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REVIEW ARTICLE **OPEN ACCESS**

Curcuma Longa: From Ancient History to Modern Medicine

Verinder Virk*, Himani Deepak, KhushbuTaneja
KanyaGurukula Campus,GurukulaKangri (Deemed To Be University)Haridwar- 249407, Uttarakhand, India.
***Corresponding author✉:**Virender.wahla@gkv.ac.in

ABSTRACT
Curcuma longa L. (Turmeric) is a member of Zingeberaceae family, belongs to one of the oldest cultivated spice crops, is indigenous to the Indian sub-continent, and is one of the most powerful herbal medicinal plants. This old spice is acknowledged from the past as both food and medication and has reemerged inside the wellbeing and nourishment networks. Curcumin is the recuperating substance that is responsible for the vibrant color, and most active component of turmeric. From folkfore to modern practices, the biological action of C. longa includes relieving from gastrointestinal disorders, menstruation, improving digestion to antimicrobial, antioxidant, antidiabetic, hepatoprotective, anti-cancerous, anti-allergic, helpful in Alzheimer's disease, immunostimulant, and other ailments. From the ages, no other medicine can replace the medicinal value of Turmeric. Today's scenario is increasingly changing towards the use of non irresistible items having conventional therapeutic value. Curcumin, a substantial component of C. longa has a wide therapeutic potential with low toxicity as well therefore, it should be considered in order to control various harmful ailments. In the present review, we aimed to summarize the potential of C. longa and its derivatives on therapeutical and pharmaceutical potential and also discussed the mechanistic insight to explore the trends and future perspective of C. longa and its derivatives in order to benefit the human welfare.
Keywords: *Curcuma longa*, Turmeric, Biological activities, Nanoformulations, Nanocurmin.

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INTRODUCTION

India has a rich heritage for flora imparting various culinary, medicinal and therapeutical principles. *Curcuma longa* L. (Turmeric) is a rhizomatous herbal plant widely used as a spice, dye and used as a medicine in Ayurveda, Unani and Siddha tradition medicinal system [1]. Turmeric belongs to the ginger family and is one of nature's most wonderful and powerful healers. The word Turmeric is derived from a Latin word "terra merita" which means "meritorious earth". In South India, turmeric is popularly known as "Manjal" and in North India, it is communally know as "Haldi", derived from a Sanskrit word "haridra". Turmeric plantation needs a temperature range from 20 to 30ºC with annual rainfall of 1500-2500 mm. The plant thrives best in sandy to loamy soil. So far, there are upto 250 compounds have been known from turmeric [Figure 1]. Where the outer surface of rhizome is rough and cuneate in appearance, the internal surface is yellow in color; substantially due to presence of Curcuminoids. The prominent curcuminoids are curcumin, demethoxycurcumin and bis-demethoxycurcumin [2]. The main ingredient in turmeric is found to be Curcumin and has been utilized for over 2500 years in India. Curcumin is derived from the underground part i.e., rhizome. The therapeutic properties of turmeric have been gradually uncovering themselves throughout the ages [3].Plant goes up to three to five feet in height with oblong pointed leaves bearing beautiful funnel shaped yellow colour flowers and rhizome that horizontally grow underground from which roots and shoots emerges. Turmeric is cultivated widely in the tropical countries, Asia, India and China [Figure. 2]. The rhizome of the plant is the threshold as the powder of rhizome has extensive medicinal values. Dried turmeric powder is the main source which imparts yellow colour in food as flavour and colour. Turmeric classification by Linnaeus and its categorization is as follows [Table 1]. India is the largest producer of turmeric in the world. The production of turmeric globally is around 11 lakh tonnes/annum. *Curcuma longa* is a domiciliary species while *Curcuma aromatica* is popularly known as wild turmeric. The most commonly used form of turmeric is its rhizome as a whole or its powder Ailments that can be treated with rhizome powder includes the treatment of biliary cholangitis, chemopreventive properties, hypertension, anorexia, coryza, hypercholesterolemia, cough, diabetic wounds, hepatic disorders, rheumatism, chest congestion and sinusitis in Indian traditional medicinal system. The first

compound isolated from the "wonder drug" was Curcumin in 1815, which imparts the yellow color to the rhizome. The structural formula was determined in 1973 by Roughley and Whiting with a melting point at 176–177°C; which upon reacting with alkali forms a reddish-brown salt. It has solubility ranging from ethanol to alkali, ketone, acetic acid and chloroform [4,5] [Table. 2].

