IJARASEM

ISSN: 2395-7852

International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)

Volume 10, Issue 1, January 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

IMPACT FACTOR: 6.551

| ISSN: 2395-7852 | www.ijarasem.com | Impact Factor: 6.551 |Bimonthly, Peer Reviewed & Referred Journal|

| Volume 10, Issue 1, January 2023 |

Fluid Extraction From Turmeric Rhizomes

Pardeep, Dr. Kailash Bhargava

Research Scholar, Dept. of Chemistry, Himalayan University, Arunachal Pradesh, India

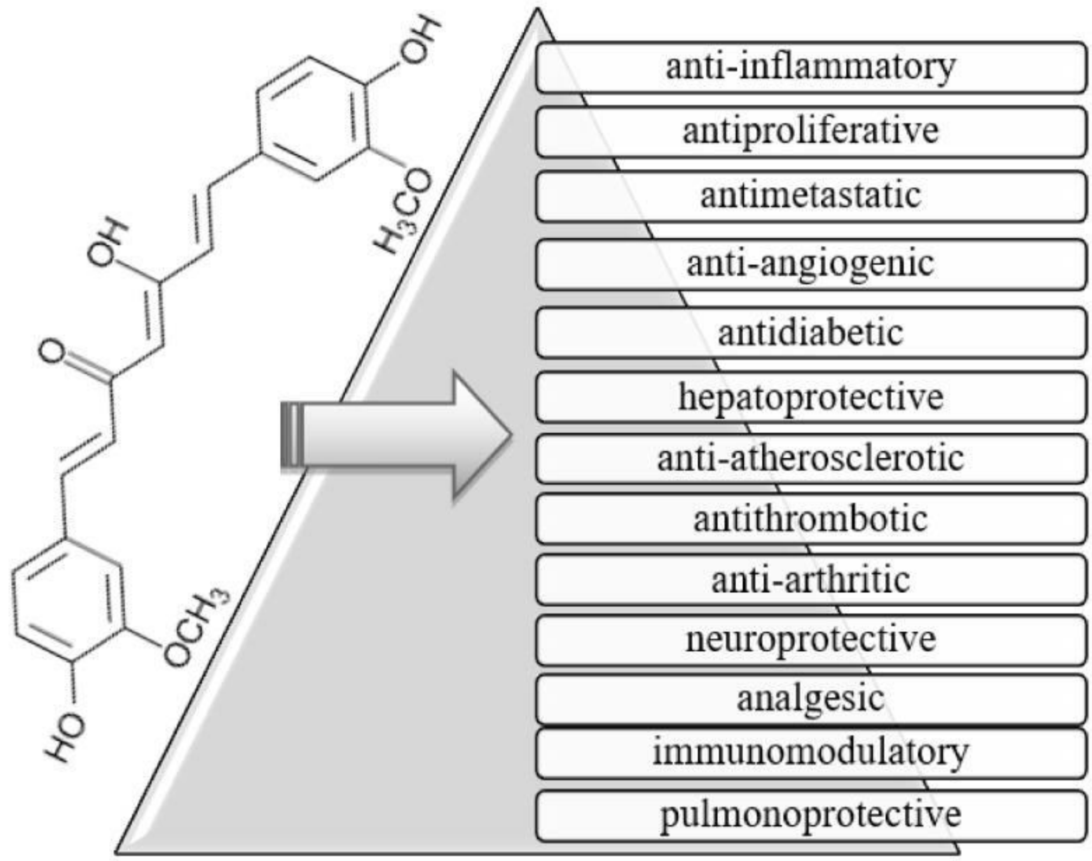
Supervisor, Dept. of Chemistry, Himalayan University, Arunachal Pradesh, India

ABSTRACT: This review discusses the impact of curcumin—an aromatic phytoextract from the turmeric (*Curcuma longa*) rhizome—as an effective therapeutic agent. Despite all of the beneficial health properties ensured by curcumin application, its pharmacological efficacy is compromised in vivo due to poor aqueous solubility, high metabolism, and rapid excretion that may result in poor systemic bioavailability.

