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Review Article

A Review On The Therapeutic Potential Of Curcumin

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ABSTRACT

Since it is the primary source of the naturally occurring polyphenol curcumin, turmeric, a spice with long-standing medical benefits, has drawn attention from both the scientific and medical communities and foodies. It helps in the management of anxiety, arthritis, metabolic syndrome, oxidative and inflammatory diseases, and hyperlipidemia. It could also aid in the control of inflammation and muscular pain brought on by exercise, improving recuperation and function in those who lead active lives. Furthermore, individuals without medical diagnoses may benefit from the complex at very modest dosages. The majority of these advantages are related to its anti-inflammatory and antioxidant properties. Because of curcumin's low bioavailability—which appears to be mostly caused by poor absorption, fast metabolism, and rapid elimination—ingesting it by itself does not provide the related health advantages. Numerous elements have the capacity to boost bioavailability. For instance, it has been demonstrated that piperine, the main active ingredient in black pepper, increases bioavailability by 2000% once it forms an association with curcumin. When mixed with boosting substances, curcumin offers a variety of health advantages. The aim of this study is to present a concise summary of the extensive body of studies on the health advantages of curcumin.

INTRODUCTION

People have used herbs and other natural items to treat a wide range of illnesses since the beginning of time. The Indian subcontinent has a wide variety of plants, containing species that are both fragrant and medicinal. Ultimately, before bringing Unani and Ayurvedic medications to the marketplace as first-line delivery systems for drugs, efforts should be undertaken to evaluate, standardise, and validate their potential, safety, and efficacy [1,2]. All cultures employ plant-based healing practices. Many nations currently use a large amount of based on plants medicine, and they allocate between 40% and 50% of their overall health expenditure to the development of new medications. It is believed that herbal medications improve health without causing any negative side effects [3,4]. The fields of science and medicine as well as cooking have both shown a great deal of potential in turmeric. Curcuma

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longa, a perennial herbaceous plant, belongs to the ginger family and is rhizomatous. Although curcumin's source, turmeric, has been used for millennia for its medical benefits, only lately has research been done to pinpoint the precise mechanism(s) that operate and identify the bioactive ingredients [5,6]. Curcumin, commonly referred to as diferuloylmethane, is the primary naturally occurring polyphenol present throughout the rhizome of Curcuma longa (turmeric) along with other Curcuma spp. Asian nations have long utilised curcuma longa as a medicinal herb because of its cancer prevention, antimicrobial, anti-inflammatory, antimutagenic, and antioxidant qualities [7]. The genus Curcuma, which has been used for medicinal purposes for a long time, is made up of about 133 species internationally. Common species of the genus Curcuma found in many parts of the world include C. longa (Haridra), C. aromatica Salisb (Vana Haridra), C. angustifolia Roxb., C. zanthorrhiza Roxb., C. amada Roxb (Amaragandhi Haridra), C. caesia Roxb (Kali Haridra), and C. zedoaria Rosc (Zedoary). Known as "Indian saffron" or "The Golden Spice of India," Curcuma longa Linn. (C. longa) is a common tall herb that grows well in tropical and other Indian regions. Indian homes employ it as a spices, food preservation agent, and colouring source for a wide range of illnesses. One of the earliest spices in India, it has been used for millennia in the West and Southern regions of the country and is a key component of Ayurvedic treatment [8,9]. The well-established medicinal benefits of C. longa in Ayurveda are covered in the works Dashemani Lekhaniya (emaciating), Kusthagna (anti-dermatosis), and Visaghna (anti-poisonous). It's referred to by a variety of names, including manjal in South India, Haldi in Hindi, Jianghuang (yellow ginger) in Sanskrit, and Kyoo or Ukon in Japanese, which all translate to "efficient medication for jaundice." In addition to being widely discussed in Indian material medica (Dravyaguna Shastra), C. longa is rubbed daily to the foreheads of Hindu ladies as part of their beautification ritual [10,11]. Curcumin is a polyphenol that has been demonstrated to exhibit action at levels within cells and to target various signalling molecules, supporting its many health advantages. It is being demonstrated to aid in the treatment of degeneration and inflammatory eye diseases, pain, metabolic syndrome, and inflammatory illnesses. It has also been demonstrated to have kidney-beneficial effects [12]. Curcumin supplements seem to provide a plethora of medicinal advantages, however the majority of these advantages stem from its anti-inflammatory and antioxidant qualities.Among the main issues with taking curcumin by itself involves its low bioavailability, which seems to be mostly caused by inadequate absorption, fast metabolism, and rapid elimination, despite its stated advantages via inflammation and antioxidant processes [13]. Curcumin's bioavailability has been studied using a number of drugs that target these different processes. To boost curcumin's bioavailability, the majority of them have been designed to obstruct its metabolic route. For instance, the main active ingredient in black pepper, piperine, is a recognised bioavailability booster and is linked to a 2000% rise in curcumin's bioavailable. Therefore, introducing compounds that improve bioavailability, such piperine, into the curcumin compound seems to remedy the problem of low bioavailability [14]. The pharmaceutical manuals of China, Japan, and Korea all recognise it well, and a wide spectrum of medical ailments can benefit from its administration. It is used to treat wounds, dermatitis, hepatitis an infection, inflammation connections, sore throats, and urticaria in China. It was described as both an aromatic stimulant and carminative in documents pertaining to Hindu mythology [15]. In fact, sprains and swelling brought on by wounds can be

effectively treated at home using turmeric powder and calcium hydroxide, or the powdered form can be administered directly to the injury site. Dried curcumin powder has long been used in traditional medicine to heal ailments. According to reports, C. longa possesses antioxidant, antibacterial, antitumor, antitoxic, and anti-inflammatory properties [16].

Phyto-chemistry of C. Longa

C. longa is a very nutritious natural dietary component since it includes fibre, carbs, phosphate, potassium, calcium, lipids (no cholesterol), certain proteins, and vitamin C. 32 Curcuma species have yielded 719 identified and isolated components to date, including terpenoids, flavonoids, alkaloids, diphenylalkanoids, steroids, and derivatives of phenylpropene. More than 235 phytoconstituents were discovered in the rhizome, the bulk of which are composed of terpenoids and polyphenols. Curcuminoids are the most prevalent polyphenols, comprising 80% of curcumin [17,18]. Eight phenolics, five diterpenes, four sterols, three triterpenoids, two alkaloids, 68 monoterpenes, 22 diarylheptanoids and diarylpentanoids, 109 sesquiterpenes, and 14 other compounds are present. C. longa typically contains moisture (>9%), volatile oils (<3.5%), other compounds (<0.5%), curcumin (5–6.6%), and mould (<3%). The aromatic compounds of roots and rhizomes are dominated by sesquiterpenes, whereas monoterpenes predominate within the essential oils of blossoms and leaves. 25% tumerone, 11.5% curdine, and 8.55% ar-turmerone are included in the oil's components. In addition to having anti-mutagenic properties, C. longa oil can stop smokers' urine mutagens from developing and excreting them. Based on the most recent examination, the rhizome's volatile oil concentration was around 3.97%, with the main components examined by gas chromatography being ar-turmerone (40%), α-turmerone (10%), and curlone (23%) [19,20]. Ar-turmerone is commonly used as an insect repellent, and the leaf extract has demonstrated its capacity to kill mosquitoes. Proteins, volatile oils (tumerone, atlantone, and zingiberone), sugars, resins, and polyphenolic curcuminoids including curcumin (about 80%), demethoxycurcumin (about 12%), and bisdemethoxycurcumin (about 12%) are all abundant in C. longa (Ashraf, 2018). The well-researched active component of raw C. longa is curcumin, which ranges from 0.3% to 5.4%. The main C. longa products, together with their uses, chemical composition, and physical appearance, are shown in Table 1 [21]. Acidic polysaccharides (ukonan A, B, C, and D) and 4.2% volatile oils (turmerone, ar-turmerone, curcumene, germacrone, and ar-curcumene as the primary constituents) are known to be present in the C. longa plant. The 5.8% essential oils are composed of 0.6% sabinene, 0.5% borneol, 1% α-phellandrene, 1% cineole, 53% sesquiterpines, 25% zingiberene, and 3-4% curcumin. The yellow colour is attributed to phenolic diketone curcumin, which is made up of curcumin I (94%), curcumin II (6%), and curcumin III (0.3%). Liao et al. (2011) reported the following: protein (6.3%), fat (5.1%), minerals (3.5%), carbs (69.4%), and moisture (13.1%).