Essential oil present in the rhizome of *Curcuma longa*.:

The chemistry of *Curcuma longa* constitutes phenolic compounds such as diarylheptanoids, diarylpentanoids, phenylpropenes, vanillic acid and vanillin, terpenes (monoterpenes, sesquiterpenes, diterpenes and triterpenoids), fatty acids (linoleic acid, 8,11-octadecadienoic acid, methyl ester, palmitic acid (***n***-hexadecanoic acid), oleic acid and stearic acid), steroids (β-sitosterol, stigmasterol, gitoxigenin and 20-oxopregn-16-en-12-yl acetate) and miscellaneous compounds (curcuma-J, 2-(2′-methyl-1′-propenyl)-4, 6-dimethyl-7-hydroxyquinoline, 2,3,5-trimethylfuran, (1,2,3-trimethyl-cyclopent-2-enyl)-methanol, dicumyl peroxide, 1-(3-cyclopentylpropyl)-2,4-dimethy-benzene, 1,4-dimethyl-2-(2-methylpropyl)-benzene, cyclohexylformate and methyl eugenol) [6].Rhizome and leaf oil from *C. longa* are widely used in pharmaceutical and cosmetic applications [Figure 3]. Ar-turmerone, α-turmerone, and β-turmerone are the biologically active constituents in the essential oil of *C. longa* with proven antimicrobial, antioxidative, antiinflammatory activity, and anticancer potentials. Therefore, both curcuminoids and volatile components are the basis for healthy efficiencies of turmeric. Other essential oil found in leaf and rhizome part includes turmerene, turmerol, zingiberene, limonene, α-phellandrene, 1,8-cineole, β-sesquiphellandrene, terpinolene, p-cymene, ar-curcumin, β-curcumin and terpinolene [7].

BIOLOGICAL ACTIVITIES OF TURMERIC

ANTIDIABETIC ACTIVITY OF TURMERIC

Diabetes mellitus (DM) is a group of metabolic conditions that have arrived at pandemic extents around the world. Diabetes is a metabolic condition arises when blood sugar level is high. The peripatetic movement of sugar from blood to different cells in the body can be carried out by insulin hormone. While in diabetic condition, body is not able to make enough insulin or if it makes, body cells have not efficient energy to metabolize that sugar. From ancient Ayurveda and Traditional medicinal system, Turmeric has been frontline choice for treating diabetes related complications. On the basis of empirical data, diversifying nature of Curcuminoids possess positive results in interconventional studies in order to treat liver related diseases, insulin resistance and glycemic conditions, etc. [8]. Curcumin plays a significant role in controlling the blood glucose production in vivo by enhancing the insulin signalling. Use of Curcumin brings about great difference in improving the insulin sensitivity by increasing the Fibroblast Growth Factor (FGF). As compared to insulin resistance, insulin sensitivity authorizes the body cells to metabolize glucose more efficiently [9]. In vivo studies suggest that Curcumin has a profound effect on decreasing Reactive Oxygen Species (ROS) and Lipid oxidation products (LOPs) by increasing antioxidant enzymatic activities. Also, turmeric has a preferential role in the homeostasis of lipid and glucose levels in serum. In addition, directing Curcumin into animal models resulted into improved renal functioning and increased mitochondrial cell numbers. Also there is reduction in pro-inflammatory cytokine level and macrophage percolation to adipose tissue and liver [10].

