dilute sulphuric acid, filtered and to the filtrate chloroform was added and shaken well. The organic layer was separated to which ammonia is added slowly. It also shows positive result, by pink to red colour in the ammonical layer [5].

Test for Flavonoids

(a) Shinoda Test: 2 ml test solution added with few fragments of Magnesium ribbon, dropwise conc. H_2SO_4 was added. The results shows pink scarlet or crimson red colour [1, 8].
(b) Alkaline Reagent Test: The test solution, was treated with sodium hydroxide solution, which gives a yellow or red colour [1, 8].
(c) Zn Test: 2 ml extract were mixed with Zn dust and conc. HCl, after a few minutes red colour observed and it means presence of flavonoid [1, 8].

Test for Tannins

(a) Ferric Chloride Test: The extract solution mixed with drops of ferric chloride solution. Presence of gallic tannins, blue colour was observed and green black for catecholic tannins [1, 5, 8].
(b) Gelatin Test: A white precipitate is obtained by mixing of 2 ml test solution and 1% Gelatin solution containing 10% sodium chloride [8].

Test for Saponins

Foam Test*:* Researchers tries to find out the presence of Saponins as follows:
5 ml extract was shaken with 20 ml distilled water and then heated to boil. Frothing shows the presence of saponins [1, 5].

Test for Triterpenoids

Salkowski Test: The test solution was added with 2 ml chloroform and few drops of conc. Sulphuric acid (3 ml), and shaken well. Formation of reddish brown colour at lower layer indicates presence of steroids and yellow colour shows the presence of triterpenoids [8].

Test for Phenol

Ferric Chloride Test: 4 drops of Alcoholic $FeCl_3$ solution were added in the test extract.

Appearance of bluish black colour indicates the presence of phenol [9, 10].

Test for Fats and Fixed Oils

(a) Stain Test: Between the two filter papers small amount of the extract was pressed, the stain on the filter paper indicates the presence of fixed oils [8].

(b) Saponification Test: Small quantity to the extract solution with a drop of phenolphthalein was treated with few drops of 0.5 N alcoholic potassium hydroxide and heated on a water bath for 1–2 h. The results shows formation of soap or partial neutralization for the alkali indicates the presence of fats and fixed oils [8].

Test for proteins and amino acids

(a) Millon's Test: 2 ml test solution is added with Millon's reagent gives a white precipitate, which on heating changes to red [1, 5, 8, 10].

(b) Ninhydrin Test: To 2 ml test solution, ninhydrin solution was treated and then boiled. Formation of blue colour indicates the presence of amino acid. Again 2ml test solution, 0.2% ninhydrin solution was treated with amino acids and proteins, then boiled shows a violet colour [1, 8].

Test for Carbohydrates

The extract was dissolved in 5–10 ml of distilled water and filtered through Whatmann No.1 filter paper and the filtrate is used for the following test of carbohydrates.

(a) Molish Test: Firstly 2 ml solution was placed in a test tube then 1 drop of Molish Reagent was added. 2 ml of conc. HCl was added from the sides of the test tube. A violet ring was observed in the test tube. Formation of a violet ring at the junction of the two liquids indicates presence of carbohydrates [5, 9].

(b) Fehling Test: Dilute HCl was hydrolysed with 2 ml of extract and extract also neutralized with alkali and heated with Fehling's solution A and B, formation of red precipitate it indicates the presence of reducing sugar [1, 9].

(c) Benedict's Test: The filtrate were treated with Benedict's reagent and heated gently, appearance of orange red precipitate indicates the presence of reducing sugar [1].

(d) Iodine Test: 5 drops of Iodine solution were treated with 2 ml of extract, gives blue colour indicates the positive test [9].

PHYTOPHARMACOLOGY

Turmeric has several therapeutic and pharmacologic activities. The following is the most important phytopharmacology and therapeutic properties of turmeric.