Table 1: The primary products of C. longa, including its application, appearance, and chemical makeup [21]

S. No	Product Name	Appearance	Chemical Composition	Uses
1	Whole rhizome (dried form)	Orange-brown, red-yellow, or pale yellow	1.5%–5% essential oils and 3%–15% curcuminoids	Medicinal purposes

2	Ground C. longa	Yellow or red-yellow	Preparation and proximity to light can both diminish curcuminoids and essential oils. A container impervious to UV light is required to keep the powder.	Used as a food additive, colorant, medication, and condiment.
3	C. longa oil	Yellow to brown oil	The essential oils of leaves and rhizomes are mostly composed of monoterpenes and sesquiterpenes, correspondingly.	Used as a nutritional supplement, medication, and spice
4	C. longa oleoresins	Reddish-brown, dark yellow, thick liquid	25% of curcuminoids and 37%–55% of essential oils	employed as a nutritional supplement, medication, and food coloring
5	Curcumin	Crystalline powder with a yellow to orange-red Colour.	Curcumin and its derivatives, bisdemethoxy and demethoxy. Up to 90% of all curcuminoids may be attributed to the three main curcuminoids. Resins and oils could account for a negligible portion of the overall makeup.	Employed as a supplement to diet and medication oils could account for a negligible portion of the overall makeup.

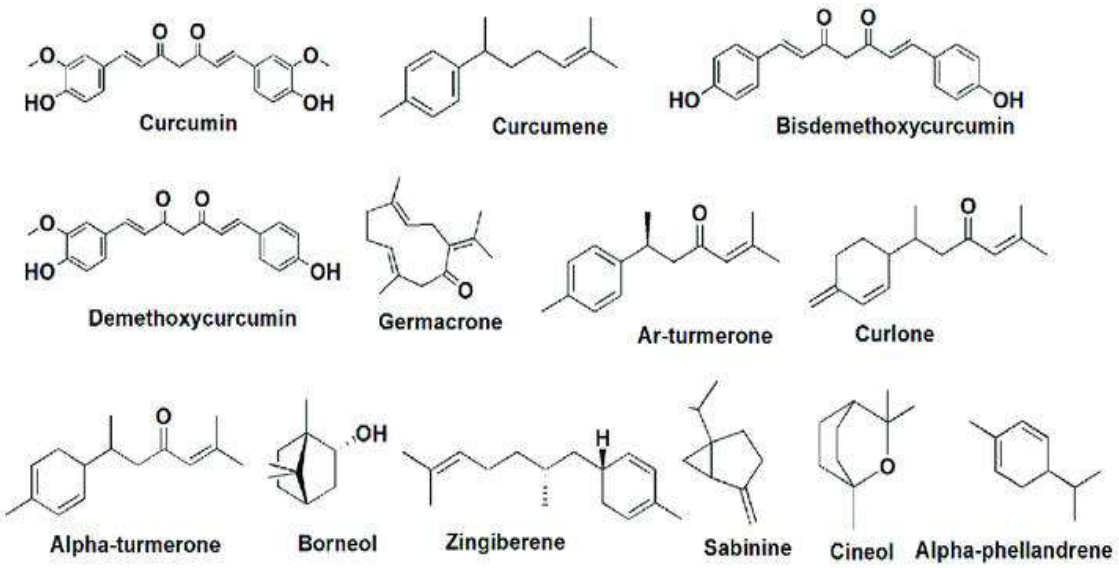

Fig 1: The composition of the phytoconstituents found in C. longa. [22]

C. longa's Pharmacological Characteristics

It is claimed that C. longa has a variety of medicinal benefits. It has been observed that C. longa contains flavonoids, terpenoids, glycosides, and curcuminoids. Healthcare practitioners have utilised the rhizome of Haridra for diseases such as diabetes, cancer, cholesterol, inflammatory processes, diarrhoea, liver issues, and asthma with little to no damage to normal cells. It has also been used as a cosmetic component. Curcumin has been shown to be secure as well as successful in human studies; the U.S. Food and Drug Administration has approved it as "generally regarded as safe."

Gastrointestinal Disorders

Clinical research has shown the therapeutic benefits of C. longa, which has been utilised for

centuries for treating digestive issues. Preclinical studies have demonstrated its anti-inflammatory properties, which may shield the digestive tract [23,24]. It has also been demonstrated to improve the condition of dyspeptic patients by increasing the secretion of gastrin, secretin, and bicarbonate, and by improving gastric wall mucus and pancreatic enzyme. Additionally, it has been shown to prevent intestinal spasms and ulcer formation brought on by anxiety, alcoholic beverages, indomethacin, pyloric ligation, and reserpine [25,26]. Fresh juice is supposed to have antihelmintic properties due to curcumin's anti-inflammatory properties and its therapeutic impact on gastrointestinal ailments such Crohn's disease, dyspepsia, gastric ulcers, Helicobacter pylori infection, acidity, and colitis with ulcers. Regarding rats experiencing NSAID-induced gastropathy, curcumin decreases stomach mucosal damage and suppresses nuclear factor (NF)-κB, leukocyte adhesions, intercellular adhesion molecule 1, and tumour necrosis factor (TNF)-α. Irritable bowel syndrome (IBS) prevalence, abdominal pain/discomfort score, and IBS quality of life ratings significantly improved with the use of C. longa tablets between baseline and 8 weeks of treatment. Curcumin lowers oxidative stress and inflammation in male rodents with damage to the liver, hence preventing acetaminophen-induced hepatitis and restoring glutathione concentrations [27,28].

Abnormalities of the respiratory system

The relaxing effect of C. longa and its ingredients on the smooth muscles of the trachea raises the possibility of a bronchodilatory effect in patients suffering from obstructive lung disease. In a laboratory model of respiratory diseases, they additionally offer protection through effects on lung pathology, airway responsiveness, immunomodulatory replies, and inflammatory cell populations and cytokines [29]. Research conducted both in vitro as well as in vivo has demonstrated the antiasthmatic benefits of curcumin. In an OVA-induced asthma paradigm in guinea pigs, curcumin treatment during OVA sensitization demonstrated noteworthy protective benefits, reducing bronchial constriction and hyperreactivity. Fresh rhizome juice is used as a treatment for bronchitis. C. longa is used internally for cough and rhinitis after being cooked in milk and mixed with jiggery [30,31]. A rhizome decoction is gargled in situations of catarrhal cough and throat discomfort associated with infection; a fragment of rhizome is chewed and gently burnt. Chemical components of C. longa with anti-asthmatic qualities include turmerones, curcuminoids, curcumin, and tetrahydrocurcumin; vapours from the Haridradhumvarti (fume wick) are employed to treat congestion and asthma [32,33].

