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Curcama Longa: A Wonder Herb From Kitchen To Medicinal World

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ABSTRACT: Turmeric [2][3] is a flowering plant, *Curcuma longa* ,[4][5] of the ginger family, Zingiberaceae, the rhizomes of which are used in cooking.[1] The plant is a perennial, rhizomatous, herbaceous plant native to the Indian subcontinent and Southeast Asia that requires temperatures between 20 and 30 °C (68 and 86 °F) and high annual rainfall to thrive. Plants are gathered each year for their rhizomes, some for propagation in the following season and some for consumption.

The rhizomes are used fresh or boiled in water and dried, after which they are ground into a deep orange-yellow powder commonly used as a coloring and flavoring agent in many Asian cuisines, especially for curries, as well as for the dyeing characteristics imparted by the principal turmeric constituent, curcumin.[6]

Turmeric powder has a warm, bitter, black pepper-like flavor and earthy, mustard-like aroma.[7][8]

Curcumin, a bright yellow chemical produced by the turmeric plant, is approved as a food additive by the World Health Organization, European Parliament, and United States Food and Drug Administration.[6]

Although long used in Ayurvedic medicine, where it is also known as *haridra*,[9] there is no high-quality clinical evidence that consuming turmeric or curcumin is effective for treating any disease.[10][11]

KEYWORDS: turmeric, Zingiberaceae, medicinal, rhizomes, kitchen, ayurvedic, food additive

I.INTRODUCTION

The greatest diversity of *Curcuma* species by number alone is in India, at around 40 to 45 species. Thailand has a comparable 30 to 40 species. Other countries in tropical Asia also have numerous wild species of *Curcuma*. Recent studies have also shown that the taxonomy of *C. longa* is problematic, with only the specimens from South India being identifiable as *C. longa*. The phylogeny, relationships, intraspecific and interspecific variation, and even identity of other species and cultivars in other parts of the world still need to be established and validated. Various species currently utilized and sold as "turmeric" in other parts of Asia have been shown to belong to several physically similar taxa, with overlapping local names.[12][13] Turmeric has been used in Asia for centuries and is a major part of Ayurveda, Siddha medicine, traditional Chinese medicine, Unani,[14] and the animistic rituals of Austronesian peoples.[15][16] It was first used as a dye, and then later for its supposed properties in folk medicine.[10][11]

From India, it spread to Southeast Asia along with Hinduism and Buddhism, as the yellow dye is used to color the robes of monks and priests. Turmeric has also been found in Tahiti, Hawaii and Easter Island before European contact.[17] There is linguistic and circumstantial evidence of the spread and use of turmeric by the Austronesian peoples into Oceania and Madagascar. The populations in Polynesia and Micronesia, in particular, never came into contact with India, but use turmeric widely for both food and dye. Thus independent domestication events are also likely.[15][16]

Turmeric was found in Farmana, dating to between 2600 and 2200 BCE, and in a merchant's tomb in Megiddo, Israel, dating from the second millennium BCE.[18] It was noted as a dye plant in the Assyrians' Cuneiform medical texts from Ashurbanipal's library at Nineveh from 7th century BCE.[17] In Medieval Europe, turmeric was called "Indian saffron."[17]

Turmeric is a perennial herbaceous plant that reaches up to 1 m (3 ft 3 in) tall.[1] It has highly branched, yellow to orange, cylindrical, aromatic rhizomes.[1]

The leaves are alternate and arranged in two rows. They are divided into leaf sheath, petiole, and leaf blade.[1] From the leaf sheaths, a false stem is formed. The petiole is 50 to 115 cm (20–45 in) long. The simple leaf blades are usually 76 to 115 cm (30–45 in) long and rarely up to 230 cm (7 ft 7 in). They have a width of 38 to 45 cm (15 to 17+½ in) and are oblong to elliptical, narrowing at the tip.[1]

At the top of the inflorescence, stem bracts are present on which no flowers occur; these are white to green and sometimes tinged reddish-purple, and the upper ends are tapered.[20]

The hermaphrodite flowers are zygomorphic and threefold. The three sepals are 0.8 to 1.2 cm (⅜ to ½ in) long, fused, and white, and have fluffy hairs; the three calyx teeth are unequal. The three bright-yellow petals are fused into a corolla tube up to 3 cm (1+¼ in) long. The three corolla lobes have a length of 1.0 to 1.5 cm (⅜–⅝ in) and are triangular with soft-spiny upper ends. While the average corolla lobe is larger than the two lateral, only the median stamen of the inner circle is fertile. The dust bag is spurred at its base. All other stamens are converted to staminodes. The outer staminodes are shorter than the labellum. The labellum is yellowish, with a yellow ribbon in its center and it is obovate, with a length from 1.2 to 2.0 cm (½ to ¾ in). Three carpels are under a constant, trilobed ovary adherent, which is sparsely hairy. The fruit capsule opens with three compartments.[21][22]
In East Asia, the flowering time is usually in August. Terminally on the false stem is an inflorescence stem, 12 to 20 cm (4+½ to 8 in) long, containing many flowers. The bracts are light green and ovate to oblong with a blunt upper end with a length of 3 to 5 cm (1 to 2 in).