ANTIBACTERIAL ACTIVITY OF TURMERIC

One of the biggest challenges facing by mankind is antimicrobial resistance against antibiotics. The diseases caused by bacteria, fungus and viruses influence human population all over the world, so there is a continuous research in discovering the unconventional therapeutic approaches to overcome the problem [11]. Turmeric extracts have better properties to penetrate in to the cell wall of bacteria, causing cell permeabilization resulting into the leakage of inorganic cations thus inhibiting pathogenic bacteria such as *Escherichia coli*, *Salmonella typhi* and *Staphylococcus aureus* [12]. Curcumin possess therapeutic properties usually at low or zero toxic doses. In combination with other antibacterial agents, it inhibits *Staphylococcus aureus* [9,13]. Currently, a possible approach of Curcumin includes its application in reducing the cross-contamination from waste water by inhibiting the growth of *Escherichia coli* [14].The continuous sources of antimicrobials are from the natural products. From traditional to modern practices, Curcumin has always been the choice of medicinal plant to treat various disorders. Previous studies have suggested that curcumin possesses a wide spectrum of biological and pharmacological properties, for example, as anti-inflammatory, anti-angiogenic and anti-neoplastic, while no toxicity is associated with the compound. More recently, it has been investigated that curcumin from *Curcuma longa* obtain the properties to invade the members of orthomyxoviridae, flaviviridae, retroviridae family. Flavonoids from rhizome suppress the Ftsz protein which is responsible for bacterial cytokinesis thereby suppressing the growth of *Staphylococcus*, *Streptococcus*, and *Pseudomonas* as well. However, curcumin as a therapeutic antiviral agent approval is still needed [15].

The strain specific activity of curcumin makes it a possible candidature for blocking the harmful action of several pathogenic bacteria such as *Staphylococcus aureus, Streptococcus pyogenes, Acinetobacterlwoffii, Enterococcus faecalis* and *Pseudomonas aeruginosa*. Hence, Curcumin can be considered as a good source for inhibiting human pathogens [16].

ANTIFUNGAL ACTIVITY OF TURMERIC

Fungal infections are increasing at an alarming rate due to increase in resistance against antifungal drugs. They are responsible for health-related complications, especially in immunocompromised patients. There are two main types of fungal infections: systemic and localized fungal infections. These limitations emphasize the need to develop new and more effective antifungal agents with lesser side effects. Ethanolic extracts tend to have higher antimicrobial potential when compared with the aqueous extraction. Ethanolic extracts are reservoir for a variety of chemical compounds such as phenolics and their derivatives, terpenes alkaloids, esters of fatty acid and so on. These compounds exhibit broad spectrum antimicrobial activity by attacking multiple target sites of pathogenic bacteria [17] **[Figure 4]**. Turmeric leaf extract has increased inhibitory action. This ability is due to the presence of an enzyme i.e., curcuminoid synthase. The role of curcuminoids synthase is to convert Feruloyl-CoA into curcumin [18]. Moreover, ethanolic extracts of *Curcuma longa* have suppressing activity against *Candida albicans*. The organic solvents such as ethanol and methanol have the proficiency to separate most of the polar molecules such as phenols, terpenes, fatty acid and their esters, glycosides and their derivatives. These compounds exhibit anti-infective activity against fungal pathogens by binding of active target sites of pathogens and blocking the expression of protein synthesis [19]. Recent studies suggest that aqueous extracts of *Curcuma longa* can be used as biopreservative, which in turn enhancing the shelf life of food by inhibiting the growth of food borne pathogens. The application of aqueous extract of *Curcuma longa* has found to be effective in inhibiting *Penicilliumpanemun, Penicillium citrinum, Cladosporiumoxysporum,* etc. Use of curcumin based extract affects the developmental stage of fungal pathogens thus prolonging the shelf life of food [20].

ANTI-INFLAMMATORY ACTIVITY OF TURMERIC

As per Computerized database MEDLINE, there has been a countless investigation on Curcumin ranging from invivo to invitro (including animals and humans). It was reported that in human trials at 8000mg/gm for up to 90 days, Curcumin was found to be effective and safe with no toxicity at all. Administration of 1125-2500 mg/gm/day in human trials was also found secured. Reports also intimated that curcumin has inhibitory effect on various inflammatory molecules such as secretory Phospholipase, lipooxygenase, cyclooxygenase, leukotrines, thromboxanes, prostaglandins, nitric oxides, tumor necrosis factor, monocyte chemoattractant protein-1, IL-12 and many more [21]. Anti-inflammatory drugs can interfere in the pathophysiology of inflammation, seeking to minimize tissue damage and provide greater patient comfort [22]. The active constituents of *C. longa* :demethoxycurcumin and bisdemethoxycurcumin have potential anti-inflammatory activity. The synergistic effect of *Curcuma longa* and *Allium hookeri* in a carrageenan-induced inflammatory model effectively inhibiting the inflammatory cytokines, such as IFN-γ and interleukins (IL-1β, IL-6, IL-13, and IL-17), and recovered inflammation-related morphological changes in the skin via the NF-κB/COX-2/iNOS pathway [23].