Disorders of Inflammation

Alternatives, as well as fibrinogen, and C-reactive protein (CRP) are examples of inflammatory indicators that are activated in response to activation by cytokines that are associated with inflammation [34]. The active ingredients in C. longa that prevent TNF-induced NF-κB activation include curcumin, demethoxycurcumin, and bisdemethoxycurcumin, as reported by Sandur et al. (2007). It was found that their activities were caused by the methoxy groups that were on the ring of phenyl. The effects of C. longa extracts on blood markers of inflammatory disease, mental health, and mood disorders in normal overweight individuals were investigated. In 1995, researchers found that curcumin inhibits the pro-inflammatory gene transcription factor (NF-κB), which has anti-inflammatory in nature characteristics [35,36]. They also identified the underlying chemical mechanism of this suppression. In human myeloid ML-1 cells, TNF-α rapidly activates NF-κB, which is made up of the p50 and p65 subunits; curcumin inhibited this activation. Curcumin also prevents activator protein 1 (AP-1) binding

proteins from binding, however it has no effect on the Sp1 binding factor. Together with TNF-α, curcumin prevents phorbol ester and hydrogen peroxide from activating NF-κB [37,38]. Moreover, curcumin inhibits the NF-κB activation pathways prior to human I kappa B alpha phosphorylation and but following the combining of many stimuli. Its ability to inhibit neutrophil activity and the pro-inflammatory prostaglandin derivative of arachidonic acid throughout inflammation could additionally be a sign of C. longa's anti-inflammatory properties [39,40]. Bromelain and curcumin are commonly combined to enhance absorption and reduce inflammation. When used orally to treat acute inflammation, curcumin is just as effective as cortisone or phenylbutazone [41]. When taken orally, C. longa significantly lowers inflammatory edoema [42]. The mechanism of action of curcumin in sepsis appears to be mediated by the stimulation of peroxisome proliferator-activated receptor gamma (PPAR-γ), which inhibits the production and release of TNF-α and other pro-inflammatory cytokines. In a study that looked at forty-three kidney transplant recipients, it was shown that 480 mg of curcumin plus 20 mg of flavonoid per capsules were effective in preventing prolonged graft rejection [43]. 71% of individuals receiving low-dose treatment and 43% to regulate patients achieved significantly decreased blood creatinine levels following transplant. The increased early efficiency of the transplanted kidneys may have been induced by induction of the hemeoxygenase enzyme, proinflammatory cytokines, and free radical scavenging correlated with tissue damage. Curcumin's antioxidant and anti-inflammatory qualities appeared to be primarily responsible for the benefits, with quercetin's role in the molecule being minimal [44]. Furthermore, a variety of reactive oxygen/nitrogen species have the ability to start an intracellular signalling cascade that amplifies the expression of genes that promote inflammation. Numerous long-term illnesses and ailments have been linked to inflammation [45]. These illnesses include metabolic syndrome, cancer, cardiovascular disease, autoimmune diseases, psoriasis, osteoarthritis, bronchitis, colitis, obesity, Type 2 diabetes, fatigue, depressive disorders, and acquired immune deficiency syndrome (AIDS). Alzheimer's disease (AD), Parkinson's disease, multiple sclerosis, epilepsy, cerebral injury, and diabetes are among them. AIDS. Nuclear factor (NF)-κB transcription stimulation controls the primary mediator of inflammation in the majority of illnesses, tumour necrosis factor α (TNF-α) [46,47]. Antibody modification using curcumin. Curcumin has a role in the regulation of antibodies that cause hyperacute rejection of transplants when they react with endothelium. Preventing dead grafts may be achieved by inhibiting the production of gene transcription factors and cytokines with inflammatory properties that are connected to fibrosis and inflammatory [48].

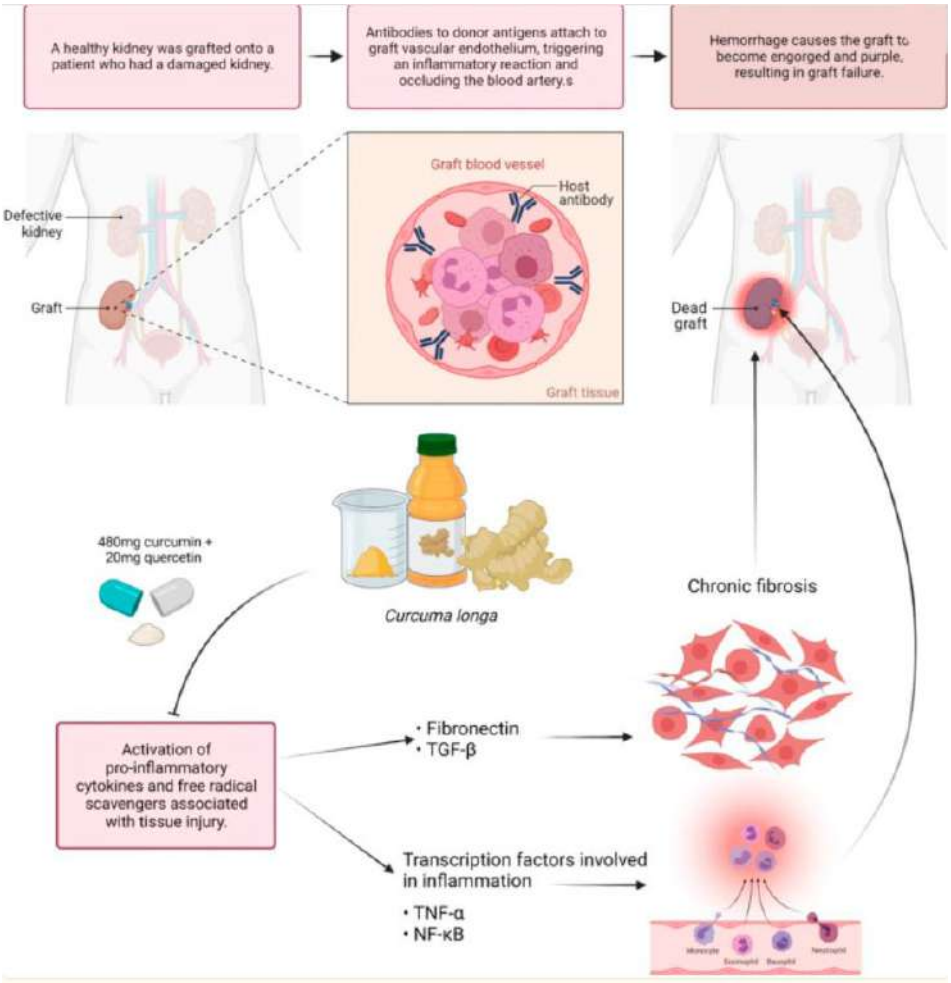

Fig 2: Antibody modification using curcumin. Curcumin has a role in the regulation of antibodies that cause hyperacute rejection of transplants when they react with endothelium. Preventing dead grafts may be achieved by inhibiting the production of gene transcription factors and cytokines with inflammatory properties that are connected to fibrosis and inflammatory. [49]

Diabetes Mellitus

C. longa rhizome powdered is especially helpful in diabetes mellitus when combined with the juice of amla and honey. The key ingredient in the rhizome, curcuminoids, lowers lipid peroxidation by maintaining greater levels of activity for catalase, peroxidase that breaks down glutathione, and superoxide dismutase. It has been shown that curcuminoids increase the resistance to insulin, decrease blood sugar and insulin levels of difficulty, increase adiponectin production, and decrease levels of resistin, leptin, interleukin (IL-6, IL-1β), and TNF-α in individuals with type 2 diabetes. The results show that the C. longa ethanolic extract containing sesquiterpenoids and curcuminoids together is more hypoglycemic than either compound individually. When C. longa extracts are studied in vivo in mouse models of type 2 diabetes, they are shown to have a hypoglycemic effect by lowering the blood sugar level [50,51]. In healthy people, C. longa having no influence on postprandial plasma glucose and insulin; 6 g of C. longa was shown to have no discernible effect on the glycemic index. Thirty and sixty minutes following the C. longa oral glucose tolerance exam (OGTT), there was a much higher decrease in insulin. following ingesting C. longa, the insulin region underneath the graph was also significantly higher following the OGTT. The antioxidant properties of curcumin and the three

derivatives—dimethoxy curcumin, bisdemethoxy curcumin, and diacetyl curcumin—have been documented. Scientific and systematic research indicates that C. longa dried rhizome powder diluted in milk has antidiabetic, hypolipidemic, and hepatoprotective qualities [52,53]. It could prove to be a highly successful and secure dietary supplement for diabetes. The human amylase, or pancreatic enzyme was inhibited by both the isopropanol and acetone extract of C. longa. This inhibits starch breakdown and lowers glucose levels.