Turmeric powder is about 60–70% carbohydrates, 6–13% water, 6–8% protein, 5–10% fat, 3–7% dietary minerals, 3–7% essential oils, 2–7% dietary fiber, and 1–6% curcuminoids.[10] The golden yellow color of turmeric is due to curcumin.[6]

Phytochemical components of turmeric include diarylheptanoids, a class including numerous curcuminoids, such as curcumin, demethoxycurcumin, and bisdemethoxycurcumin.[10][6] Curcumin constitutes up to 3.14% of assayed commercial samples of turmeric powder (the average was 1.51%); curry powder contains much less (an average of 0.29%).[23] Some 34 essential oils are present in turmeric, among which turmerone, germacrone, atlantone, and zingiberene are major constituents.[24][25][26]

Turmeric is one of the key ingredients in many Asian dishes, imparting a mustard-like, earthy aroma and pungent, slightly bitter flavor to foods.[7][8] It is used mostly in savory dishes, but also is used in some sweet dishes, such as the cake *sfouf*. In India, turmeric leaf is used to prepare special sweet dishes, *patoleo*, by layering rice flour and coconut-jaggery mixture on the leaf, then closing and steaming it in a special utensil (*chondrõ*).[27] Most turmeric is used in the form of rhizome powder to impart a golden yellow color.[7][8] It is used in many products such as canned beverages, baked products, dairy products, ice cream, yogurt, yellow cakes, orange juice, biscuits, popcorn, cereals, sauces, and gelatin. It is a principal ingredient in curry powders.[7][28] Although typically used in its dried, powdered form, turmeric also is used fresh, like ginger.[28] It has numerous uses in East Asian recipes, such as a pickle that contains large chunks of fresh soft turmeric.

Turmeric is used widely as a spice in South Asian and Middle Eastern cooking. Various Iranian *khoresh* recipes begin with onions caramelized in oil and turmeric. The Moroccan spice mix ras el hanout typically includes turmeric. In South Africa, turmeric is used to give boiled white rice a golden color, known as *geelrys* (yellow rice) traditionally served with bobotie. In Vietnamese cuisine, turmeric powder is used to color and enhance the flavors of certain dishes, such as *bánh xèo, bánh khọt*, and *mì Quảng*. The staple Cambodian curry paste, *kroeung*, used in many dishes, including fish amok, typically contains fresh turmeric. In Indonesia, turmeric leaves are used for Minang or Padang curry base of Sumatra, such as *rendang*, *sate padang*, and many other varieties. In the Philippines, turmeric is used in the preparation and cooking of *kuning*, *satti*, and some variants of *adobo*. In Thailand, fresh turmeric rhizomes are used widely in many dishes, in particular in the southern Thai cuisine, such as yellow curry and turmeric soup. Turmeric is used in a hot drink called "turmeric latte" or "golden milk" that is made with milk, frequently coconut milk.[29] The turmeric milk drink known as *haldī dūdh* (*haldī* [हलदी] means turmeric in Hindi) is a traditional indian recipe. Sold in the US and UK, the drink known as "golden milk" uses nondairy milk and sweetener, and sometimes black pepper after the traditional recipe (which may also use ghee).[29]

Turmeric is approved for use as a food color, assigned the code E100.[6][28] The oleoresin is used for oil-containing products.[6]

In combination with annatto (E160b), turmeric has been used to color numerous food products.[6][28] Turmeric is used to give a yellow color to some prepared mustards, canned chicken broths, and other foods—often as a much cheaper replacement for saffron.[28][30]

In 2019, the European Medicines Agency concluded that turmeric herbal teas, or other forms taken by mouth, on the basis of their long-standing traditional use, could be used to relieve mild digestive problems, such as feelings of fullness and flatulence.[31]