ANTIOXIDANT ACTIVITY OF TURMERIC

Plants contain a large number of bioactive compounds with high antioxidant activity. Endogenous factors which are responsible for causing oxidative stress such as reactive oxygen species (ROS) including the hydroxyl radical, superoxide anion radical, hydrogen peroxide, singlet oxygen, nitric oxide radical, hypochlorite radical, etc., and exogenous factors such as smoking, ionizing radiation, pollution, organic solvents, pesticides, etc. These factors have the capacity to strike macromolecules as well as micro molecules resulting in the loss of structure and function. In the human body, there is a balance between the amount of free radicals produced and antioxidants. Curcumin, a well-known yellow pigment, is a potential substance that may control oxidative stress-induced cellular damage owing to its radical scavenging activity [24]. The flavonoids and polyphenolic contents from aqueous and ethanolic extracts of turmeric (*C. longa*) have high free radical scavenging activity through the suppression of H_2O_2-induced ROS generation in Vero cells (in vitro) and in Zebrafish (*invivo*) model [25,33]. Proinflammatory cytokines, lipid peroxidation products, PI3K/Akt, and hepatic stellate cell activation are among the mechanisms suppressed, as are cellular responses to oxidative stress, such as the expression of Nrf2, SOD, CAT, GSH, GPx, and GR. The scavenginc activity is mainly due to phenolic, β-Diketone and methoxy groups [26].

HEPATOPROTECTIVE ACTIVITY

Accumulation of bundles of collagen, proteoglycans and other related macromolecules in the extracellular matrix resulting in the liver cirrhosis. Turmerone, altlantone, zingiberene and flavonoids are the active components responsible for inhibiting Thioacetaimde induced liver toxicity [27]. TAA induced liver toxicity can be inhibited by the action of curcuminoids present in the rhizome of Curcuma longa. Increased level of antioxidants and glutathiones can also be the reason behind hepatic detoxification [28]. However, curcumin

along with other phytochemicals such as picroliv and ellagic acid were found effectual against CCL4 induced liver toxicity in mice and induction of CCL4 in liver cells shortens the production of cytochrome [28,29]. Transaminase enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ASP) are normally present in blood serum at lower concentration. Elevated levels of transaminase enzymes suggested the hepatic damage and cellular degeneration. Aqueous extract of *C. longa* control the elevated serum levels in albino wistar rats with a dosage of 100mg/kg upto 400mg/kg for 28 days. These findings suggest that *Curcuma longa* is suitable for controlling the liver damage [30] **[Table 3]**.

NANOFORMULATIONS

Besides various applications of curcumin in medicinal, pharmaceutical and food industry, it has some drawbacks of being low solubility and easy excretion from the body, causing hindrance in its bioavailability as a therapeutic agent. In order to improve the pharmacokinetic index of curcumin, various approaches have been undertaken. These approaches include use of adjuvants (in order to improve its absorptivity), nanoformulations, encapsulation, curcumin-phospholipid complex and synthesizing complex nanostructures. Amongst all, a nanoformulation is quite rapid and provides increased bioavailability for curcumin [47]. Recently, the use of plant-based nanoformulations (nanoencapsulation and nanocurcumin) has solved the problem of solubility making curcumin feasible for therapeutic application and noticeable for their remarkable properties and applications. Ionic gelation and antisolvent precipitation techniques are used for synthesis of nanocurcumin [48]. Green synthesis of nanoparticles has receives a great attention because of various advantages such as: low cost, less laborious, easy to access, biocompatible, and eco-friendly. Nanotechnology has emerged as a revolution in food industry. Application of nanocurcumin comparative to curcumin yields more positive results. Turmeric and its components such as cellulose and starch can be used to make nanostructures (nanocellulose and nanostarch, respectively) which further enhance the efficacy of turmeric in food industry [49]. These nanostructures act as a carrier for delivering nanoparticulates into the possible target sites [50]. Amongst various metal nanoparticles such as gold, silver, zinc, platinum, titanium, iron, thallium, silver nanoparticles are extensively studied for a wide array of commercial value. Silver nanoparticles directly or indirectly interact with DNA and proteins by breaking the nuclear membrane resulting into enhanced reactive oxygen species (ROS); thus triggering the cell cytotoxicity inside the pathogenic bacteria. Aqueous extract based silver nanoparticles reveal that TuAgNPs (Turmeric-silver-Nanoparticles) have better antimicrobial, antioxidant and anticancerous activity [51] **[Figure 5]**. Oral administration of nanocurcumin emanates the decreased expression of pro inflammatory cytokines (IL-6 and IL-1β). However, nanocurcumin was not able to control the expression of mRNA, TNF-α and IL-18 [52, 59] **[Table 4]**.