Heart-related Conditions

Cardiovascular diseases (CVDs) are associated with high rates of illness and mortality, making them appear to be a worldwide health concern.Preclinical and clinical experiments have demonstrated curcumin's anti-hypercholesterolemic, anti-atherosclerotic, and anti-inflammatory effects against heart ischemia and reperfusion. Curcumin can be used as a dietary supplement to conventional CV medications or as a stand-alone treatment since it improves the cholesterol level of patients, which may have an anti-CVD effect. Numerous studies have also shown that curcumin has anticoagulant and heart disease-prevention qualities. The CV preventive properties of C. longa include lowering blood levels of cholesterol and triglycerides, reducing the susceptibility of low-density lipoprotein (LDL) cholesterol to lipid peroxidation and preventing the assembly of platelets, which, based on animal studies, both prevents thromboxane the development and aids in the defence against cardiovascular disease [54]. Curcumin causes higher levels and mobilisation of α-tocopherol from adipose tissue, which protects versus oxidative stress that takes place throughout atherosclerosis. Curcumin raises VLDL cholesterol trans-protein plasma. The animals' fatty acids, however, were less prone to oxidising in the circulatory vessel. It has been proposed that taking 500 mg of curcumin orally every day for a week causes a considerable decrease in the levels of total blood cholesterol (12%) and serum lipid peroxide (33%) while raising the level of HDL cholesterol (29%). Cao et al. (2018) suggest that curcumin may alleviate chronic cardiovascular disease by upregulating p38 MAPK, JNK, and ASK1. Recent studies have employed curcumin and its constituents to assess the effectiveness of medicine administration methods employing nanomaterials in patients with cardiovascular disease [55].

Hepatoprotective agent

Rhizome powder mixed with amla juice is used to treat jaundice. Combining corriliyum (Anjana) with haridra, red ochre (Gairika), and amalaki (Emblica officinalis Gaertn.) also works to heal jaundice. Investigations against a number of hepatotoxic illnesses, such as the use of carbon tetrachloride, galactosamine, and paracetamol (paracetamol), have demonstrated the hepatoprotective properties of C. longa. At oral doses of 250 and 500 mg/kg, the ethanolic crude extract of rhizomes was shown to include significant hepatoprotective potential together with curcumin, tumerone, atlantone, and zingiberene [56,57]. The reduction of lipid peroxidation, plasma bilirubin and gamma-glutamyl transpeptidase levels, and hepatic protection from bleomycin toxicity were all examined by Karamalakova et al. (2019). Reduction of the amount of reactive oxygen species (ROS) strengthens the concentrations of superoxide dismutase, catalase, and malondialdehyde. According to several reports, curcumin decreases hepatic fibrogenesis, inflammation, and significant liver damage while simultaneously promoting apoptosis in damaged hepatocytes [58]. Curcumin and C. longa may have hepatoprotective effects by direct scavenging of free radicals, increasing glutathione levels, and aiding in liver detoxification. Curcumin and C.

longa also prevented lipid changes, necrosis, and biliary hyperplasia brought on by aflatoxin. One form of curcumin salt with choleretic properties is sodium curcuminate, which increases biliary excretion of salts of bile, bilirubin, cholesterol, and bile solubility, all of which aid in the prevention and treatment of cholelithiasis. This may be connected to the phenolic compounds that contribute to curcumin's antioxidant activity [59]. Tacrine's hepatotoxic and T-cell-destructive effects are widely recognised. In studies using human hepatocyte cells which were already damaged by tacrine, curcumin proved over tenfold more effective than ascorbic acid, the conventional treatment.

Neuroprotective Intent

Curcuma oil reduces nitrosative and oxidative stress, which lessens the harmful effects of ischemia. Curcuma oil significantly reduced the sequential events of ischemia, which include the breakdown of the mitochondria's potential at the membrane, the dissolution of cytochrome c, alterations in the Bax:Bcl-2 protein ratio, and caspase activation, all of which contribute to the onset of apoptosis. Because of this, there is proof of Curcuma oil's neuroprotective effects and a broad therapeutic window for reducing ischemic brain damage. In a transgenic mouse model of Alzheimer's disease, curcumin restored amyloid pathology and reduced oxidative stress. Curcumin's anti-inflammatory and antioxidant properties have been shown to reduce the oxidative stress and inflammation that accompany Alzheimer's disease [60]. Parkinson's disease (PD), primarily damages the dopaminergic cells of the substantia nigra pars compacta (SN and reduces dopamine (DA) within the striatal terminals, is discovered to be the next most prevalent neurodegenerative illness after Alzheimer's disease. It is claimed that curcumin can be used as a medicinal and nutraceutical ingredient for the management of Parkinson's disease. Curcumin has the interesting property of inhibiting the manufacture of MOA-B enzyme, which raises the concentration and accessible amount of docosahexaenoic acid in the brain. In an animal model of Parkinson's disease using 6-hydroxydopmine, curcumin was shown to have neuroprotective properties, reduce aberrant turning behaviour, and enhance the lifespan of striatal TH fibres and SNpc neurons [61]. Future treatments for a number of neurological conditions, such as serious depression, involuntary movement, and neuropathy due to diabetes, may involve the use of curcumin. In the rat hippocampal region, it was shown that an ethanol extract of C. longa exhibited neuroprotective benefits on neuronal loss brought on by dexamethasone therapy. An in vivo investigation conducted in 2018 found that giving C. longa extract to trimethyltin-treated Sprague-Dawley rats with neurotoxic damage at a dose of 200 mg/kg appeared to prevent the impairments in spatial memory retention as well as partially prevent the reduction in the number of pyramidal neurons found in the CA2–CA3 area. As a result, C. longa's antioxidant and anti-inflammatory properties were noted [62]. In addition, Yuliani and Mustofa (2019) investigated the neuroprotective effects of an ethanolic C. longa gather at 200 mg/kg in an in live experiment by stopping oxidative stress by lowering malondialdehyde levels in the brain and plasma and elevating levels of glutathione in the cerebral as well as the activities of the enzymes super oxide dismutase, catalase, and the peroxidase glutathione in TMT-exposed rats with Sprague-Dawley syndrome. It is also necessary to utilise aquatic and terrestrial animals for study. Contaminants such as Benzo[a]pyrene (B[a]P) are sunk by aquatic environments, and studies on fish models are necessary to comprehend the impact of B[a]P on oxidant stress-related neurodegeneration and anxiety-like behavioural responses in aquatic