Turmeric grows wild in the forests of South and Southeast Asia, where it is collected for use in classical Indian medicine (Siddha or Ayurveda).[10] In Eastern India, the plant is used as one of the nine components of *nabapatrika* along with young plantain or banana plant, taro leaves, barley (*jayanti*), wood

apple (*bilva*), pomegranate (*darimba*), *Saraca indica*, *manaka* (*Arum*), or *manakochu*, and rice paddy. The Haldi ceremony called *gaye holud* in Bengal (literally "yellow on the body") is a ceremony observed during wedding celebrations of people of Indian culture all throughout the Indian subcontinent.[32]

In Tamil Nadu and Andhra Pradesh, as a part of the Tamil–Telugu marriage ritual, dried turmeric tuber tied with string is used to create a Thali necklace. In western and coastal India, during weddings of the Marathi and Konkani people, Kannada Brahmins, turmeric tubers are tied with strings by the couple to their wrists during a ceremony, *Kankana Bandhana*.[33]

Turmeric makes a poor fabric dye, as it is not light fast, but is commonly used in Indian clothing, such as saris and Buddhist monks' robes.[8] During the late Edo period (1603–1867), turmeric was used to dilute or substitute more expensive safflower dyestuff in the production of *beni itajime shibori*.[34]:1 Friedrich Ratzel reported in *The History of Mankind* during 1896, that in Micronesia, turmeric powder was applied for embellishment of body, clothing, utensils, and ceremonial uses.[35] Native Hawaiians who introduced it to Hawaii (Hawaiian: *ʻōlena*) make a bright yellow dye out of it.[36]

II.DISCUSSION

Turmeric paper, also called curcuma paper or in German literature, *Curcumapapier*, is paper steeped in a tincture of turmeric and allowed to dry. It is used in chemical analysis as an indicator for acidity and alkalinity.[37] The paper is yellow in acidic and neutral solutions and turns brown to reddish-brown in alkaline solutions, with transition between pH of 7.4 and 9.2.[38] As turmeric and other spices are commonly sold by weight, the potential exists for powders of toxic, cheaper agents with a similar color to be added, such as lead(II,IV) oxide ("red lead"). These additives give turmeric an orange-red color instead of its native gold-yellow, and such conditions led the US Food and Drug Administration (FDA) to issue import alerts from 2013 to 2019 on turmeric originating in India and Bangladesh.[39] Imported into the United States in 2014 were approximately 5.4 million kilograms (12 million pounds) of turmeric, some of which was used for food coloring, traditional medicine, or dietary supplement.[40] Lead detection in turmeric products led to recalls across the United States, Canada, Japan, Korea, and the United Kingdom through 2016.[40]

Lead chromate, a bright yellow chemical compound, was found as an adulterant of turmeric in Bangladesh, where turmeric is used commonly in foods and the contamination levels were up to 500 times higher than the national limit.[41] Researchers identified a chain of sources adulterating the turmeric with lead chromate: from farmers to merchants selling low-grade turmeric roots to "polishers" who added lead chromate for yellow color enhancement, to wholesalers for market distribution, all unaware of the potential consequences of lead toxicity.[41]

Another common adulterant in turmeric, metanil yellow (also known as acid yellow 36), is considered by the British Food Standards Agency as an illegal dye for use in foods.[42]

Turmeric and curcumin have been studied in numerous clinical trials for various human diseases and conditions, with no high-quality evidence of any anti-disease effect or health benefit.[10][11][43][44] There is no scientific evidence that curcumin reduces inflammation, as of 2020.[10][11][45] There is weak evidence that turmeric extracts may be beneficial for relieving symptoms of knee osteoarthritis,[46] as well as for reducing pain and muscle damage following physical exercise.[47] There is good evidence that turmeric is an allergen.[48]

Curcumin is a bright yellow chemical produced by plants of the *Curcuma longa* species. It is the principal curcuminoid of turmeric (*Curcuma longa*), a member of the ginger family, Zingiberaceae. It is sold as a herbal supplement, cosmetics ingredient, food flavoring, and food coloring.[1]

Chemically, curcumin is a diarylheptanoid, belonging to the group of curcuminoids, which are phenolic pigments responsible for the yellow color of turmeric.[2]

Laboratory and clinical research have not confirmed any medical use for curcumin. It is difficult to study because it is both unstable and poorly bioavailable. It is unlikely to produce useful leads for drug development.[3]

Curcumin was named in 1815 when Henri Auguste Vogel and Pierre Joseph Pelletier reported the first isolation of a "yellow coloring-matter" from the rhizomes of turmeric.[4] Later, it was found to be a mixture of resin and turmeric oil. In 1910, Milobedzka and Lampe reported the chemical structure of curcumin to be as diferuloylmethane.[5] Later in 1913, the same group accomplished the synthesis of the compound.