Anti-inflammatory

Curcuma longa exhibit potent anti-inflammatory effects due to volatile oils and curcumin. One half of curcumin if taken as oral is effective for Chronic inflammation, was found to be as helpful as cortisone or phenylbutazone in instances of acute inflammation [11]. Turmeric is credited with hot potency and anti-inflammatory action with specific lipoxygenase- and COX-2-inhibiting properties. Rheumatic complaints are often connected with inflammatory changes of joints It cures the etiological factors and pathological changes of inflammation [6, 12]. Curcuminoids have a properties that inhibit LOX, COX, phospholipases, leukotrienes, prostaglandins, thromboxane, nitric oxide elastase, hyaluronidase, collagenase, monocyte chemoattractant protein-1, interferon inducible protein, TNF and interleukin-12 [5]. In an animal model ,in case mice application of curcumin at doses between 50 and 200 mg/kg has inhibited oedema. Curcumin can reduce 50% in oedema when it applied with a dose of 48 mg/kg body weight. It is same effective as cortisone and phenylbutazone at similar doses. Again in rats, when applied a lower dose of 20–80 mg/kg decreased paw inflammation and oedema. Curcumin with a dose of 40 mg/kg can inhibited formaldehyde induced arthritis in rats and demonstrated no acute toxicity at doses up to 2 g/kg/day. In an animal study, it shows 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 [4, 13].

Antimicrobial Properties

The growth of a variety of bacteria, parasites, and pathogenic fungi are reduced due to turmeric extract and the essential oil of Curcuma longa. A study of chicks which is infected with the caecal parasite. Eimera maxima proved that diets supplemented with

turmeric helps in a reduction in small intestinal lesion scores and improved weight gain. Another study show that topically applied turmeric oil, inhibited dermatophytes and pathogenic fungi when guinea pigs were infected with either dermatophytes, pathogenic molds, or yeast. The lesions disappeared at seven days post-turmeric application was observed in the dermatophyte- and fungi-infected guinea pigs. It has been observed while using Curcumin to have moderate activity against *Plasmodium falciparum* and *Leishmania major* organisms [4, 14, 13].

Antidiabetic Properties

The experimental study has proved that turmeric have significant role in diabetes. It has been observed that a hexane extract (containing ar-turmerone), ethanolic extract (containing ar-turmerone, curcumin, demethoxycurcumin and bisdemethoxycurcumin) and ethanolic extract from the residue of the hexane extraction (containing curcumin, demethoxycurcumin and bisdemethoxycurcumin) are dose-dependent stimulation of adipocyte differentiation. The result shows that the extract of turmeric ethanolic is the composition of curcuminoids and sesquiterpenoids is more strongly hypoglycemic than either curcuminoids or sesquiterpenoids. The effects of turmeric on postprandial plasma glucose and insulin are remarkable. It was observed that the ingestion of 6 g *Curcuma longa* had no significant effect on the glucose response [15–20]. Insulin changes extensively higher 30 min and 60 min after the OGTT including *Curcuma longa*. It is also been observed that AUC of insulin increases significantly after the ingestion of *Curcuma. longa* and OGTT [5]. Turmeric also decreases complications in diabetes mellitus. Experimental study on albino rats shows the effectiveness of turmeric on blood sugar and polyol pathway found that both turmeric and curcumin decreased blood sugar level in alloxan-induced diabetes [12].

Antioxidant Effects

Water and fat soluble extracts of turmeric and its curcumin component possess strong antioxidant activity, when it is comparable to vitamins C and E. Curcumin pre-treatment has effective result which decreases ischemia-induced changes in the heart. An *in vitro* study was conducted utilizing bovine aortic endothelial cells for measuring the effect of curcumin on endothelial hemeoxygenase-1, an inducible stress protein. This study also enhanced cellular resistance to oxidative damage, when curcumin incubated for 18 h. It can protect lipids or hemoglobin from oxidation. Curcumin have antioxidants properties so it can significantly inhibit the generation of reactive oxygen species (ROS) such as H_2O_2, superoxide anions and nitrite radical generation by activated macrophages. Its derivatives. can prevent and treating cholelithiasis, as derivatives (bis-demethoxycurcumin and demethoxycurcumin) also have antioxidant activities [4, 11, 13].

Hepatoprotective Effects

Turmeric demonstrated both hepatoprotective and reno-protective characteristic similar to silymarin mainly due to its antioxidant properties, as well as its ability to decrease the formation of pro-inflammatory cytokines (3–5). Animal studies have revealed that turmeric's hepatoprotective effects from a variety of hepatotoxic insults, including carbon tetrachloride (CCl_4), galactosamine, acetaminophen (paracetamol), and Aspergillus aflatoxin. It is noticed that in rats with CCl_4-induced acute and subacute liver injury ,administration of curcumin drastically decreased liver injury in test animals compared to controls. Extract of turmeric is very effective which inhibit production of fungal aflatoxin by 90% when tested on ducklings infected with *Aspergillus parasiticus* preventing and treating cholelithiasis possible due to sodium curcuminate, a salt of curcumin, also exerts choleretic effects by increasing biliary excretion of bile salts, cholesterol, and bilirubin, as well as increasing bile solubility [4, 11].