organisms. B[a]P plays a significant role in changes in antioxidant capacity as well as the mechanical effects of oxidative stress on proteins, nucleic acids, and lipid membranes. By decreasing the anti-anxiety behavioural response and changing the antioxidant capacity with an apparent rise in pyknotic neuronal qualifies in the periventricular grey zone of the optic tectum, which controls anxiety against B[a]P-induced neurological damage in grown-up zebrafish, curcumin may function as a co-supplement [63]. In cooperation with essential oils, Banji et al. (2021) showed the neuroprotective and antioxidant propertie of C. longa extract against aluminum-mediated neurotoxicity. Enhanced bioavailability and regional distribution of pure curcumin and the associated metabolites have been found in the brain and plasma, suggesting that it may find application in neurodegenerative diseases. A different type of neurodegenerative illness called amyotrophic lateral sclerosis (ALS) results in the death of motor neurons specifically in the brainstem, spinal cord, and motor cortex. Curcumin was investigated to see if it may prolong the survival of individuals with ALS, especially those with bulbar dysfunction . In a double-blind experiment, curcumin treatment decreased the onset of ALS and oxidative damage. A research found that curcumin-based drug delivery systems are helpful in treating ALS patients. However, Rakotoarisoa and colleagues noted that curcumin exhibits chemical instability, limited oral bioavailability, and a poor solubility in water rate among ALS patients [64]. Curcumin has the capacity to partially agonist PPAR-γ, a ligand-activated transcription factor implicated in neuroprotective and anti-inflammatory signalling pathways, as well as interact subsequently with a wide range of transcription factors, such as NF-κB, activator protein 1 (AP-1), β-catenin, and signal transducer and activator of transcription (STAT) proteins. It has been shown that curcumin can aid with several illnesses, particularly the neurological disorder multiple sclerosis (MS).Because curcumin has a limited bioavailability throughout the body, curcumin-D-monoglucuronide, also known as curcumin monoglucuronide, or CMG, was created as a prodrug. CMG has been shown to be safe for usage and is safe to inject intravenously. When used in mice transplanted in human colorectal cancer cells, it produces a blood quantity of unstructured curcumin that is 1,000 times greater than oral curcumin, which has been shown to have an anticancer effect [65]. When administered intraperitoneally, CMG appeared to have minimally harmful anticancer impacts on oxaliplatin-resistant colon cancer in mice xenograft models. The microbiota is altered following CMG administration, and this may be connected to immune pathology reduction in experimental forms of autoimmune encephalomyelitis (EAE) and multiple sclerosis (MS) models. It is being proposed that the gut microbiota is largely responsible for the onset and severity of multiple sclerosis. MS patients exhibited a higher concentration of bacteria from the genera Akkermansia, Blautia, and Pseudomonas, or a lower concentration of bacteria from Prevotella and Parabacteroides compared with controls who were healthy.

Properties of Antioxidants

In water- and soluble in fat extracts, C. longa and its curcumin component exhibit strong antioxidant activity that is comparable to that of vitamins C and E. The body can eliminate hydroxyl radicals, single- Oxygen radicals containing superoxide, carbon monoxide, and NO with the aid of curcumin. It has been demonstrated that curcumin pretreatment lessens cardiac mutations brought on by ischemia. An in vitro study using bovine aortic endothelial cells revealed the effectiveness of curcumin on endothelium heme oxygenase-1 (stimulated stress protein), leading to enhanced cellular resistance to oxidative stress. Curcumin

also reduces intracellular ROS and lipofuscin concentrations throughout ageing, which prolongs the life of Caenorhabditis worms [66]. Prior studies have demonstrated that C. longa can protect male Wistar rat hippocampus cells from lead-induced harm and lessen the lipid peroxidation brought on by harmful heavy metals. By reactive oxygen species scavenging, resveratrol and curcumin enhance the antioxidant reaction, mitigating oxidative stress on the organs and working together to heal them. In one of the previous investigations, curcumin's antioxidant and anti-inflammatory properties were found to be synergistically improved with quercetin, and rats given diazinon also showed a synergistic protective benefit. Berberine and curcumin have anti-inflammatory properties that may reduce oxidative damage, inflammation in the liver, and the breakdown of lipids. The combined use of berberine and curcumin significantly decreased inflammatory and reactive oxygen species reactions in the rat cortex and hippocampal [67].

Anti-Cancer Intent

The preventative and therapeutic effects of C. longa were assessed by Annapurna et al. (2011) in relation to the modulation of N-methyl-N-nitrosourea-induced cancer of the breast in rats over a 24-week period. This included both oral and topical administration as pre-induction and post-induction treatments. When compared to therapeutic topical treatment, preventive topical administration of C. longa at a dose of 200 mg/kg has dramatically decreased the mean tumour volume. This was the first study to demonstrate C. longa's anticancer efficacy when applied topically to a breast cancer model. In an in vivo study where 1% C. longa was given as food and topical curcumin was applied to CD-1 mice, 0.05% of the plant's ethanol extract significantly decreased the prevalence, weight, and dimensions of skin tumours initiated by dimethyl benz[a]anthracene (DMBA) and those promoted by 12, O-tetradecanoylphorbal-13-acetate (TPA). The initial study to show curcumin's anti-cancer capability in the in vitro and in real-world experiments was done by Kuttan and his coworkers. By inducing a DNA damage response, curcumin paves the way for the medicinal application of these nutritional supplements in the chemotherapy prevention of prostate tumours. Curcumin has a broad anti-carcinogenic impact on rat aortic cells of smooth muscle through mechanisms such as activation of apoptosis and suppression of cell-cycle progression. The cell death effect could be partially mediated by inhibiting the activity of protein tyrosine kinase, protein kinase C, and expressions of c-myc mRNA and bcl-2 mRNA. The antiproliferative impact is partially regulated by impeding c-myc mRNA production and protein kinase tyrosine movement. Curcumin possesses anti-proliferative properties in a variety of malignancies and suppresses the transcription element NF-κB (Figure 3) as well as other downstream gene products as c-myc, Bcl-2, COX-2, the nitric oxide synthase (NOS), Cyclin D1, TNF-α, ILs, and matrix metallopeptidase 9 (MMP-9). By decreasing leptin blood levels and raising adiponectin levels, curcumin may help diabetics with type 2 diabetes prevent colorectal cancer (CRC). To increase the colorectal medication liberation mechanism of curcuminoids in CRC therapy, poloxamer 407 can be utilised as a polymer [68]. An innovative strategy for osteosarcoma adjuvant therapy involves mixing curcumin with a synthetic form of the natural substance pancratistatin. According to a controlled investigation, the water solubility and anticancer activity of the nanoparticulate emulsion are enhanced when poly-lactic-co-glycolic acid is used to synthesise and characterise nano-curcumin. Curcumin suppresses NF-κB and signal transducers and activators associated with transcription 3 (STAT3) pathways, which in turn has an antitumor effect on cancer cells. It also

affects a variety of receptors for growth factor and attachment molecules that are linked to tumour growth, angiogenesis, and metastasis

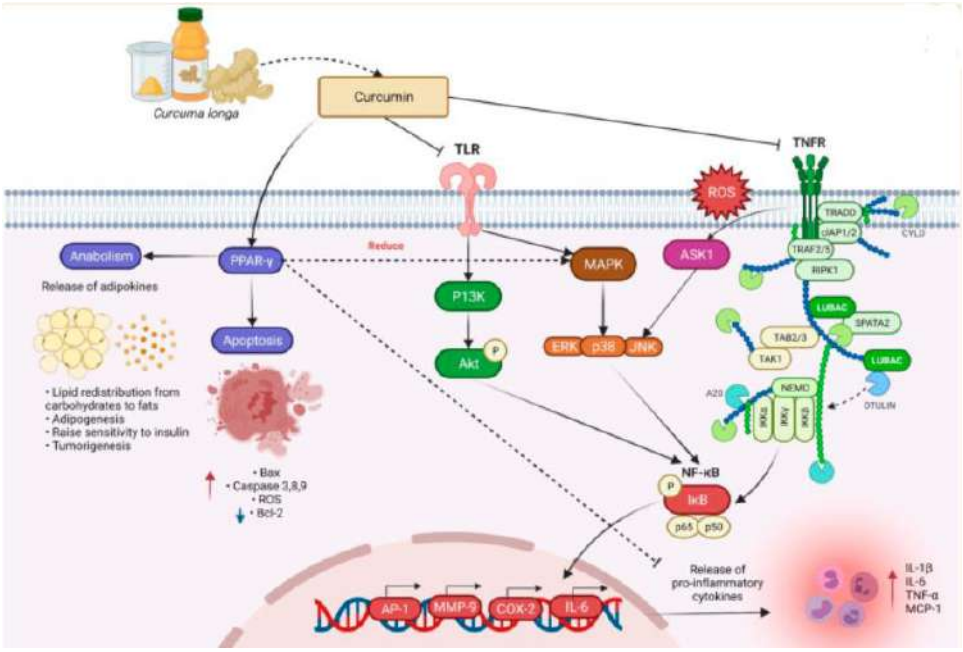

Fig 3: The way curcumin works to prevent cancer [69]

