

# TURMERIC (*CURCUMA LONGA*): FROM ANCIENT MEDICINE TO CURRENT POTENTIAL THERAPEUTIC AGENT AS CURCUMIN

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*Turmeric is one of the prominent herbal medicines. Its use as a therapeutic agent, spice and colourant is known since the Vedic period. Biologically active constituent of turmeric is curcumin. Due to astonishing antioxidant and antiinflammatory properties of curcumin, it has become an attractive target for the development of novel drugs for the treatment of many challenging diseases such as cancer, cardiovascular disease, dementia, diabetes, arthritis, etc. During the recent years curative properties of curcumin have been explored extensively all over the world, and many clinical trials are in progress for deeper understanding of mechanism of its therapeutic action. Safety, non-toxicity, and high tolerability are the unique pharmaceutically significant features of curcumin. Recently, various methods have been developed to enhance the water solubility and bioavailability of curcumin which are based on the use of metal ions, and biocompatible organic substances.*

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## Introduction

Plants have been used by humankind for the treatment of almost all types of ailments for centuries due to presence of a vast array of pharmacologically useful chemical entities in them. Plant cells are endowed with remarkable property of synthesising different kinds of chemical compounds using their constituent enzymes and simple raw materials. India is probably the richest nation of the world in its traditional wealth that has been used in healthcare extensively. Among the various Indian tribal and folklore traditions, the traditional medicinal system is rich and unique. It has a long and laudable history in the service of humanity. India has a rich heritage of knowledge on plant based medicines which constitute the major portion of Aurvedic Pharmacopeia. Despite the great development in modern synthetic drugs, herbal medicines are being widely used. According to World Health Organization

(WHO), 80 percent of the global population is using herbal medicines for primary healthcare due to their compatibility and lesser side effects. Herbal products also play a significant role in healthcare systems of the remaining 20 percent of the world's inhabitants mainly in developed nations.

In herbal medicines, the term “*herb*” is used not only to refer to herbaceous plants (seed producing plants with nonwoody stems which vanish at the end of the growing season) but also to roots, stems, bark, leaves, flowers, fruits, and seeds of trees, shrubs and woody vines, and their extracts which are used for their curative properties<sup>1</sup>. In the realm of herbal medicines, turmeric (*Curcuma longa*) occupies a prominent position because of its deep rooted relationship with Indian culture. Its use as indigenous therapeutic agent, spice and colourant is quite wide.

Turmeric is the common name for the plant *Curcuma longa* belonging to family zingiberaceae. Turmeric or *Curcuma longa* is one of the 35 species of Genus, *Curcuma*. The wild variety of turmeric is known as *Curcuma aromatica* while the domestic variety is named as *Curcuma longa* (syn. *Curcuma domestica*). Rhizomes of the turmeric plant are thoroughly washed boiled, dried,

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and finely powdered. Besides the medicinal purpose, the yellow coloured powder so obtained is used as spice, flavouring agent and colourant. Many names are in use for turmeric. Some of the prominent names are: Haldi (Hindi and Bengali), Haridra (Sanskrit), Manjal (Tamil). Turmeric plant widely occurs in tropical and subtropical regions, particularly in India, China, and South East countries such as Indonesia, Thailand, Vietnam, and Philippines. India is the largest worldwide producer, consumer, and exporter of turmeric. In Aurvedic, Unani and Sidha systems of medicine extensive applications of turmeric are described for the treatment of vast number of diseases.

### **History**

The turmeric plant, *Curcuma longa* has a glorious past and fascinating history since the Vedic period. The rhizome of this plant has been used for centuries as a spice, colourant and traditional medicine for numerous diseases in India, China and other Asian countries. Ayurveda describes many recipes containing turmeric with wide therapeutic applications including healing of wounds, treatment of sprains, skin diseases, lung congestion, scorpion stings, etc. The medicinal efficacy of turmeric is also mentioned in *Charak Samhita*. This treatise gives an account of turmeric as a remedy for jaundice, haemorrhoids (piles), snake bites, conjunctivitis, skin blemishes, and chicken-pox, etc. Applications of turmeric in healthcare, as a spice, and in colouring of food made it a vital component of human civilization. Due to its valuable properties, it is regarded as “*Indian Solid Gold*”. The famous Italian explorer, Marco Polo mentioned turmeric in the description of his journey to China and India long back in the year 1280<sup>2</sup>. He remarked “*I have found a plant that has all qualities of saffron, but it is a root*”. In 13<sup>th</sup> century, turmeric was brought to Europe by Arab Traders. Later on, the Portuguese sailor Vasco da Gama visited India in 15<sup>th</sup> century, and introduced large number of spices including turmeric to west. During the British rule in India, export trade of spices flourished remarkably making the turmeric most popular in Britain and other western countries. It is this period, during which “*Curry powder*” was invented by mixing some other spices with turmeric.