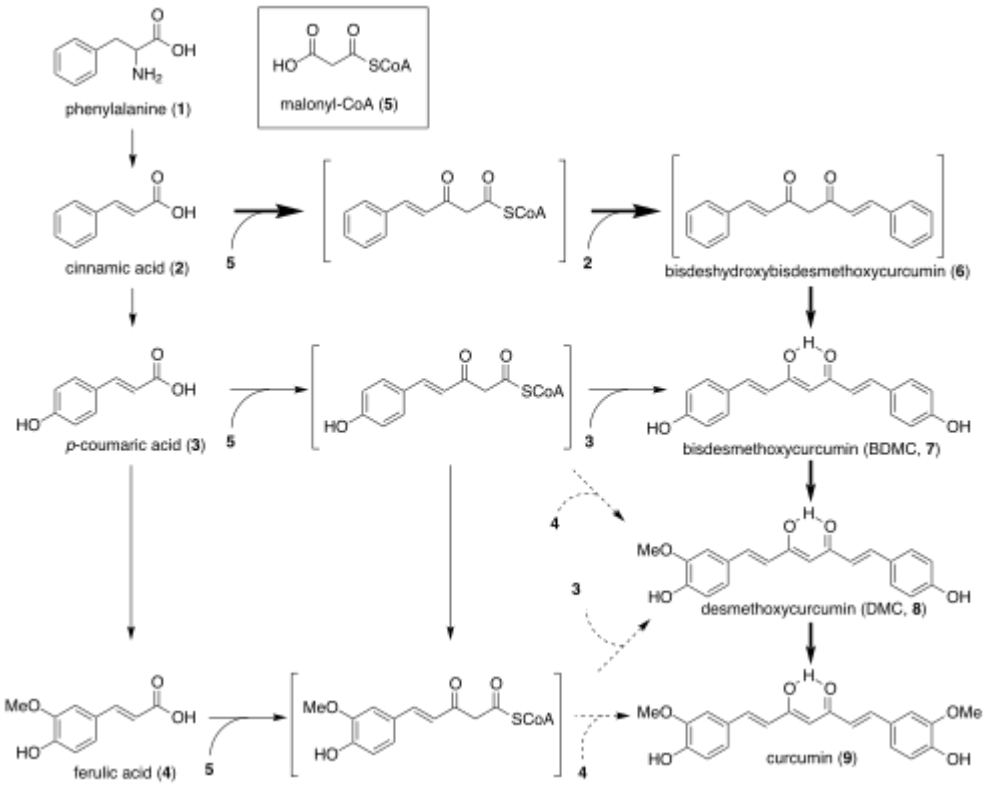
Although curcumin has been used historically in Ayurvedic medicine,[6] its potential for medicinal properties remains unproven as a therapy when used orally.[3][7][8]

III.RESULTS

The most common applications are as an ingredient in dietary supplement, in cosmetics, as flavoring for foods, such as turmeric-flavored beverages in South and Southeast Asia,[1] and as coloring for foods, such as curry powders, mustards, butters, cheeses. As a food additive for orange-yellow coloring in prepared foods, its E number is E 100 in the European Union.[9][10] It is also approved by the U.S. FDA to be used as a food coloring in US.[11] Curcumin incorporates a seven carbon linker and three major functional groups: an α,β-unsaturated β-diketone moiety and an aromatic O-methoxy-phenolic group.[2][5] The aromatic ring systems, which are phenols, are connected by two α,β-unsaturated carbonyl groups.[2][12] It is a diketone tautomer, existing in enolic form in organic solvents and in keto form in water.[13] The diketones form stable enols and are readily deprotonated to form enolates; the α,β-unsaturated carbonyl group is a good Michael acceptor and undergoes nucleophilic addition.[Because of its hydrophobic nature, curcumin is poorly soluble in water.[2] However, it is easily soluble in organic solvents.[5]

Curcumin is used as a complexometric indicator for boron.[2][14] It reacts with boric acid to form a red-colored compound, rosocyanine. The biosynthetic route of curcumin is uncertain. In 1973, Peter J. Roughley and Donald A. Whiting proposed two mechanisms for curcumin biosynthesis. The first mechanism involves a chain extension reaction by cinnamic acid and 5 malonyl-CoA molecules that eventually arylize into a curcuminoid. The second mechanism involves two cinnamate units coupled together by malonyl-CoA. Both use cinnamic acid as their starting point, which is derived from the amino acid phenylalanine.[15]

Plant biosynthesis starting with cinnamic acid is rare compared to the more common *p*-coumaric acid.[15] Only a few identified compounds, such as anigorufone and pinosylvin, build from cinnamic acid.[16][17]