Both C. longa and curcumin shown the capacity to mitigate the effects of many recognised causal agents of mutations and cancer in various bodily tissues, according to a study conducted on in vitro and in vivo models. Curcumin (50 μM) induces the colorectal HT-29 malignant cells to proliferate and starts to destroy human kidney cells, most likely as a result of cell cycle arrest. According to lab studies, curcumin also causes colon malignant cells to undergo programmed cell death and prevents the gastrointestinal tract's micro-inflammation, which is connected to diseases such as inflammatory bowel disease. The effect of adding powdered C. longa on the amount of carcass produced and intestinal growth in rabbit production is studied by Okanlawon et al. (2020) [70]. The combined impacts of kolaviron and curcumin on rats' testicular damage caused by DBP were investigated by Farombi et al. in 2007. Mice injected with human prostate tumour cells showed improved apoptosis, decreased microvessel density, and increased cell proliferation after receiving curcumin therapy. Heme oxygenase activity and tolerance to oxidative damage were shown to increase in endothelial cells generated from bovine aorta treated to curcumin (5–15 μM) under normoxic (oxygen tensions between 10–21%) or hypoxic (oxygen tensions within 1–5%) conditions. Alcohol consumption makes the pancreas more sensitive to initiating an inflammatory response by activating NF-κB through protein kinase C, also known as epsilon. A pilot research found that individuals with tropical pancreatitis might regain lipid peroxidation by taking 500 mg of curcumin and 5 mg of piperine orally. Curcumin-based therapies centred on EGFR, miRNA, autophagy, and cancer stem cells may show to be effective avenues for addressing lung cancer. Additionally, curcumin appears to accelerate tumour growth, which lessens docetaxel's effectiveness in lung cancer sufferers. Simultaneous administration of curcumin with docetaxel results in mild toxicity to normal organs, including the liver and bone marrow. Curcumin has been suggested as an adjuvant in lung cancer because it reduces the

migratory and invasive potential of A549 cells in vivo and inhibits the production of adiponectin, which is assumed to be regulated using the NF-κB/MMP networks [71]. Improvements in p53 levels and its capacity to bind DNA were linked to apoptosis, as was the expression of the Bax protein. Curcumin's primary method of action against cancer is phosphorylation of CDC27, which blocks cell growth and proliferation through an apoptotic pathway and ultimately results in cell death. Hepatocellular carcinoma (HCC) patients have been shown to have higher levels of circulating miR-21. This makes it a potential target for therapy and a diagnostic marker for HCC, and it has also been connected to the development of distant metastases.In individuals hepatoma cell lines like HepG2 and HCCLM3, Li and his colleagues found that suppressing miR-21 enhanced curcumin's anticancer effects, including cell growth suppression, apoptosis via increased target gene, and TIMP3 expression. The way this works may involve the inhibition of the TGF-β1/smad3 signalling pathway.

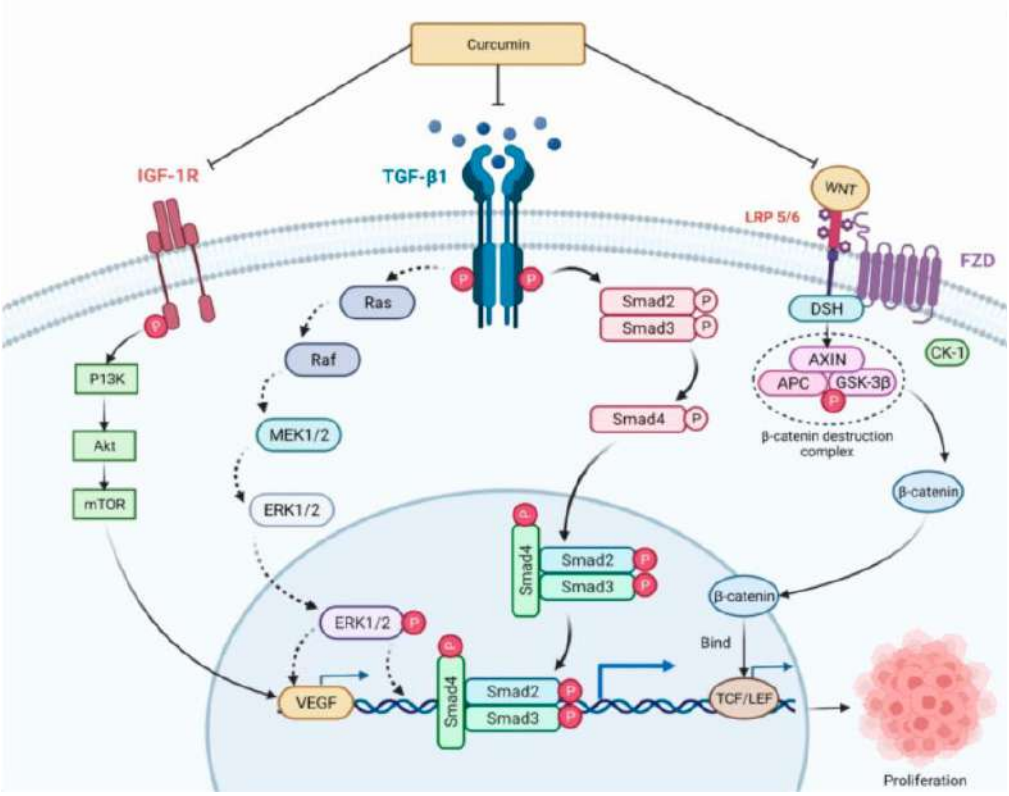

Fig 4: Curcumin's mechanism of controlling the growth of cancer [72]

When combined with ionising radiation, curcumin treatment of Burkitt's lymphoma cell lines increases the vulnerability of lymphoma cells to apoptosis produced by ionising radiation and enhances arrest of the cell cycle in the G2/M phase. In individuals with malignancies of the blood and bone marrow, curcumin and L-ASP work in concert. By altering the AKT-mammalian targeting of rapamycin pathway for suppression, curcumin also prevents the development of uterine leiomyosarcoma cells and lessens the propagation of castrate-resistant illness and human leiomyosarcoma cells. The ability of curcumin, or C. longa extract, to reduce chemically produced tumours was studied. Research has shown that curcumin and C. longa crude extract can help prevent papilloma formation during the whole carcinogenesis and advancement process. By performing on 7,12-dimethyl benz[a]anthracene (DMBA) and 12,0-tetradecanoylphorbol-13-