The yellow colour of turmeric is due to presence of few polyphenolic compounds, viz., curcumin or curcumin I, curcumin II, and curcumin III which are collectively known as curcuminoids. Among these curcuminoids, curcumin is the main bioactive compound responsible for the curative properties of turmeric, and almost all the past and present pharmacological researches are focused on it.

The curcumin was first isolated from turmeric in 1815 by Vogel and Pelletier<sup>3</sup>. In 1870, Curcumin was successfully obtained in pure and crystalline form<sup>4</sup>, and in 1910, its structure as diferuloylmethane was established<sup>5</sup>. A century after the isolation of curcumin, its synthesis was reported by Lampe in 1913<sup>6</sup>. An early study on biological property of curcumin was published in the journal, *Lancet* in 1937<sup>7</sup>. Subsequently, antibacterial action of curcumin was reported in *Nature* in 1949<sup>8</sup>. These seminal reports on medicinal properties initiated a wide interest on therapeutic potential of curcumin as evident by large number of publications on this subject. During the recent years, the research interest in curcumin/turmeric increased exponentially and diverse aspects of its chemistry, biochemistry and pharmacology have been examined extensively all over the world in view of excellent antioxidant and antiinflammatory properties associated with this wonder molecule<sup>9,10</sup>.

Based on traditional knowledge of Ayurvedic, Unani and Sidha system of medicine, turmeric is used indigenously as a home-medicine in India, particularly in rural areas. In Aurveda, turmeric is regarded as an excellent agent for elimination of three *doshas* of human body-*vatha*, *pitha* and *kapha*. According to Aurveda, *vatha*, *pitha* and *kapha* are waste products (*malas*) of the digestion taking place in stomach and other parts of the body. They play an important role as *dhatu*s in maintaining body functions. But, when their balance is disturbed by taking inappropriate diet and indulging in harmful activities, they become *doshas*, and produce different kinds of ailments by upsetting the functions of *dhatu*s.

### **Role of Turmeric in the Treatment of Some Challenging Diseases in Modern Era**

The use of turmeric as a traditional and indigenous medicine is very old. Ayurvedic system of medicine describes treatment of numerous ailments with the help of turmeric indicating that cure of every disease is inherent in it. Turmeric has been branded as “*herbal aspirin*” and “*herbal cortisone*” due to its potential of providing relief in autoimmune and inflammatory diseases<sup>11</sup>. Curcumin is the main biologically active compound of turmeric which was isolated in 1815. Thus, the scientific history of curcumin is two hundred year old. Curcumin is a highly pleiotropic compound having very good safety profile targeting multiple pathological conditions. Scientific research during the last forty years, has clearly confirmed the various pharmacological properties of curcumin, and demonstrated its ability as a chemopreventive and chemotherapeutic agent in the treatment of large number of challenging diseases. Huge number of researches are

underway to develop curcumin as a new and more effective drug for the diseases which even in the modern age of today are without any satisfactory remedy, and consequently claiming a heavy toll of human life. Some of these diseases and use of curcumin in their treatment is described briefly below.