KEYWORDS: curcumin, phytoextract, rhizome, pharmacological, metabolism, fluid, therapeutic

I.INTRODUCTION

Curcumin, a curcuminoid is a bioactive fluid representing 1.5–3 wt.% of the rhizome of turmeric (*Curcuma longa*) , also known as diferuloylmethane. This yellow pigmented powder can be obtained by grinding the rhizome of turmeric , owing the color to the curcumin present . It has been used over the centuries for cooking, especially in Asia, as well as for treatment due to its curing properties in diseases, such as dysentery, chest congestion, and pain. Moreover, it has been known as a strong antioxidant . Over the past half a century, curcumin has received growing interest in biological ,pharmacological and nutraceutical research . Interestingly, it was in 1949 that its antibacterial properties were discovered . Since then, many studies have proved that curcumin also possesses other potential beneficial properties, such as anti-inflammatory , antiproliferative,antimetastatic , anti-angiogenic ,antidiabetic ,hepatoprotective , anti-atherosclerotic , antithrombotic , wound healing ,anti-cancer , anti-arthritic , neuroprotective ,analgesic , immunomodulatory ,and pulmonoprotective , properties, among many other effects .



Chemical structure and selected properties of curcumin ($C_{21}H_{20}O_6$).

| ISSN: 2395-7852 | www.ijarasem.com | Impact Factor: 6.551 |Bimonthly, Peer Reviewed & Referred Journal|

| Volume 10, Issue 1, January 2023 |

Curcumin ($C_{21}H_{20}O_6$), also named [1,7-bis (4-hydroxy-3- methoxyphenyl)-1,6-heptadiene-3,5-dione] has a molecular weight of 368.38 g/mol and it is solid at room temperature. It is a hydrophobic molecule, mostly insoluble in water (only 30 nM can be dissolved) and poorly soluble in hydrocarbon solvents however, curcumin is very soluble in polar solvents .The chemical structure of curcumin contains two aromatic ring systems with o-methoxy phenolic groups.Thanks to three functional groups—an aromatic o-methoxy phenolic group, α,β-unsaturated β-diketo moiety, and a seven carbon chain—the component is biologically active .Despite all its benefits, curcumin has low bioavailability . Because an oral dose of curcumin has a reduced absorption, the molecule is rapidly metabolized in the intestine and the liver by aldo-keto reductase and subsequently eliminated rapidly limiting those benefits. Its metabolization results in different curcumin conjugates that have either active or inactive form. These, in turn, are further transformed into their extractable forms, glucuronide and sulfate conjugates. These compounds can bond with curcumin through its exposed -OH and -OCH_3 sites to form conjugates, whose bonds can be broken by glucuronidases and sulfatases, respectively .

The main metabolic pathways of curcumin are conjugation and reduction. When orally administered, curcumin undergoes conjugation resulting in the formation of glucuronide and curcumin sulfates in the intestine and liver. If administered by intraperitoneal or other systemic routes, curcumin is transformed into hexahydrocurcumin and octahidrocurcumin by reduction. The latter are converted into monoglucuronic conjugates (the main metabolites), or curcumin glucuronide, dihydrocurcumin glucuronide, and tetrahydrocurcumin glucuronide (these being less active) .Additionally, curcumin can degrade in a quick manner into other substances when present in physiological conditions. These include ferulic acid, ferulic aldehyde, feruloyl methane, and vanillin, among others .

Concerning the benefits of curcumin, it is known to be capable of modulating growth factors, enzymes, transcription factors, kinase, inflammatory cytokines, and proapoptotic and antiapoptotic proteins, being a versatile molecule to treat several diseases. Specific in wound healing, the curcumin acts in the inflammatory phase, reducing the cytokines as tumor necrosis factor (TNF-α), interleukin-1 (IL-1), and inhibits the nuclear factor-kB (NK-B). A similar activity is observed in cancer treatment. Curcumin reduces the inflammatory condition using different pathways. It interacts with immune mediators and shows antioxidant activity . Due to its easy metabolization, studies have been conducted to enhance the stability and bioavailability of curcumin through molecular modification . In the last 20 years, a vast number of drug delivery systems, such as micelles, liposomal vesicles, nanoemulsions, phospholipid complexes, and polymeric implants, has been developed ,enabling their use for therapeutic prevention or risk reduction in the precancer stage or even across the blood–brain barrier, allowing for the treatment of neurodegenerative diseases .