Biosynthetic pathway of curcumin in *Curcuma longa*.[15]

Curcumin, which shows positive results in most drug discovery assays, is regarded as a false lead that medicinal chemists include among "pan-assay interference compounds". This attracts undue experimental attention while failing to advance as viable therapeutic or drug leads,[3][7][18] although some derivatives of curcumin such as EF-24 have seen a significant amount of research.[19]

Factors that limit the bioactivity of curcumin or its analogs include chemical instability, water insolubility, absence of potent and selective target activity, low bioavailability, limited tissue distribution, and extensive metabolism.[3] Very

little curcumin escapes the GI tract and most is excreted in feces unchanged.[20] If curcumin enters plasma in reasonable amounts, there is a high risk of toxicity since it is promiscuous, and interacts with several proteins known to increase the risk of adverse effects, including hERG, cytochrome P450s, and glutathione S-transferase.[3]

As a component of turmeric, curcumin may interact with prescription drugs and dietary supplements.[21] In high amounts, it may be unsafe for women during pregnancy.[21] It may cause side effects, such as nausea, diarrhea, hives, or dizziness.[21] Between 2004 and 2022 there were ten cases of liver injury caused by curcumin herbal and dietary supplements.[22] Curcumin is a contact allergen.[23]

The intended use of curcumin as a food additive is generally recognized as safe by the U.S. Food and Drug Administration.[24]

IV.CONCLUSIONS

Although curcumin has been assessed in numerous laboratory and clinical studies, it has no medical uses established by well-designed clinical research.[25] According to a 2017 review of more than 120 studies, curcumin has not been successful in any clinical trial, leading the authors to conclude that "curcumin is an unstable, reactive, non-bioavailable compound and, therefore, a highly improbable lead".[3] Curcumin exhibits numerous interference properties which may lead to misinterpretation of results.[3][7][26]

The US government has supported US$150 million in research into curcumin through the National Center for Complementary and Integrative Health, and no support has been found for curcumin as a medical treatment.[3][27] Bharat Aggarwal was a cancer researcher at the University of Texas MD Anderson Cancer Center, who as of July 2021 had 29 papers retracted for research fraud.[28][29][30] Aggarwal's research had focused on potential anti-cancer properties of herbs and spices, particularly curcumin, and according to a March 2016 article in the *Houston Chronicle*, "attracted national media interest and laid the groundwork for ongoing clinical trials".[31][32][33] Aggarwal co-founded a company in 2004 called Curry Pharmaceuticals, based in Research Triangle Park, North Carolina, which was seeking to develop drugs based on synthetic analogs of curcumin.[32][34] SignPath Pharma, a company seeking to develop liposomal formulations of curcumin, licensed three patents invented by Aggarwal related to that approach from MD Anderson in 2013.[35] Between 2018 and 2023, the FDA issued 29 warning letters to American manufacturers of dietary supplements for making false claims of anti-disease effects from using products containing curcumin.[36] In each letter, the FDA stated that the supplement product was not an approved new drug because the "product is not generally recognized as safe and effective" for the advertised uses, that "new drugs may not be legally introduced or delivered for introduction into interstate commerce without prior approval from FDA", and that the "FDA approves a new drug on the basis of scientific data and information demonstrating that the drug is safe and effective".[36] Though there is no evidence for the safety or efficacy of using curcumin as a therapy,[3][7] some alternative medicine practitioners give it intravenously, supposedly as a treatment for numerous diseases.[37][38][39] In 2017, two serious cases of adverse events were reported from curcumin or turmeric products—one severe allergic reaction and one death[37]—that were caused by administration of a curcumin-polyethylene glycol (PEG40) emulsion product by a naturopath.[39] One treatment caused anaphylaxis leading to death.[37][39] Decontamination of food by ionizing radiation, or food irradiation, is considered a safe and efficient process for elimination of pathogenic bacteria.[40][41] Ionizing radiation treatment can be applied to either raw materials or ready to eat foods, with some countries, like the United States, imposing limitations on its use.[40][42] In 2016, laboratory research established and compared the radiosensitivity of three organic food colorants including curcumin, carmine, and annatto to create data to be used for application whenever food products containing these food colors were to undergo the radiation process.[40] The researchers used spectrophotometry and capillary electrophoresis to establish radiosensitivity of the three organic food colorants. Carmine samples were quite stable against radiation treatment, annatto showed limited stability, and curcumin was found to be stable at high temperatures and in acids, but unstable in alkaline conditions and in the presence of light.[40]

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