**Ageing and Age-related Diseases:** Although ageing entails various types of functional and structural changes in human body leading to an adverse effect on health and survival, but generally, it is not regarded as a disease by itself. Of course, many diseases such as cancer, cardiovascular disease, type 2 diabetes, arthritis, atherosclerosis, osteoporosis, dementia, senile blindness and deafness, depression, infections, obesity, *etc.* are closely associated with ageing<sup>12</sup>. It has been reported that chronic inflammation is the main cause of enhancement of ageing-process as well as almost all the age-related diseases. Chronic inflammation is also known as “low grade” inflammation. It increases the stiffness of the blood vessels, joints, and the bladder, and impair the function of kidney, heart, retina,, and other organs of the body<sup>13</sup>. Majority of the researchers are of the opinion that pharmaceutical and nutraceutical interventions may delay ageing and provide care to age-related diseases<sup>14</sup>. Nutraceuticals are physiologically useful components of the diet which provide protection against chronic diseases. Curcumin is regarded as a safe and very effective nutraceutical. The curative properties of curcumin may be attributed to its excellent ability of eliminating chronic inflammation by scavenging reactive oxygen species (ROS) and reactive nitrogen species (RNS) which damage the cell structures, *e.g.* carbohydrates, proteins, lipids, and nucleic acids. Due to damage of these essential macromolecules, a hazardous condition is developed that is known as “*oxidative stress*”. It is the basic cause of the above mentioned degenerative and chronic diseases<sup>15</sup>. Curcumin also provides antioxidant defense to body by increasing level of certain enzymes, like glutathione. With the help of animal and cell line models, attempts were made to understand the molecular mechanism and biological effects of curcumin<sup>12</sup>. Few clinical trials are also underway all over the world to study the curative role of curcumin<sup>16</sup>.

**Alzheimer’s Disease:** Alzheimer’s disease is the most common type of pre-senile and senile dementia. It is one of the different brain disorders in old age leading to loss of memory in a person, and ultimately, making him or her unable to perform daily tasks. Alzheimer’s disease is a neurodegenerative disorder caused by the death of brain cells due to formation of peptide plaques which are named as A $\beta$  amyloids. Curcumin plays a significant role in the

treatment of Alzheimer’s disease<sup>17</sup>. Due to its suitable structural feature curcumin has the potential of entering the brain in desired amount by penetrating the blood- brain-barrier<sup>18</sup>. Here it binds to plaque forming Alzheimer’s peptide-and reverses the existing amyloidal pathology. Antioxidant and antiinflammatory properties of curcumin also facilitate the treatment of Alzheimer’s disease by warding off oxidative stress.

**Cardiovascular Disease:** It is a disease of heart and blood vessel, and includes several problems that are related to a process known as atherosclerosis. Atherosclerosis develops when arteries become hard and narrow due to deposition of a substance called plaque on their walls. Plaque is made up of fat, cholesterol, triglycerides and other substances found in blood. This creates a hindrance in the flow of blood in arteries and may cause a heart attack or stroke. A heart attack occurs when the blood to a part of heart is blocked by a clot. If the blood vessel supplying blood to brain is blocked (usually by a clot) the problem is known as ischemic stroke. Another problem is haemorrhage stroke in which blood vessel inside the brain bursts due to uncontrolled blood pressure (hypertension).

Curcumin is reported to exhibit excellent biological properties relevant to prevention of cardiovascular diseases *viz.* lowering the cholesterol and triglyceride levels, decreasing susceptibility of low density lipoprotein (LDL) to lipid peroxidation, and inhibiting platelet aggregation<sup>19</sup>. Because of its antiinflammatory action also, curcumin is capable of providing protection against cardiac injury. Several animal studies have indicated that it protects heart from cardiac ischemia and some other related heart problems<sup>20</sup>. Many experimental trials, using curcumin are under study in order to save the humankind from the curse of widely prevalent cardiovascular diseases.

**Cancer:** Human body is composed of numerous structural units known as cells. Formation of new cells and destruction of the old cells is a well controlled and programmed continuing process taking place throughout the life of an individual . The genes which are composed of nucleic acids, and located in nucleus of the cells as a part of chromosomes, are the controlling agents of this phenomenon. But, when due to involvement of some factors, a gene or its constituent RNA undergo some structural deformity commonly known as mutation, a group of body cells starts uncontrolled growth without the death of old cells (apoptosis) resulting in huge mass of cells called lumps or tumours. These are capable of reaching to other parts of body also through blood circulation. The disease caused due to formation of such tumours is named as cancer. There are several types of cancer. Some of them

are produced without the formation of tumour, e.g. leukemia which is a cancer of blood cells and bone marrow. Factors responsible for the mutation or gene deformity are broadly divided in two groups: (i) external factors such as tobacco, chemicals, radiations, infections, and (ii) internal factors inside the cells such as inherited mutations, hormones, immune conditions, etc.

On average 33% of the human population suffers from cancer. Although cancer can develop in any age, but it is more common among the persons of advanced age usually more than 65 years. The common symptoms of cancer are : lumps or tumours, abnormal bleeding, prolonged cough, unexpected weight loss and change in bowel movement.