Fig.1Plantation of *Curcuma longa* L

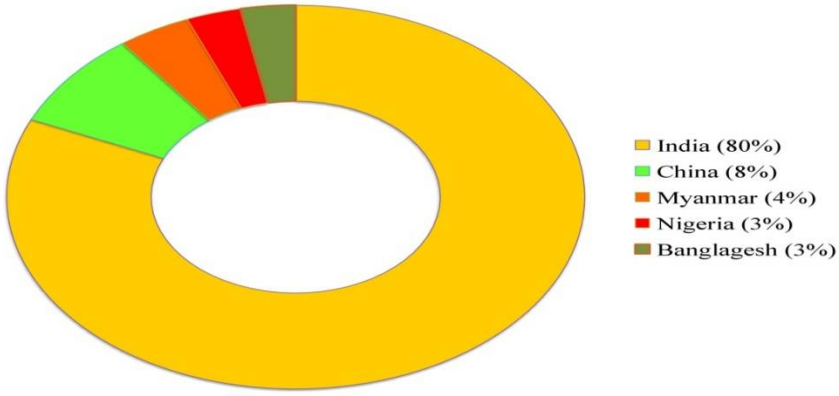

Fig. 2: Turmeric production globally per year.

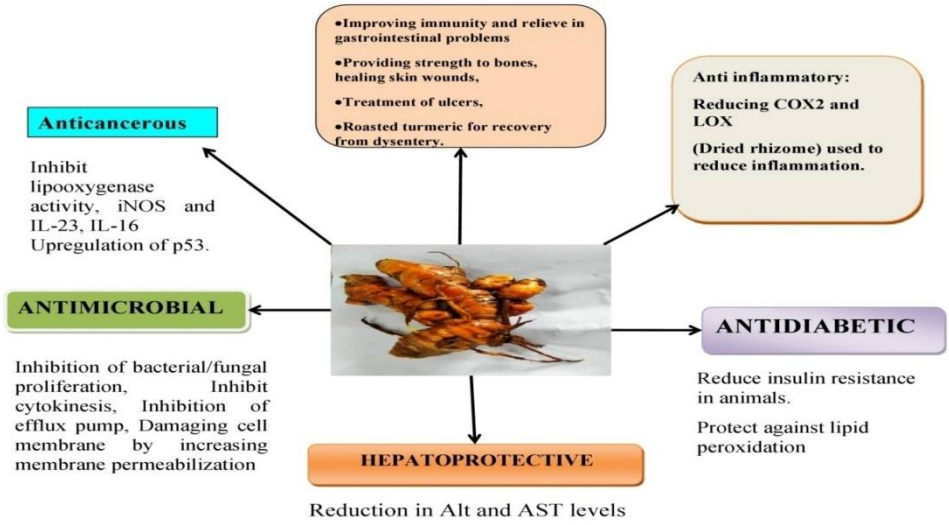

Fig. 3: Schematic diagram showing various biological activities of *Curcuma longa* L.

