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Review Article

Chemical Constituents and Experimental Pharmacology of Curcuma longa: A Comprehensive Review

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Abstract

Numerous studies have been spurred by the complex chemical composition and range of pharmacological properties of turmeric, or Curcuma longa. This research provides a thorough analysis of the chemical components of Curcuma longa, with a focus on curcumin, demethoxycurcumin, and bisdemethoxycurcumin—the plant's main bioactive compounds. The experimental pharmacology of the substances is also examined, with a focus on their neuroprotective, antioxidant, anti-inflammatory, and anticancer characteristics. The review investigates the therapeutic potential of Curcuma longa in a range of medical diseases and clarifies the mechanisms of action behind these pharmacological activities through a synthesis of recent research findings. The study delves into the difficulties encountered in converting these experimental findings into clinical practises and proposes future research avenues aimed at enhancing the effectiveness and practicality of turmeric-derived treatments.

Key words: ODC (ornithine decarboxylase); TPA (tetradecanoylphorbol acetate); Curcumin (CCM); Docosahexaenoic acid (DHA)

Introduction

The perennial herb turmeric (Curcuma longa L.) is a member of the zingiberaceae family. It is one of the primary Ayurvedic medications used in southern and western India for therapeutic purposes. The first individual to identify Curcuma longa as a therapeutic vegetable was Marco Polo. Studies on the various components and extracts of the turmeric rhizome have demonstrated that, when taken either on its own or in combination with other ingredients, it has a wide range of therapeutic benefits, including anti-inflammatory, antioxidant, digestive, anti-proliferative, antimutagenic, and hepatoprotective effects.

For many years, people have used a variety of herbal treatments to cure a wide range of illnesses. Indians have long known that many of the plants that grow on their subcontinent are medicinal in nature.They began preparing medications from these plants to treat various illnesses. Afterwards, using herbal remedies to heal patients became a part of their customary practices. The first text, the Rigveda, was composed using herbs with therapeutic qualities between 4500 and 1600 BC (Agrawal et al., 2007). One of the herbs mentioned in the old materia medica of the Indians was turmeric.

The perennial herb turmeric is a member of the zingiberaceae family. It has tuber rhizomes and is orange on the inside. Its rhizomes, which are 1.2 meters long and have an oval shape, are where its leaves begin. The golden flowers measure 10 to 15 cm in length. Actually, this plant originated in Asia, where it goes by the name "haldi." Since it comes from Asia, research on it has already been conducted in Indonesia, Malaysia, and India. Because of their flavor and color, turmeric rhizomes are frequently employed in cooking (Scartezzini et al., 2000). Hindu women use it to their foreheads as a beauty point. Prior to marriage, it is customary for brides to be applied with turmeric paste (Paranpe et al., 2001).

Turmeric was classified in Ayurveda under several headings, such as emaciating, anti-poisonous, and anti-dermatosis (Acharya et al., 1994).

Historical Review on Turmeric

It is referred to as "Haridra" in Hindu religious terminology, which is Sanskrit for "effective medicine for jaundice" (Sharma et al., 2000). It is a component of the primary Ayurvedic medications used in western and southern India to cure illnesses. Since it originates in India, it was mistakenly referred to as Indian saffron. Turmeric gained use outside of India after being well-known there, in China in 700 AD, East Africa in 800 AD, and West Africa in 1200 AD. Additionally, it is said that in the thirteenth century, Arab settlers brought turmeric with them to Europe.

.. Marco Polo was the one who traveled the Silk Road to India and learned about turmeric. He was struck by the vegetable's therapeutic qualities. Further research on turmeric in the 19th century produced a coloring chemical that was isolated from rhizomes and was thought to have anti-inflammatory properties (Govindarajan et al., 1980).

Chemical Constituents

Turmeric, or Curcuma longa, is well-known for a wide range of chemical components, chiefly a class of substances called curcuminoids. The most well-known of these is curcumin, which accounts up between 2 and 5% of the dried rhizome and is primarily responsible for turmeric's yellow hue and medicinal qualities. Curcumin I (demethoxycurcumin), Curcumin II (bisdemethoxycurcumin), and Curcumin III (curcumin) are the three primary forms of curcumin, which is a diarylheptanoid. Turmeric contains other bioactive substances, such as turmerone, and essential oils in addition to curcuminoids, which give it its distinct scent and possible health advantages. Sesquiterpenes such ar-turmerone and β-turmerone, which are thought to have unique pharmacological actions, are other noteworthy ingredients. Turmeric's total therapeutic potential is enhanced by the synergistic interactions between these components, which makes it a relevant research topic in both traditional medicine and modern pharmacology (Kokate et al., 2006; Soudamini et al., 1989). Essential oils derived from turmeric (Curcuma longa L.) are renowned for their distinct scent and therapeutic properties. They have a complex and varied chemical makeup. Turmeric essential oil has a large number of sesquiterpenes and monoterpenes. Significantly contributing to the oil's composition are three significant sesquiterpenes: ar-, β-, and α-turmerone. Ar-turmerone's potential anti-inflammatory and neuroprotective effects make it particularly remarkable. Other notable components include zingiberene, which adds a warm, spicy scent, and camphene, which adds a crisp, herbaceous tone. The intricate interactions among these components influence not only the essential oil's fragrance but also its pharmacological characteristics, which include antibacterial, antioxidant, and anti-inflammatory effects. Understanding the chemical composition of turmeric essential oil helps to optimize its application in therapeutic and cosmetic mixtures, increasing its potency and usefulness (Leela et al., 2002; Khanna et al., 1999)