acetate (TPA), which promoted skin tumours, 0.2% and 1.0% of dietary curcumin may decrease the quantity of papillomas. This was investigated by Limtrakul et al. (2001) as curcumin dropped the level of expression of the oncogenes ras-p21 and fos-p62 in a dose-dependent manner. Because C. longa showed strong anti-apoptotic actions that preserved cardioprotective qualities and heart function, Mohanty et al. (2006) investigated the efficacy of C. longa on apoptosis of myocardial cells in clinically induced myocardial ischemia-reperfusion damage. In addition to showing antimutagenic efficacy against mutagens, aqueous C. longa extract also prevented Salmonella typhimurium strains from progressing through forestomach tumours caused by benzo[a]pyrene. Insulin-like growth factor-binding protein-3, or IGFBP-3, is a highly bound protein with proapoptotic and anti-proliferative properties that modifies the mitogenic effects of IGFs. IGFBP-3 cDNA transfection causes apoptosis in breast cancer cell lines that express either wild-type (MCF-7) or mutant (T47D) p53. A greater ratio of pro-apoptotic to anti-apoptotic Bcl-2 blood relatives is caused by IGFBP-3. Through a p53-dependent mechanism, curcumin caused cell death in MCF-7, suggesting that it may have therapeutic potential for breast cancer patients. Combining curcumin with cyclophosphamide in the model of mice reduced the effectiveness of cyclophosphamide and hence impeded tumour shrinkage. When cytochrome p450 isoenzymes and copper are present, curcumin leads to base degradation and breaking down of DNA. Moreover, curcumin bound to copper did not inhibit the formation of spontaneous hepatic tumours in an animal model of liver cancer, as shown by Frank et al. (2003). The increased copper burden might be the cause of the increased toxicity and oxidative stress. Curcumin has the ability to reduce the efficacy and absorption of irinotecan, chemotherapy medications used to treat colon cancer. In a xenograft mice model of human breast cancer, curcumin with paclitaxel (Taxol) significantly reduced the spread of breast cancer to the lung compared to either treatment alone. Significantly less T cells are produced by curcumin, yet T cells recovered from mice with the 3LL tumour had higher levels of curcumin at low doses. As a result, more CD8+ T cells produced better IFN-γ secretion and proliferation, particularly in the case of 3LL tumour cells [73]. With a surge in the proliferation of peripheral blood mononuclear cells and the composition of cytokines, C. longa extracts (which includes curcuminoids, volatile oil, and water-soluble polymers of carbohydrates) could be used as an adjuvant supplement for cancer patients whose immune systems have been compromised by chemotherapy. Human blood vessel cells have shown anti-angiogenic properties for aromatic-turmerone, according to in vitro as well as in vivo investigations. Food ingredients like curcumin and docosahexaenoic acid (DHA) have been shown to exhibit different antiproliferative properties in a variety of breast cell lines. They also showed synergism in SK-BR-3 (a human breast cancer cell line) cells, that may be because DHA increases the metabolism of curcumin in cells. This is a phenomenon that is specific to the combined activity of these food ingredients.

Anti-Allergy Inhibition

Curcumin prevented compound 48/80 from causing rat peritoneal mast cells to degranulate and release histamine.The biological process of action was examined using cAMP assays in mast cells and measures of calcium uptake. Curcumin significantly decreased the mast mediated by cells passive cutaneous anaphylactoid response in an animal model.Curcumin decreased both nonspecific and selective mast cell-mediated allergic responses while also increasing intracellular cAMP levels.As assessed by serum-dependent leukotriene C4, dependent

prostaglandin D2, and histamine levels, curcumin dramatically decreased IgE/Ag-induced PSA (passive systemic anaphylaxis). This suggests that curcumin may be helpful in the development of medications for allergic inflammatory diseases. Curcumin inhibits the production of inflammatory cytokines such as IL1β, IL-6, and TNF-α from LPS-stimulated dendritic cell cells and can decrease dendritic cells' tendency to express CD80, CD86, and class II antigens.

Antidermatophytic Action

Rhizome powder is incorporated into cow's urine to ease internal irritation and dermatitis, and rhizome juice is used as an antiparasitic in the treatment of a variety of skin conditions. Because of their numerous in vitro and in vivo antifungal activities, including their powerful fungicidal action, extended shelf life, high inoculum density tolerance, thermostability, numerous antidermatophytic effects, and lack of adverse effects, leaves have a great deal of potential against human pathogenic fungi. Curcumin can shield the skin from harmful UV rays because of its demonstrated antimutagenic, antioxidant that reactive oxygen species scavenging, anti-inflammatory, and anti-carcinogenic effects [74].

Bowel Irritability Syndrome

Inflammatory cells are much more prevalent in the colon and ileum mucosa of IBS patients. Ng et al. (2018) investigated the potential role of curcumin in the manifestation of IBS. The two main types of inflammatory bowel disorder (IBD), which are marked by bloating, increased stool frequency, abnormal bowel habits, and abdominal discomfort, are Crohn's disease (CD) and ulcerated colitis (UC). A pilot research by Holt et al. (2005) examined the effects of curcumin treatment on individuals with IBD who had previously undergone conventional UC or CD therapy. When combined with regular UC therapy, curcumin has a greater positive impact on recuperation that a placebo does.

Gastritis and Dyspepsia

For 12 weeks, patients with peptic ulcers might avoid the formation of ulcers by taking 600 mg of curcumin on five occasions a day; but, in certain cases, this could result in symptoms such as dyspepsia, gastritis, and erosions. Curcumin has significantly reduced symptoms, including abdominal discomfort, in 1-2 weeks. By blocking H2 histamine receptors, oral administration of ethanolic C. longa extract reduced acid production in the stomach, gastric juice output, and ulcer start in male rats (Kim et al., 2005). This effect is comparable to that of ranitidine. Similar to this, the ethanolic extract of C. longa has been shown to have antiulcer properties, since it considerably reduces both stomach acidity and the ulcer index. Additionally, C. longa extract reduced the severity of lesions caused by necrotizing agents and inhibited the elimination of stomach wall mucus caused by hypothermic restraint stress.

Properties of Antidepressants

Chronic moderate stress (CMS) in rats results in significantly decreased sucrose consumption, elevated levels of cortisol, TNF-α, IL-6, and CRF, a smaller medulla oblongata, and decreased NK cell activity in the spleen. Ethanolic extract was employed to treat the CMS disease, despite resulting in a smaller-than-normal medulla oblongata. Although C. longa seems to prevent monoamine oxidase buildup in the brain and nervous system, it may have antidepressant effects. Numerous properties of curcumin are significant to the pathophysiology of depression. The ethanolic C. longa extract raised serum corticotrophin-releasing factor levels, the level of cortisol, and serotonin turnovers while blocking the decline in dopamine, noradrenalin, and serotonin levels. The effects of taking curcumin orally on behaviour under conditions of depression or chronic stress are shown in the rat paradigm. Infusion of curcumin had effects comparable to those of imipramine, a well-known antidepressant

medication, and have been suggested by a number of experts as a potential substitute source in cases of depression.

Curcumin Stops Medication Resistance

One potent anti-drug resistance agent found in curcumin. Its unique ability to inhibit the rise in P-glycoprotein and its mRNA that is generated by adriamycin is associated with greater intracellular drug buying and selling, which raises the lethality of ADM. Drug-resistant cancer cells become chemosensitive when curcumin inhibits NF-κB activity. Additionally, it has been demonstrated that curcumin and tamoxifen co-treatment exposes tamoxifen-resistant breast cancer cells, indicating that it may be a useful strategy for reducing tamoxifen resistance or re-sensitizing refractory sickness to tamoxifen therapy.

Antimicrobial Intensity

Researchers evaluated curcumin's antibacterial effectiveness against several kinds of bacteria, including Mycobacterium tuberculosis, Salmonella paratyphi, Trichophytongypseum, Staphylococcus aureus, and Streptococci mutans. While Lemna minor exhibited signs of toxicity, the extract had antibacterial efficacy against Trichophyton longifusus, Microsporum canis, and S. aureus. Wounds in the rabbit group treated with C. longa showed a tendency towards increased collagen production and lower inflammation due to a considerably higher average value for wound contraction.Shigella flexneri, Staphylococcus epidermis, Klebsiella pneumoniae, Lactobacillus, Pseudomonas aeruginosa Vibrio cholerae and Salmonella typhi were all susceptible to the ethanol-based extract of C. longa.Combining drugs can have strong or reduced pharmacokinetic effects that can affect how well they work clinically by regulating how they are absorbed, distributed, metabolised, and excreted. Another investigation identified the phytoconstituents, such as alkaloid, flavonoid, anthocyanin, steroids, and coumarin in C. longa extracts, and demonstrated the synergistic combinatorial effect produced by copper metal ions when combined with water-soluble extracts of the plant against Paenibacillus popilliae, a known food spoilage bacterium. Aqueous extract of C. longa and chitosan exhibit noteworthy synergism and antimicrobial effectiveness at 512 µg/ml and 1,024 µg/ml against methicillin-resistant S. aureus, Pseudomonas resistant to carbapenem, Enterobacteriaceae producing AmpC and resistant to carbapenem, as well as antibiofilm producers. H. pylori, Streptococcus, Staphylococcus, and Lactobacillus species are suppressed by the oil fraction, curcumin a component and water-soluble portion of C. longa, which all shown antibacterial qualities.