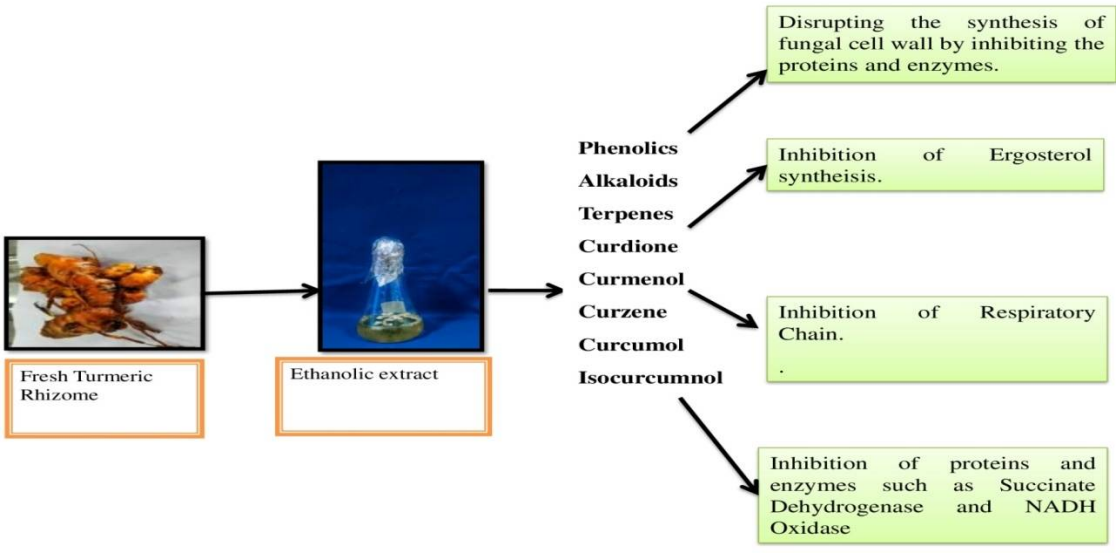

Fig. 4: Antifungal activity of *Curcuma longa*.

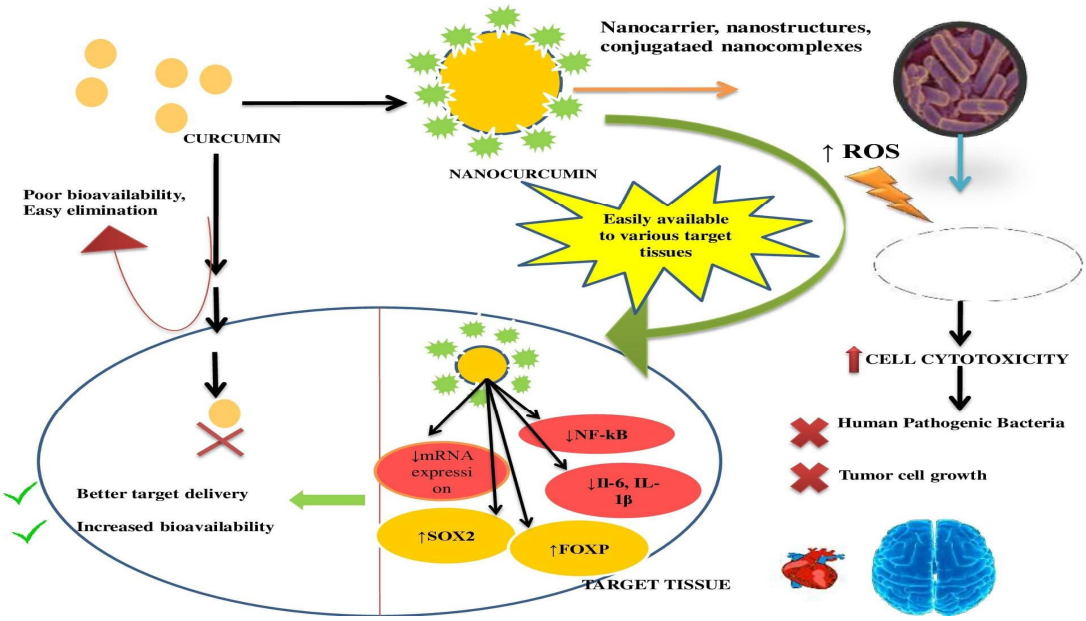

Fig.5: Curcumin and Nanocurcumin bioavailability to various target tissues.

Table 1: General classification of *Curcuma longa* L.

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Monocots
Class	Liliopsida
Subclass	Commonlinids
Order	Zingiberales
Family	Zingiberaceae
Genus	Curcuma
Species	*Curcuma longa*

Table 2: Nutritive value of Turmeric/100g. (Source: USDA National Nutrient Database.).