II.DISCUSSION

Turmeric [2][3] is a flowering plant, *Curcuma longa* [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] 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]

Curcuminoids and oleoresin from *Curcuma longa* are susceptible to degradation by oxidation catalyzed by light and heat. Currently, the extraction methods of curcuminoid and oleoresin have favored techniques in which heating can be easily managed. After the extraction of curcuminoids, pigments and other chemically stable compounds are extracted by percolation (boiler and reflux), steam-, and hydro-distillation. Carbon dioxide as a supercritical antisolvent (SAS/CO_2-FSC) has been used to extract oleoresin and curcuminoids from *Curcuma longa* and *Curcuma amada*. Carbon dioxide is inert, readily available, non-toxic, non-corrosive, non-flammable, recyclable, and it is stable at mild conditions (i.e., 37 °C and 72.8 bar), which enables it to extract heat-labile compounds and also preserve their quality . Nagavekar and Singhal improved the extraction efficiency upon the use of 30% ethanol as a modifier or with enzymatic before treatment with CO_2-FSC .Deep eutectic solvent (DES) is a micro-extraction method with selective fast, environmentally friendly and good thermal stability. It is a system formed from a eutectic mixture which can contain a variety of ionized species with select properties of the ionic solvents. Generally, the vortex is used to assist the extraction from edible essential oil samples .An aqueous two-phase extraction system, combined with a dispersive liquid–liquid microextraction method using imidazolium as an ultrasound-assisted ionic liquid, has been used for the separation of curcuminoids. In this method, when the ionic solution is acidified (pH < 4.0), the recovery rate is 93% .Supramolecular solvents attract the intentions of scientist in the field of the extraction of organic compounds. Using ultrasonic-assisted restricted access supramolecular solvents is an emerging trend for the separation of phenolic bioactive compounds. The specific properties of supramolecular solvents are considered for liquid-phase extraction due to their physical properties. The amount of extraction solution using supramolecular solvents can be reduced, and thus the excessive discharge of organic solvents into the waste can be significantly decreased .Researchers employ ultrasonic-assisted restricted access supramolecular solvent-based microextraction (UA-RAS-LPME) using long chain alkanols or acids (C7–C14) to extract curcumin. Here, the -OH and -O functional groups of curcumin can form hydrogen bonds with the supermolecular solvents, and van der Waals and dispersion forces attract the apolar chain of curcumin. This creates a double way to extract curcumin to complete the procedure within 20 min using ultrasonic waves, providing an attractive way to extract the active compound.

Other extraction methods are based on the extraction of turmeric oil and oleoresin. Turmeric oil can offer bactericidal and fungistatistical activities. In order to extract turmeric oil, researchers have used steam distillation, hydro-distillation, and extraction using hexane. Hexane was combined with the oils after curcumin extraction and heated to 60 °C three times for one hour. The solvent was removed, which resulted in successful turmeric oil extraction [66]. Steam distillation is used with volatile solvents to extract turmeric essential oils. Here, an autoclave machine was used to create controlled pressure and controlled temperatures to pass through the turmeric, after which the steam was cooled down using water and the essential oils were obtained. Moreover, a similar technique was used with a volatile solvent, rather than the autoclave, where they were both heated to 40 °C. The extraction took place by separating the volatile solvent from the solid oil after cooling down and filtering . Hydro-distillation is the last technique used to extract turmeric oil, where the turmeric oil is passed through a hydro-distillation machine, yielding the essential oils .Conventional Soxhlet extraction is a traditional apparatus commonly used for the extraction of lipids and materials that are not water-soluble. Soxhlet can even store these substances, maintaining their properties. The study using the stock liquor after the isolation of curcumin from oleoresin contains approximately 40% oil. The isolation and identification of the antibacterial fractions from the leftover turmeric oleoresin were done by Soxhlet extraction. The best extraction was obtained with 5% ethyl acetate in hexane, while the ar-turmerone, turmerone, and curlone were identified as the significant compounds after gas chromatography analysis. The material showed antibacterial activity against *Bacillus cereus, Bacillus coagulans, Bacillus subtilis, Staphylococcus aureus, Escherichia coli,* and *Pseudomonas aeruginosa* .The microwave-assisted extraction occurs in a way opposite to conventional heat extraction, rotation dipole, and ionic conduction. For microwave heating, it is necessary that the flask used for the extraction is made of a transparent material, such as quartz or Teflon. All of the material inside the bottle is heated directly and it is common to note that parts of the bottle containing the material to be analyzed remain at a temperature close to the environment immediately after being heated. Additionally, the material used in the system must be able to absorb the microwave energy and convert it into heat. Dried rhizomes were extracted by the microwave process and showed a reduction in the time of extraction and solvent use. Additionally, the rate of extraction was 27% more efficient than the conventional Soxhlet extraction, and the result can be attributed to the dual heating phenomenon of the solvent and sample matrix used .