Anti-Cancer Effect

Numerous animal studies involving rats and mice, as well as *in vitro* studies utilizing human cell lines have been done on turmeric that influence on the carcinogenesis. Several in vitro studies have reported that curcumin is

 © STM Journals 2019. All Rights Reserved

able to control carcinogenesis at three stages: angiogenesis, tumour promotion, and tumour growth. Curcumin exerts inhibition of cell proliferation and tumour growth, noted by two studies of colon and prostate cancer. The activity of several common mutagens and carcinogens are also suppressed by turmeric and curcumin. Turmeric and curcumin have anti-carcinogenic effects have been related to direct antioxidant and free-radical scavenging effects, as well as their ability to indirectly 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 [11, 13].

It has been observed in Swiss mice that the dietary turmeric could be well used as a chemopreventive agent in benzo-(alpha)-pyrene-induced for stomach tumours. It is reported that to produce notable symptomatic relief in patients with external cancerous lesions when an ethanolic extract of turmeric, as well as an ointment containing curcumin is applied. Turmeric demonstrate that it neutralize carcinogenic free radicals due to its antioxidants property. Acetyl curcumin was found inactive. Many reports showed that turmeric inhibited tumour necrosis factor (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 as well act as a antitumor agents to be helpful in inducing apoptosis or programmed cell death (PCD) in human myeloid leukaemia cells (HL—60). It is evident from the test that the Curcumin-I, II, and III from turmeric have the properties of cytotoxicity, antioxidant and anti-inflammatory. Extensive research reveals that these compounds possess strong inherent property against leukaemia and colon, central nervous system (CNS), melanoma, renal, and breast cancer cell lines [12].

Cardiovascular Effects

Due to antioxidant property of turmeric which generates a protective effect on the cardiovascular system include lowering cholesterol and triglyceride levels, decreasing susceptibility of low density lipoprotein (LDL) to lipid peroxidation, and inhibiting platelet aggregation. A study reports that turmeric extract being given to 18 atherosclerotic rabbits with low-dose (1.6–3.2 mg/kg body weight daily) shows decreasing susceptibility of LDL to lipid peroxidation, in addition to that it lowers the plasma cholesterol and triglyceride levels. The higher dose decreases cholesterol and triglyceride level but it did not decrease lipid peroxidation of LDL. Turmeric extract's has its potential effect on cholesterol levels may possible be due to decreased cholesterol uptake in the intestines and increased conversion of cholesterol to bile acids in the liver. It was also observed that *C. longa* inhibits platelet aggregation to be *via* potentiation of prostacyclin synthesis and inhibition of thromboxane synthesis [4, 11, 13].

Gastrointestinal Effects

The constituents of *Curcuma longa* namely Sodium curcuminate and p-tolymethylcarbinol have several protective effects on the gastrointestinal tract. Sodium curcuminate exhibits the characteristics of inhibition of intestinal spasm and p-tolymethylcarbinol, increases gastrin, secretin, bicarbonate, and pancreatic enzyme secretion. Turmeric has also been seen that it can inhibit ulcer formation caused by stress, alcohol, indomethacin, pyloric ligation, and reserpine, considerably increasing gastric wall mucus in rats applied to these gastrointestinal insults [11]. A study performed with an open, phase II trial given on 25 patients with endoscopically-diagnosed gastric ulcer, where 600 mg powdered turmeric given five times daily, showed completely healed in 48% of patients. The results show no adverse reactions or blood abnormalities. It was noted that curcumin reduced mucosal injury in mice with experimentally induced colitis. In rat models of experimentally-induced pancreatitis, curcumin was able to decrease inflammation. In other type of induced pancreatitis such as cerulean or ethanol, curcumin was also able to inhibit the inflammatory mediators as measured

by histology, pancreatic trypsin, serum amylase, and neutrophil infiltration [13].