ENERGY	354Kcal	FOLATES	39µg	SODIUM	38mg
CARBOHYDRATES	64.9g	NIACIN	5.14mg	POTASSIUM	2525mg
PROTEINS	7.83g	PRYIDOXIN	1.8mg	CALCIUM	183mg
FATS	9.8g	VITAMIN C	25.9mg	IRON	41.42mg
CHOLESTEROL	0	VITAMIN K	13.4µg	MAGNESIUM	193mg

Table 3: Various Biological Activities Exhibited By Turmeric.

S.No.	Plant Part (Turmeric)	Biological Activity	Response	Compounds	References
1.	Rhizome	Antioxidant Antimicrobial	Inhibiting α-glucosidaseactivity	Digalloyl-hexoside, Caffeic acid hexoside, Curdione, Coumaric, Caffeic acid, Sinapic acid, Qurecetin-3-D-galactoside, Casuarinin, Bisdemethoxycurcumin, Curcuminol, Demethoxycurcumin.	[31]
2.	Leaf	Antimicrobial	Against *Escherichia coli, Staphylococcus aureus, Shigelladysenteria.*	Alkaloid, flavonoid, glycoside, saponin and triterpenoid /steroid compounds	[32]
3.	Leaf	Antioxidant	Activity against H_2O_2-induced oxidative stress 9Invitro and Invero-cells and Invivo in Zebrafish)	Diosmetin, Quercitrin, Rutin, Miquelianin, Taxifolin, Myrictrin, Puerarin, Narirutin, Naringin, Quercetin.	[33]
4.	Rhizome	Anti-inflammatory, Antibacterial, Antioxidant, Hypoglycemic	↓Inflammatory cytokines, ↑Immunoglobulin E level, ↓oxidative stress	7-O-rhamnoside 4-O-glucoside, 7-methoxyapigenin-6-C-glucoside N-(3-methoxyphenyl)-acetamine	[34]
5.	Curcuma longa essential oil (CL-EO)	Antiaging	Ultraviolet-B induced skin damage	Ar-turmerone, β-turmerone, germacrone, curlene, 8,9-dehydro-9-formylcycloisolongifolene, β-sesquiphelandrene, α-himachalene, ledane	[35]
6.	Rhizome	Insect repellent activity, crop protection	Activity against mosquito	Juice, essential oil	[36]
7.	Rhizome Extract	Antimicrobial	inhibit cytoplasmic membrane formation, cell disruption	Alkaloids, tannins, flavonoids, glycoside, carbohydrate	[37]
8.	Rhizome Methanolic Extract	Antibacterial	Activity against *Staphylococcus aureus*	AR-tumerone, arachinsaeure, alpha-tumerone	[38]
9.	Rhizome Essential Oil	Antimicrobial, Weedicide, Food preservative	Crops infection, broad spectrum activity against food spoilage microorganisms.	Ar-turmerone, α-turmerone, β-turmerone	[39]
10.	Rhizome	Antioxidant	Protection against free radical scavenging damage.	Polyphenol, flavonoid, tannins, ascorbic acid	[40]
11.	Rhizome	Anticancerous, antimalarial, antioxidant	-	Taxol, curcumin, and vinblastine, artemisinin and acridone	[41]
12.	Rhizome	Anti-cancerous	Activity against prostate cancer PC3 cells, downregulation of protein expression	Curcuminoids (Curcumin, bisdemethoxycurcumin, demethoxycurcumin)	[42]
13.	Rhizome	Anticancerous	Downregulating cancer cell formation.	β-sesquiphellandrene (SQP), α-curcumene, ar-	[43]

				turmerone, α-turmerone, β-turmerone, γ-turmerone	
14.	Rhizome	Antidiabetic, Anticholinesterase (AChE), Butrylcholinesterase (BChE)	Downregulate the action of α-glucosidase enzyme.	Curcumin, Bis-demethoxycurcumin, demethoxycurcumin	[44]
15.	Rhizome	Antidiabetic and Pharmacokinetic Profile	↓ Blood glucose level, ↑ Beta cell functioning, ↑ Insulin sensitivity, ↓ Insulin resistance.	Curcumin, desmethoxycurcumin, bisdemethoxycurcumin, curcumin-O-glucuronide and curcumin-O-sulfate	[45]
16.	Rhizome	Antiviral, Immunomodulatory	Prophylactic activity against SARS-CoV-2, blocking of viral proteases, inhibition of NF-κβ,inflammosomesHMGB1(High mobility group box 1) pathway	-	[46]

Table No.4: Summary of curcumin nanoformulations with their properties.