III.RESULTS

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]

Curcumin, naturally occurring in the rhizome of turmeric, has multiple therapeutic effects in advanced diseases, mainly in the treatment of cancer, cancer prevention, neurodegenerative diseases, and gastrointestinal diseases. Despite many advantages, curcumin has various limitations, including low bioavailability and water solubility, which cause many difficulties during absorption. Due to these limitations, an alternative way of curcumin administration has been investigated in order to make it possible to use it as a therapeutic drug. It has been proven that curcumin can enhance the therapeutic efficiency of chemotherapeutics by inhibiting the ABC efflux transporter, and hence, helping with the treatment of cancer. Despite all of curcumin's promising properties, there is still a need for more research.

IV.CONCLUSIONS

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

| ISSN: 2395-7852 | www.ijarasem.com | Impact Factor: 6.551 |Bimonthly, Peer Reviewed & Referred Journal|

| Volume 10, Issue 1, January 2023 |

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]

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]

REFERENCES

1. "Curcuma longa L." Kew, England: Plants of the World Online, Kew Science, Kew Gardens, Royal Botanic Gardens. 2018. Retrieved 26 March 2018.
2. ^ "turmeric". Dictionary.com Unabridged (Online). n.d.
3. ^ "turmeric". Merriam-Webster Dictionary.
4. ^ "curcuma". Dictionary.com Unabridged (Online). n.d.
5. ^ "longa". Merriam-Webster Dictionary.
6. ^ "Curcumin". PubChem, US National Library of Medicine. 21 November 2020. Retrieved 25 November 2020.