CONCLUSION

It has been revealed by wide-range of survey of the literature that *Curcuma longa* with diverse pharmacological characteristics is considered as a Universal panacea among the herbal medicine. This plant considered as a versatile medicinal plant which is responsible for the various usefulness as it possess various types of chemical compounds. So, it is obvious that to combat with the diseases a wide-ranged research is required to find their therapeutic utility. From time immemorial it is observed that crude extracts of different part of plants has its medicinal uses and the process of development of modern drugs now a days usually done by wide-ranged of research towards its bioactivity, manufacturing process, pharmacotherapeutics, toxicity and subsequently require proper standardization and clinical trials. Nowadays non-toxic plant-products used as traditional medicine like *Curcuma longa* required extensive research and development work towards utilising its medicinal value and effort should be made to explore the possibilities of practical clinical applications and details of hidden and untold areas towards its usefulness for the welfare of mankind.

REFERENCES

1. Phytochemical and Physicochemical Investigation of Curcuma Longa Linn Rhizome. MA Pawar. International Journal of Chemical and Physical Sciences. Jan 2015;4(special issue)NCSC.
2. Turmeric, Curcumin and Our Life: A Review. Jaggi Lal. *Bulletin of Environment, Pharmacology and Life Sciences*. June 2012; 1(7): 11–17.
3. Versatility of turmeric: A review the golden spice of life. Roshan Prasad Yadav *Journal of Pharmacognosy and Phytochemistry*. 2017; 6 (1): 41–46
4. Akram M. Curcuma Longa and curcumin: a review. *Rom. J. Biol. Plant Biol*. Bucharest, 2010;55(2):65–70.
5. Phytochemical Evaluation Curcuma Longa and Curcumin. Dhulipalla Naga Harish *International Journal of Pharmaceutical and Chemical Science.* Vol. 5 (4) Oct-Dec 2016.
6. Pandey NK. Book on Medicinal Plant Resources of South Bengal Research Wing Directorate of Forest Government of West Bengal Kolkata.
7. Turmeric: A spice with multifunctional medicinal properties. *Journal of Herb Med Pharmacology*. 2014; 3 (1): 501–508.
8. Pharmacognostic and Phytochemical Evaluation of the Rhizomes of Curcuma longa Linn. Nilanjana Deb. Journal of Pharma Sci. Tech. 2013; 2(2):81–86.
9. RS Sawant. Qualitative phytochemical screening of Rhizome of Curcuma Longa. *International Journal of Science, Environment. and Technology*. 2013; Vol. 2, No 4, , 634–641.
10. Duraisankar M. Identification of Curcuma Longa Rhizomes by Physicochemical and TLC Fingerprint Analysis. International Journal of Pharm Tech Research. 2015; 8 (6):198–205.
11. Longa Linn Rhizome. MA Pawar. *International Journal of Chemical and Physical Sciences*. Jan 2015;4(special issue)NCSC.
12. Turmeric: Nature precious Medicine Duggi Shrishail Asian Journal of Pharmaceutical and Clinical Research.
13. Velayudhan KC. Ethnobotany of Turmeric *Indian Journal of Traditional Knowledge*. October 2012;11(4):607–614.
14. Turmeric (Curcuma longa L.): A promising spice for phytochemical and pharmacological activities. Deepika Yadav, Shiv Kumar Yadav. International Journal of Green Pharmacy. April-June 2013.
15. Ravindran PN, Nirmal Babu K, Sivaraman K. Turmeric. The goldenspice of life. In: Turmeric. The Genus Curcuma. Boca Raton, FL, USA: CRC Press; 2007. p. 1-14.
16. Ammon HP, Wahl MA. Pharmacology of Curcuma longa. Planta Med 1991;57:1-7.
17. Saxena J, R Sahu. Evaluation of Phytochemical constituents in Conventional and Non-conventional species of Curcuma. *International Research Journal of Pharmacy*. 2012; 3 (8): 203–204.

18. WHO. Rhizoma Curcumae Longae, WHO monographs on selected medicinal plants Vol 1: World Health Organisation 1999.
19. Leela NK, Tava A, Shaf PM, John SP, Chempakam B. Chemical Composition of essential oils of turmeric (Curcuma longa L.). *Acta Pharma*. 2002; 52: 137–141.
20. Ammon HPT, Wahl MA. Pharmacology of Curcuma longa. *Planta Medica.* 1991; 57: 1–7.
21. Soudamini NK, Kuttan R. Inhibition of chemical carcinogenesis by curcumin. *J Ethnopharmacol.* 1989; 27:227–233.

Cite this article
Sayantani Chanda, T.V. Ramachandra. Phytochemical and Pharmacological Importance of Turmeric (Curcuma longa): A Review. *Research & Reviews: A Journal of Pharmacology*. 2019; 9(1): 16–23p.