Nanoformulation	Mode	Doses	Properties	References
CUR/HP-β-CD	Hydroxypropyl-β-cyclodextrin-encapsulated CUR complex	2mg/kg; intranasal administration	Reduction in cellular cytotoxicity, antioxidant activity	[53]
THERACURMIN	Curcumin (10%), curcuminoids (2%), glycerine (46%), gum ghatti (6%),water (38%).	30mg-210mg; Oral administration	Better absorption, ↑Plasma curcumin level	[54]
Nanoformulated PLGA-Curcumin	Orally	5mg PLGA-Curcumin (70μg/mg - 350μg/mg)	Treatment of Human Cerebral Malaria; inhibit inflammatory cytokines in the brain, inhibiting chemokine receptor and its ligand (CXCR3 and CXCL, respectively),	[55]
Nanocurcumin	Randomized Double Blind Placebo-Controlled Clinical Trial	80mg; oral administration	Decreasing the expression of Distal symmetric polyneuropathy in Type 2 Diabetes Mellitus	[56]
Curcumin nanoparticles	PLGA-encapsulated NPs	Curcumin NPs; 5mg/kg/day, Curcumin suspension; 100mg/kg/day	Reduction in Hepatic steatosis, Controlled systolic blood pressure,	[57]
Encapsulated Curcumin Nanoparticles (ENCPs)	Chitosan entrapped curcumin nanoparticles	1.5mg/kg	Better antioxidant activity, Decreased arsenic toxicity	[58]

*PLGA= Poly(lactic-co-glycolic-acid), HSA=Human serum albumin, HTA=Holotransferrin, Nano-CUR=nanocurcumin.

CONCLUSION AND FUTURE PERSPECTIVE

To recapitulate, the present review summarizes the application of traditional medicinal plant on to the mankind itself. From the ages, people have endeavoured the medicinal plants in order to relieve from pain and illness. A large number of medicinal plants along with their therapeutical properties have come to known with a wide array of usefulness such as health facility, cosmetic industry, and pharmaceutical industry and so on. The application of turmeric comprises the plethora of treatment in order to cure wounds, bacterial/fungal infections, gastrointestinal related disorders, osteoarthritis, stress injuries, skin diseases, diabetes, anti-inflammatory, antioxidant, immunomodulatory, oxidative stress, hepatic toxicity, cardiovascular complications, blood purification, promoting bone health, relieving from menstrual pain, along with antifertility, antiprotozoal, antiviral, and anticoagulant activities as well [6, 60]. Poor solubility curtails the bioavailability of curcumin in different target tissues. Subsidiary levels of curcumin does not infiltrate towards the tissue level. Nesfatin-1 is a hypothalamic polypeptide which regulates the blood glucose level. The level of Nesfatin-1 polypeptide after curcumin treatment in brain, adipose tissue and blood plasma was found to be 2.202±02ng/ml, 1.699±0.09ng/ml and 203±38.4mg/dL, respectively when compared with the diabetic induced condition [67]. While comparing the nanocurcumin and ordinary curcumin efficacy invivo, nanocurcumin gets easily bioavailable in the stomach and the small intestine for its fast absorption. Uptake of nanocurcumin resulted in increased lipid profile, increased fasting blood sugar, insulin resistance and increased serum levels of alpine. Moreover, lower concentration (200mg/kg) is more effective rather than the higher concentration of nanocurcumin (>200mg/kg). Thus, therapeutic effects of nanocurcumin rely on dose-dependent manner. With increasing the dose concentration, there is decrease in the therapeutic efficacy [68]. Hence, lower concentrations of nanoformulations have to be checked in order to better therapeutic delivery. Nevertheless, these findings indicate that further research is necessary to resolve the impact of dose-dependent nanocurcumin with contrasting various biological activities in order to treat different ailments. To ameliorate the bioavailability of curcumin, much focus is needed towards the synthesis of nanobioparticulates, nanocores, nanostructured carriers, liposome-mediated nanoparticulates, metal coated nanoparticles, nanoadsorbants and cycodextrin-conjugated nanoparticles, which can be the frontiers of therapeutic agents.

Conflict of Interest

The authors declare no conflict of interest.

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