Besides having many positive pharmacological properties including antioxidative, antiinflammatory and antiseptic properties, curcumin possesses a special curative feature that makes it an anticancer agent, both as a chemopreventing and chemoprotecting compound. Due to its multitargetting action curcumin exhibited a remarkable activity against many types of cancers in some clinical trials involving humans<sup>21</sup>. On the basis of experimental studies it has been concluded that curcumin is capable of acting efficiently in inhibition of tumour formation, promotion, and progression in many animal models<sup>22</sup>. It showed an ability of inhibiting both tumour initiation and tumour formation induced by some chemical compounds<sup>23</sup>. Curcumin was also found to inhibit skin, oral, fore-stomach, duodenal, colon, and tongue carcinogenesis in mice and rats<sup>24</sup>. The above mentioned experimental results clearly indicate that curcumin may find a prominent place as a drug in cancer therapy. Recently, some phase I human trials showed that curcumin is safe and well tolerated chemopreventing agent.

**Diabetes:** Diabetes mellitus (DM) is a unique metabolic disease which is closely related with the lifestyle of a person. In this disease concentration of sugar is increased in the blood of the human beings, and consequently, the symptoms of the polyuria, polydipsia, and polyphagia are produced. There are three types of diabetes mellitus: (i) Type 1 diabetes (T1DM) in which body is unable to secrete insulin, (ii) Type 2 diabetes (T2DM) in which body is unable to use the insulin properly, and (iii) Gestational diabetes which is developed in women during pregnancy. Insulin is a peptide hormone secreted by beta cells of pancreatic islets. It regulates the sugar metabolism and maintains the proper sugar level in blood.

In the treatment of T2DM curcumin offers a promising option due to its antiinflammatory property<sup>25</sup>. On the basis of experimental rodent models, it has been suggested that

administration of curcumin can cure hyperglycemia and some other diabetes related disorders<sup>20</sup>. In addition to decreasing blood sugar level, curcumin increases plasma insulin level, inhibits diabetic cataract, counteracts dyslipidemia, renal dysfunction and attenuates neuropathic pain in animals<sup>20,26</sup>.

**Arthritis:** Arthritis is generally a disease of joints or joint pain. There are several types of arthritis which mainly include osteoarthritis, rheumatoid arthritis and gout. Common symptoms of arthritis are swelling, pain, stiffness, and decreased range of motion in joints. This is a degenerative disease, and can affect people of all ages and sexes, but it is most common among women particularly in older age. Osteoarthritis develops when the cartilage (a slick, cushioning surface at the ends of bones) wears away causing painful friction or rubbing between the bones at the joints. Rheumatoid arthritis is an autoimmune disease. Although, immune system of the body provides protection against infection and diseases by generating a protective internal inflammation, but when it damages the healthy cells at the joints, it leads to a condition named as rheumatoid arthritis. This disease primarily affects the joints inflaming their lining (synovium) resulting in pain and swelling that eventually leads to deformity. Third type of arthritis is gout. It is a metabolic disease caused by the development of high levels of uric acid in the body. In many cases uric acid builds up and forms needle- like crystals in the joints, resulting in unbearable pain. If the harmful levels of uric acid are not reduced, the disease may become chronic causing pain and disability.

Recently, S. C. Gupta *et al.*, have described the utility of curcumin in the treatment of arthritis<sup>25</sup>. Efforts to treat arthritis by curcumin have been made continuously since the year 1980. In an experimental trial, the efficacy of curcumin was compared to the standard drug phenylbutazone in patients with rheumatoid arthritis. The use of 1200 mg of curcumin per day showed good effectiveness in improving joint swelling, morning stiffness and walking time<sup>27</sup>. Although, compared to phenylbutazone, curcumin was found to be less effective but it seems to be safer and without harmful side effects. Another study revealed that curcumin alone or as a mixture with diclofenac was safe and effective in the treatment rheumatoid arthritis.<sup>28</sup> Khanna *et al.*, also described the use of curcumin in the treatment of this disease<sup>29</sup>. Some more reports also show that curcumin is useful therapeutic agent in providing relief in arthritis<sup>30</sup>.