Interaction that Works Together

When utilised alongside antibiotics like oxacillin, ampicillin, ciprofloxacin, gentamicin, amikacin, polymyxin B, and norfloxacin, curcumin has been shown to have synergistic effects rather than antagonistic ones. It has also been shown to have beneficial effects on inflammation while paired with a particular cytotoxic agent, with treatment with chemotherapy, or with a diet high in polyphenol derivatives. Different extracts made from medicinal plants have been used by researchers to treat MDR bacteria, which is acknowledged as a worldwide issue. The quality of the seafood was enhanced during conservation by a combination of C. longa, galanga powder, and the essential oil of lemongrass, which inhibited the breakdown of raw white firm clam muscle.

Antifungal Properties

It has been demonstrated that curcumin enhances the antifungal properties of polyene and common azole. A separate investigation found that external application of C. longa oil to guinea pigs afflicted with moulds, yeast, and dermatophytes inhibited the growth of these harmful fungi and dermatophytes. After using C. longa for seven days, animals treated with dermatophytes and

fungal-infected lesions recovered and the lesions vanished. Khattak et al. (2005) investigated the antifungal, antibacterial, phytotoxic, cytotoxic, and insecticidal properties of an ethanolic extract of C. longa. According to various writers, C. longa's oil and ether, chloroform, and extracts made from ethanol have antifungal properties against Aspergillus flavus, Aspergillus parasiticus, Fusarium moniliforme, and Penicillium digitatum. For both Candida albicans and Cryptococcus neoformans, the methanolic extract of C. longa demonstrated antifungal activity, with minimum inhibitory concentrations (MIC) of 128 and 256 g/ml, respectively. A recent investigation found that although curcumin had antifungal activity against all test strains of Candida, with MICs ranging from 250 to 2,000 g/L, it is less effective than fluconazole. Changes in ergosterol synthesis, proteinase production, or membrane-associated ATPase activity might be the cause.

Antiviral and Parasitic Properties

Curcumin inhibits HIV-1 LTR promoter driven gene expression without compromising cell survival, demonstrating its antiviral efficacy even against HIV.When it came to Leishmania and Plasmodium falciparum, curcumin was only somewhat effective.Although curcumin possesses anti-P. falciparum and anti-Leishmania effects in vitro, the ethanol extracts show anti-Entamoeba histolytica activity. HIV and the Epstein-Barr virus appear to be targets of curcumin's antiviral action. Aquaculture uses C. longa extract, both in aqueous and ethanolic forms, to treat bacterial infections. In addition to its nematocidal properties, curcumin also exhibits anti-parasitic activity versus African trypanosomes and schistosomicidal activity against mature Schistosoma mansoni worms. In chicks afflicted with the cecal protozoan Emmereria maxima, diets combined with C. longa increased weight growth and decreased small intestine lesion scores. In silico modelling studies have shown that curcumin fits well into the protease's active site. Curcumin has also been shown to be a potent inhibitor of HIV integrase, preventing it from connecting against its substrate by binding to acidic residues in the integrase's catalytic region. According to a molecular docking analysis, curcumin's keto-enol and terminal o-hydroxyl group are specifically connected to the binding area of the integrase, which is made up of residues like Glu92, Thr93, Asp116, Ser119, Asp64, His67, Thr66, Asn120, and Lys159. Current research has also demonstrated C. longa's medicinal promise against the coronavirus illness 2019 (COVID-19) (Emirik, 2020), and C. longa's capacity to control the cytokine storm in COVID-19 patients has sparked a powerful resurgence of curiosity in the plant.

Infertility prevention

The World Health Organisation advises using traditional medicine as a more affordable option compared to synthetic antifertility medications. Aqueous rhizome extract of C. longa was administered orally to the Parkes mouse strain; this results in irreversible spermatogenesis, a reduction in the diameter of seminiferous tubules, and an unravelling of the germination epithelium, suggesting possible benefits for male fertility. Hembrom et al. (2015) also investigated the effects of an aqueous extract from the rhizome of C. longa on the number of sperm, the movement of spermatozoa, and the acidity of the seminal fluid in male Swiss Albino mice who were infertile. In female Sprague-Dawley rats, the combined effects of curcumin and andrographolide greatly reduced the overall amount of implants and litter size, altered the duration of estrus cycle stages, and decreased the number of follicles within the ovaries. When administered orally to rats, petroleum ether combined with the rhizome's aqueous extract exhibits antifertility effects and completely inhibits implantation. Additionally, curcumin decreases the motility of human sperm,

indicating both its antispermatogenic properties and its use as an intravaginal contraception.

Side Effects, Security measures, Limitations, and Safety Features of C. longa

Research indicates that consuming too much turmeric may cause uterine contractions during pregnancy and may prevent the absorption of iron; therefore it should be taken cautiously in people who are iron deficient. When used orally, turmeric has been shown to lower testosterone levels, slow down sperm motility in males, and cause blood clotting, thus it should be stopped at least two weeks before to a planned operation. Some studies state that those with gallbladder and blood issues shouldn't take turmeric. Curcumin has a well-established track record of safety. For instance, curcumin's Allowable Daily Intake (ADI) is 0–3 mg/kg body weight, citing reports from the European Food Safety Authority (EFSA) and the Joint United Nations and World Health Organisation Expert Committee on Food Additives. Many studies conducted on healthy participants have substantiated curcumin's safety and effectiveness. Even with its well-established safety, there have been a few unfavourable side effects noted. In a dosage response trial, seven participants who received 500–12,000 mg and were monitored for 72 hours had yellow stool, dermatitis, diarrhoea, and headaches. In a different trial, individuals who received 0.45 to 3.6 g/day of curcumin for a period of one to four months also had a rise in the levels of lactic dehydrogenase and alkaline phosphatase in their serum, along with symptoms of nausea and diarrhoea.

FUTURE COURSES

In order to maximise C. longa's utility for the greater good of humanity as a whole efforts ought to be made to look into both the opportunities of realistic therapeutic uses along with the specifics of hidden and untold areas. C. longa required extensive studies and development in order in order to maximise its medicinal value. In the most serious form of COVID-19, inhibition of the cytokine storm is recommended. Thus, we may continue working on it to overcome the COVID-19 mutation pandemic. A precise understanding of the safe dosage, mechanism of action, and effectiveness of turmeric and curcumin is essential for their sensible application in the treatment of human disorders, including COVID-19.

CONCLUSION:

Curcumin's numerous health advantages have drawn interest from all over the world. These benefits seem to be mostly attributed to its anti-inflammatory and anti-oxidant properties. Curcumin's bioavailability is greatly increased when coupled with substances like piperine, so this is the most efficient way to attain these effects. Curcumin may be able to assist with the treatment of metabolic syndrome, oxidative and inflammatory diseases, arthritis, anxiety, and hyperlipidemia, according to research. It could be helpful in the control of inflammation and stiffness in the muscles brought on by exercise, improving recuperation and performance in those who engage in physical activity. Furthermore, for those without medical diagnoses, a comparatively little dosage may have positive health effects.

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The authors confirm that the content of the article has no conflict of interest.

DATA AVAILABILITY:

The original data that support the findings of this study are included in the Article.

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