Pharmacological Activities

Anti-inflammatory

Both the alcoholic and aqueous extracts that were used to extract it seemed to have anti-inflammatory properties. Arachidonic acid was used to cause inflammation in the ears of mice used in the experiment. All of the observations and analysis combined demonstrated that it functions as an anti-inflammatory by influencing the mediators and metabolism of the cyclo-oxygenase pathway, also known as the arachidonic acid pathway (Kumar et al., 2009).

Anti-tumor Actions

One of the primary active ingredients with anti-tumor action is germacronone. When its efficacy was evaluated on the proliferation of human glioma cells, its cytotoxic mode of action demonstrated the ability to limit proliferation by inducing apoptosis and stopping the cell cycle. Because it increases the production of a protein involved in apoptosis and cell cycle arrest, it is also thought to be beneficial as a chemoprotective medication. (Liu and others, 2014)

Additional components identified from the rhizome of turmeric, referred to as beta elemene, had anti-proliferative properties. To assess the proliferation inhibitory efficacy of volatile oils derived from turmeric, two different kinds of studies were conducted. Hepatoma was produced in mouse cells, and the inhibitory properties of volatile oils were assessed using immune histochemical staining and DNA imaging. In several trials, the results showed 51 and 52 percent inhibitory activity, respectively. This activity was considerable when compared to the control group (Wu et al., 2000).

Anti-Melanogenic Activity

Tyrosinase actions were examined in order to assess this activity. Melanin and tyrosinase were the primary factors in melanogenesis. UV light exposed the melanoma cells, which led to an increase in melanin production and the subsequent development of skin cancer and hyperpigmentation. This experiment's primary goals were to measure the inhibitory activity of UV radiation on oxidative stress and to increase the activity of antioxidant enzymes already present in cells, such as glutathione and catalase. According to Panich et al. (2010), the reviewed results demonstrated unequivocally that it was beneficial in preventing oxidative stress and supportive when antioxidant enzymes were depleted.

Antioxidant Action

Numerous diseases are primarily caused by oxidative stress, which damages cellular components and speeds up the aging process (Osawa et al., 1994). Curcumin is an active ingredient that primarily functions as an antioxidant by scavenging free radicals and safeguarding DNA structure. Curcumin has demonstrated the capacity to inhibit the enzymes lipoxygenase and cyclooxygenase in in vitro investigations. Topical application of curcumin to the skin proved its antiaging properties, and it was determined that this would lead to increased glutathione production and glutathione transferase function. When applied topically, it has anti-inflammatory and antioxidant properties. It is also becoming apparent that its ability to scavenge free radicals makes it more beneficial than vitamin E (Prakash et al., 2004). Curcumin inhibited the action of ODC, demonstrating antioxidant properties when applied to mouse skin and subjected to UV light and TPA (Pons et al., 2003).

Hepatoprotective

When jaundice was treated with a powdered form of turmeric rhizome combined with amla (Pandey et al., 2002). When combined with turmeric, a number of additional plants, including Anjana, red ochre, and amalaki, can help treat jaundice (Tripathi et al., 2009). Due to its anti-inflammatory and antioxidant properties, curcumin has been shown to reduce inflammation by increasing the mortality rate of injured liver cells. An experiment was conducted to determine the dosage that was shown to be beneficial in treatment. Two distinct quantities of the ethanolic extract—250 mg and 500 mg—per kilogram of body weight were utilized.

Tangerone, atlantone, zingiberene, and curcumin are included in the extract. Extract activity was found to be dosage dependent (Salama et al., 2013).

Synergistic Activity

Additionally, curcumin works in concert with other ingredients to cure a variety of ailments. One illustration is the way in which curcumin and DHA inhibit the growth of breast cancer cells. Together, these two elements work against SK-BR-3. Actually, curcumin is taken up by breast cancer cells with the assistance of DHA (Altenburg et al., 2011). Additionally, additional research showed that curcumin and garcinol work together to inhibit the growth of pancreatic cancer cells. Increased apoptosis was seen within 48 hours of evaluation using ELISA and DNA histology (Mansi et al., 2012).

Conclusion and Recommendations

It is determined that turmeric functions as a medicine and offers numerous health benefits to people. It is also customarily rubbed to Hindu women's foreheads to enhance their attractiveness, and it is used as a spice in cuisine all over the world. Its pharmacological actions are wide and include antiaging, diabetic treatment, and inflammatory skin treatment. Since curcumin is one of the most researched active ingredients in turmeric, its pharmacological properties are well established. Still, there is always more to learn and explore when it comes to herbs, thus research on them can never end.

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