**Gastrointestinal Conditions:** The antiinflammatory potential of turmeric has made it a valuable therapeutic

tool for the treatment of a number of gastrointestinal problems such as dyspepsia, Helicobacter pylori infection, peptic ulcer, irritable bowel syndrome (IrBS), Crohan's disease and ulcerative colitis<sup>31</sup>. Here, only irritable bowel syndrome (IrBS) is being mentioned briefly because it is a common disorder of digestive system that affects the large intestine. The exact cause of IrBS is unknown, but most experts believe that it is related to increased sensitivity of gut and problem of digesting food. The main symptoms of this disease are stomach cramps, abdominal pain, bloating, gas, altered bowel habits and increased stool frequency. There are more than one million cases of irritable bowel syndrome per year in India. Turmeric extract was found to exert a beneficial effect on the patients sufferings from this disease<sup>32</sup>. The beneficial effect of turmeric on IrBS has been attributed to its ability to increase the bowel motility and to activate hydrogen producing bacteria in the colon<sup>33</sup>.

**Skin Diseases:** Human body is a wonderful combination of large number of parts, each playing a significant role in its functioning and survival. Skin is the outermost safety wall composed of layers of tissues, that protects the body from diseases caused by devastating invasions of heat, chemicals, environmental pollutants and radiations. During the process of providing such protection, the skin itself often becomes the victim of various diseases such as scleroderma and psoriasis, etc. Curcumin has been reported to act as an effective remedy for the treatment of different kinds of skin diseases<sup>34</sup>.

Scleroderma is known as a systematic sclerosis. It is one of the autoimmune rheumatic diseases. The most visible manifestation of this disease is hardening of the skin. In fact, the name scleroderma is derived from two Greek words, "Sclera" meaning hard, and "derma" meaning skin. In this disease, scars may be formed on lungs and kidneys, and blood vessels become thick. Curcumin has been reported to be useful in the treatment of scleroderma as it is capable of modulating protein kinase C (PKC) and inducing an antioxidant enzyme<sup>35</sup>.

Psoriasis is another painful autoimmune disease which results in itchy or sore patches of thick red flakes with silvery scales on various parts of the body. Curcumin has the remarkable property to reduce the keratinocyte proliferation, and therefore, it may be developed as an effective antipsoriatic therapeutic agent as evident by a mouse-tail animal model experiment<sup>36</sup>. The use of curcumin has also been suggested in phototherapy of psoriasis.

Vitiligo is a disorder in which white patches appear on different parts of the human body. This disease happens

when melanin forming cells i.e. melanocytes are destroyed. Melanin is a pigment that is responsible for the colour of the human skin. Vitiligo generally causes psychological stress and those affected may be stigmatized. It is a non-contagious and non-hereditary disorder. The exact reason for the destruction of melanocytes is still unknown. But, it is a general belief that oxidative stress is a possible cause of vitiligo. The disease is usually treated with ultra-violet (UV) rays. A more effective treatment involves the synergetic combination of UV rays and application of tetrahydrocurcuminoid cream<sup>25</sup>. It seems that curcumin present in the cream, enhance the efficacy of UV rays treatment.

**Curcumin in the Treatment of Malaria:** Despite the mosquito control, various protective measures and invention of the recent effective antimalarial drug, artemisinin, malaria afflicts 250 million people worldwide and kills 6000,000 people every year<sup>37</sup>. The discovery of chloroquine and its various predecessors, quinine, etc., was considered a big success in the treatment of malaria, but soon these antimalarials lost their efficacy due to resistance developed by malaria parasite. This was a matter of great concern. Under this gloomy situation, Mao Zedong who was a supreme leader in China, ordered Chinese scientists to discover an effective new drug for the treatment of malaria. In fact, he was deeply concerned to protect the lives of North Vietnamese soldiers from chloroquine-resistant malaria, who were fighting against US forces in the forests in 1960s. Madam Youyou Tu, a women scientist working at the China Academy of Tradional Chinese Medicine, accepted the challenge and started an intensive search for a new antimalarial to meet the required need. She and her coworkers screened 200 recipes with traditional herbs of China. 380, Extracts of these herbs were examined, and ultimately, desired results were obtained with the extract of *Artemisia annua* or sweet wormwood after testing it on malaria infected mice and monkeys. Finally, she established the safety of *Artemisia annua* extracts in humans including herself, and isolated the active compound and named it artemisinin. Subsequently, artemisinin and its derivatives (ARTs) were synthesized that were very useful in the treatment of malaria. For this achievement Madam Youyou Tu was awarded Nobel Prize in 2015 in the field of physiology/medicine. Although, artemisinins (ARTs) are being used as front- line antimalarials, but unfortunately, the notorious malaria parasite has started to develop resistance against these also. Researchers at the Indian Institute of Science, Bangalore, under the leadership of G. Padmanaban disclosed that curcumin- artemisinin combination may act as an excellent antimalarial<sup>38</sup>, because both are naturally occurring, and so far no resistance is