7. ^ "Turmeric". Drugs.com. 2009. Retrieved 24 August 2017.
8. ^ Brennan, J (15 October 2008). "Turmeric". The National.
9. ^ Peter, K. V. (2008). Underutilized and Underexploited Horticultural Crops, Volume 2. New India Publishing. p. 341. ISBN 9788189422691.
10. ^ Nelson, KM; Dahlin, JL; Bisson, J; et al. (2017). "The Essential Medicinal Chemistry of Curcumin: Miniperspective". Journal of Medicinal Chemistry. 60 (5): 1620–1637. doi:10.1021/acs.jmedchem.6b00975. PMC 5346970. PMID 28074653. None of these studies [has] yet led to the approval of curcumin, curcuminoids, or turmeric as a therapeutic for any disease
11. ^ "Turmeric". National Center for Complementary and Integrative Health, US National Institutes of Health. May 2020. Retrieved 25 November 2020.
12. ^ Leong-Škornickova, Jana; Šida, Otakar; Wijesundara, Sirtl; Marhold, Karol (May 2008). "On the identity of turmeric: the typification of Curcuma longa L. (Zingiberaceae)". Botanical Journal of the Linnean Society. 157 (1): 37–46. doi:10.1111/j.1095-8339.2008.00788.x.
13. ^ Nair, K.P. Prabhakaran (2013). The Agronomy and Economy of Turmeric and Ginger: The Invaluable Medicinal Spice Crops. Newnes. pp. 7–10. ISBN 9780123948243.
14. ^ Chattopadhyay I, Kaushik B, Uday B, Ranajit KB (2004). "Turmeric and curcumin: Biological actions and medicinal applications" (PDF). Current Science. 87 (1): 44–53. ISSN 0011-3891. Retrieved 16 March 2013.
15. ^ Kikusawa, Ritsuko; Reid, Lawrence A. (2007). "Proto who utilized turmeric, and how?" (PDF). In Siegel, Jeff; Lynch, John; Eades, Diana (eds.). Language Description, History and Development: Linguistic indulgence in memory of Terry Crowley. John Benjamins Publishing Company. pp. 339–352. ISBN 9789027292940.
16. ^ McClatchey, W. (1993). "Traditional use of Curcuma longa (Zingiberaceae) in Rotuma". Economic Botany. 47 (3): 291–296. doi:10.1007/bf02862297. S2CID 20513984.
17. ^ Pickersgill, Barbara (2005). Prance, Ghillean; Nesbitt, Mark (eds.). The Cultural History of Plants. Routledge. p. 170. ISBN 0415927463.
18. ^ Scott, Ashley; Power, Robert C.; Altmann-Wendling, Victoria; et al. (17 December 2020). "Exotic foods reveal contact between South Asia and the Near East during the second millennium BCE". Proceedings of the National Academy of Sciences. 118 (2): e2014956117. doi:10.1073/pnas.2014956117. hdl:10550/76877. ISSN 0027-8424. PMC 7812755. PMID 33419922.
19. ^ "Turmeric". Unabridged Random House Dictionary. Dictionary.com. 2013. Retrieved 11 October 2012.
20. ^ "Curcuma longa Linn". efloras.org. Flora of China, South China Botanical Garden. Archived from the original on 13 August 2016. Retrieved 30 November 2013.
21. ^ Siewek, F (2013). Exotische Gewürze Herkunft Verwendung Inhaltsstoffe (in German). Springer-Verlag. p. 72. ISBN 978-3-0348-5239-5.
22. ^ Hänsel, Rudolf; Keller, Konstantin; Rimpler, Horst; Schneider, Gerhard, eds. (2013). Drogen A-D (in German). Springer-Verlag. p. 1085. ISBN 978-3-642-58087-1.
23. ^ Tayyem RF, Heath DD, Al-Delaimy WK, Rock CL (2006). "Curcumin content of turmeric and curry powders". Nutr Cancer. 55 (2): 126–131. doi:10.1207/s15327914nc5502_2. PMID 17044766. S2CID 12581076.
24. ^ Hong, SL; Lee, G. S; Syed Abdul Rahman, SN; et al. (2014). "Essential Oil Content of the Rhizome of Curcuma purpurascens Bl. (Temu Tis) and Its Antiproliferative Effect on Selected Human Carcinoma Cell Lines". The Scientific World Journal. 2014: 1–7. doi:10.1155/2014/397430. PMC 4142718. PMID 25177723.
25. ^ Hu, Y; Kong, W; Yang, X; et al. (2014). "GC-MS combined with chemometric techniques for the quality control and original discrimination of Curcumae longae rhizome: Analysis of essential oils". Journal of Separation Science. 37 (4): 404–11. doi:10.1002/jssc.201301102. PMID 24311554.
26. ^ Braga, ME; Leal, PF; Carvalho, JE; Meireles, MA (2003). "Comparison of yield, composition, and antioxidant activity of turmeric (Curcuma longa L.) extracts obtained using various techniques". Journal of Agricultural and Food Chemistry. 51 (22): 6604–11. doi:10.1021/jf0345550. PMID 14558784.
27. ^ Pereira Kamat, M (16 August 2008), "A tradition wrapped in leaves", The Times of India, Goa, India, archived from the original on 9 October 2018, retrieved 16 August 2017
28. ^ "E100: Curcumin". UKfoodguide.net. Archived from the original on 7 July 2017. Retrieved 14 April 2017.
29. ^ Imtiaz, Sabia (11 May 2016). "Turmeric latte: the 'golden milk' with a cult following". The Guardian. Retrieved 7 January 2018.
30. ^ NIIR Board of Consultants & Engineers (2006). The Complete Book on Spices & Condiments (with Cultivation, Processing & Uses). Delhi: Asia Pacific Business Press. pp. 188–191. ISBN 9788178330389.
31. ^ "Curcuma longa L., rhizoma". European Medicines Agency. 14 February 2019. Retrieved 19 November 2020.

| ISSN: 2395-7852 | www.ijarasem.com | Impact Factor: 6.551 |Bimonthly, Peer Reviewed & Referred Journal|

| Volume 10, Issue 1, January 2023 |

32. ^ Khan, Maheen (11 November 2014). "A Bangladeshi Wedding Journal – Gaye Holud: Pre-Wedding Ceremony". The Daily Star. Retrieved 22 February 2017.
33. ^ Singh K, S; Bhanu, BV (2004). People of India: Maharashtra, Volume 1. Popular Prakashan. p. 487. ISBN 9788179911006.
34. ^ Arai, Masanao; Iwamoto Wada, Yoshiko (2010). "BENI ITAJIME: CARVED BOARD CLAMP RESIST DYEING IN RED" (PDF). Textile Society of America Symposium Proceedings. Lincoln: University of Nebraska. Archived from the original on 2 November 2021.
35. ^ Ratzel, Friedrich (1896). The History of Mankind. London: MacMillan.
36. ^ Welch, Zoe (27 May 2020). "Making dye from native and canoe plants". Mānoa Heritage Centre. Retrieved 28 October 2022.
37. ^ Ravindran, P. N., ed. (2007). The genus Curcuma. Boca Raton, FL: Taylor & Francis. p. 244. ISBN 9781420006322.
38. ^ Berger, S; Sicker, D (2009). Classics in Spectroscopy. Wiley & Sons. p. 208. ISBN 978-3-527-32516-0.

International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)