known to curcumin. G. Padmanaban *et. al.*, have reported that curcumin not only synergises with artemisinin, but also strengthens the immune system to provide protection against parasite recrudescence<sup>38</sup>. These scientists have also suggested the use of curcumin in an adjunct therapy in the cure of cerebral malaria<sup>39</sup>.

### **Bioavailability and Safety**

In pharmacology, bioavailability is the amount of a drug that becomes available to a target organ or systematic circulation of an organism when introduced into the body by an appropriate method. The bioavailability of curcumin has been investigated by several trials involving humans and rodents<sup>2</sup>. These studies revealed that curcumin is rapidly metabolized in the liver, and slowly absorbed in the intestine resulting in its low bioavailability<sup>29</sup>. Most of the administered curcumin is eliminated unchanged through faeces, and only a negligible amount is excreted through the urine. Low bioavailability of any drug lowers its activity, and hence, considered as a great drawback. Consequently, attempts were made to increase the bioavailability and water solubility of curcumin by complexing it with other substances. One such substance is piperine which is an alkaloid present in black peppers. In humans 20 mg of piperine given concomitantly with 2 g of curcumin has significantly improved the bioavailability to the extent of 20 fold<sup>31</sup>. The enhancement of the solubility of hydrophobic curcumin is an essential factor for enhancing the bioavailability. It has been observed that formation of complexes with metal ions such as Zn<sup>2+</sup>, Cu<sup>2+</sup>, Mg<sup>2+</sup>, Se<sup>2+</sup> as well as with serum albumin increases the solubility of curcumin<sup>2</sup>. Recently, new formulations based on biocompatible organic substances, *e.g.*, liposomes, polyethylene, glycols, biopolymers, corn oil, hydrogels, *etc.*, have been developed to solve the problem of bioavailability of curcumin<sup>40</sup>. Supramolecular assemblies of curcumin with cyclodextrin and cucurbituril; and modern method of nanotechnology are also used to tackle this problem<sup>40</sup>.

Turmeric is usually consumed daily as a spice in many countries of the world, particularly in India and some other countries of Asia. The daily dietary consumption of turmeric is reported to be between 2 g and 2.5 g corresponding to a maximum of about 100 mg of curcumin<sup>2,41</sup>. In humans, dietary curcumin has very little or no toxic effect<sup>2</sup>. For general use, turmeric or curcumin are regarded as safe and well tolerated. Even, at doses as high as 12 g of curcumin per day did not exhibit any adverse effect over placebo<sup>42</sup>.

### **Concluding Remarks**

Turmeric is deeply associated with different facets of human life such as cultural, economic, spiritual and medical. It has been used for millennia in Indian and Chinese traditional medicine system as a reliable and effective therapeutic agent for the treatment of diverse physiological and psychosomatic disorders. The isolation of its biologically active compound, curcumin started a new era in the search of cure for many challenging diseases including cancer, cardiovascular disease, and age-related deformities. The discovery of excellent antioxidant and antiinflammatory properties of curcumin, made it an attractive and topical target of pharmacological research in 21<sup>st</sup> century all over the world. In addition to above mentioned diseases curcumin have been found suitable for the treatment of malaria by a new approach known as “*Combination Therapy*”. The low bioavailability and water insolubility of curcumin are the serious drawbacks associated with this useful compound. However, this problem has also been resolved by complexing it with other, suitable substances such as piperine, metal ions and making the use of modern methods such as molecular assemblies and nanotechnology. The pharmacological potential of curcumin is derived on the basis of cell culture, animal studies, and few human pilot experiments. Present trials indicate that curcumin exerts a curative effect by modulating the immune system, but the exact molecular mechanism of the process is still uncertain. Therefore, to unveil the unknown aspects related with therapeutic potential of this wonder molecule, larger clinical trials are required. It is hoped that time is not far behind, when curcumin will find a glorious place at the fore-front of the novel drugs of this century. □

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