Guest Articles

Chemical Constituents of the Golden Spice – Turmeric

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Recently, "**Turmeric**" has become one of the most popular topics in Sri Lanka. The high price of turmeric made it popular among spice farmers in Sri Lanka. Undoubtedly, it can be called the "golden spice" because of its immense medicinal value.

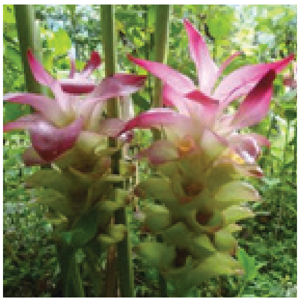
The history of turmeric (Indian saffron) started about 6000 years ago. This plant is considered native to India, even though, it is cultivated in Pakistan, Burma, Thaiwan, China, Indonesia, Thailand, Peru, Jamaica, Sri Lanka, *etc*. India produces ca. 80% of turmeric, for the global market and they export 60% of it. Turmeric is considered auspicious and sacred in Hindu culture. Turmeric can enhance the appearance of the cuisine. It is used as a flavoring, preserving and coloring agent in food processing and ayurvedic preparations. It is also used as an additive in cosmetics. India exports turmeric-based products such as raw and dry rhizomes, powder, curcumin and oleoresin (a viscous material obtained when it is extracted with non-polar solvents).

Sri Lankans use turmeric as a sanitizer, by mixing turmeric powder with water. Hindus apply grounded turmeric rhizome on the body of the bride and groom as a ritual in wedding ceremonies (*i.e.*, Haldi ceremony). Hindu devotees clean the statues of their Gods and other equipment related to their cultural rituals with an aqueous extract of turmeric, as they believe it a divine plant.

Diversity of turmeric plant

Curcuma longa is the species commonly used as turmeric. About 70-100 species can be found in genus Curcuma, which belong to the family *Zingiberaceae*. Turmeric is a perennial plant with a height of 60-90 cm that grows at temperatures between 20-30 °C with a significant amount of rainfall. *C. longa* blooms yellow-colored flowers while *C. aromatica* (or wild turmeric) gives pink flowers, even though the insides of rhizomes of both species are yellow. Wild turmeric (also known as Kasthuri Manjal) is a famous ingredient in cosmetic products.


Figure 1: Rhizome & the flowers of *C. longa*

Figur 2: Rhizome & flowers of *C. aromatica*

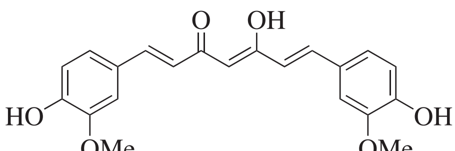
C. caesia (or black turmeric) is a rare type of turmeric. Inside of the rhizome seems to appear in blue color and the mid ribs of the leaves are composed with a blue pigment. This black turmeric is also used as a spice and drug in a similar manner to wild turmeric. Hindus named *C. caesia* after the name of goddess "Kali" and they use this "Kali haldi or black turmeric" to show their devotion to her.


Figure 3: Rhizome & the leaves of *C. caesia*

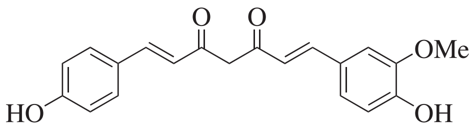
C. angustifolia, Roxb. (Indian arrow root), *C. Amada,* Roxb. (Mango ginger), *C. Zadoaria*, Rosc. (Kachura), *C. Xanthorrhiza* (Arrow root) are some of the other economically important species of turmeric.

Phytochemistry of turmeric

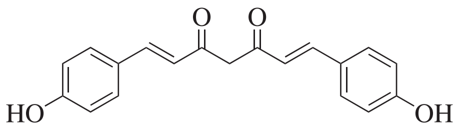
Phytochemistry is a branch of chemistry which studies about the chemical substances present in plants. Phytochemical constituents differ by geographical variation, soil conditions, environmental conditions, method of cultivation, collection, preparation and storage, *etc*. The main phytochemicals that can be found in turmeric are curcuminoids and curcumin. Demethoxycurcumin and bismethoxycurcumin are the major curcuminoids present in the turmeric rhizome. Curcumin is an orange-yellow crystalline substance that is insoluble in water, but soluble in organic solvents such as acetone, ketone, chloroform and ethanol. Above mentioned phytochemicals cause these rhizomes to appear in yellow.



Curcumin

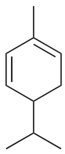


Demethoxycurcumin

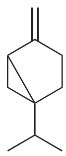


Bismethoxycurcumin

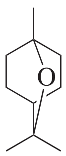
Several types of essential oils (EO) can be obtained from turmeric via steam distillation. Most (53%) of them are sesquiterpines (*e.g.*, zingiberene, Ar-cucumene). Some are monoterpenes such as alpha-phellandrene, sabinene, and 1,8-cineole.



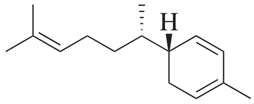
α-phellandrene



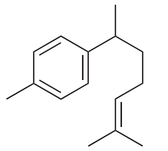
Sabinene



1,8-cineole

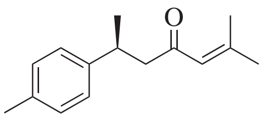


Zingiberene

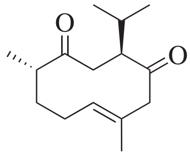


Ar-Curcumene

Volatile oils such as ar-turmerone, curdione, gingibaron give a special aroma to the rhizome of turmeric.



Ar-turmerone



Curdione

Turmeric is enriched in not only carbohydrates such as D-Xylose, D-glucose, D-rhamnose, but also Vitamin C, folate and several minerals such as Ca, P, Mg, Zn, K, and Na.

Turmeric rhizome oil (TO) is extracted from steam distillation of powdered dried rhizome which contains 3-6% of essential oils. The constituents in TO are Ar turmerone, α-turmerone, β-turmerone, germacrane, elemane, spironolactone, carane, selinane, santalane, and caryophyllane.

Adulterations

The process of adding any substance intentionally or unintentionally which lowers its quality is known as adulteration. Turmeric is one of the main spices that are being adulterated. This can be tested using a microscope, DNA barcoding, and other analytical instruments such as IR, MS, NMR, HPLC, LC-MS *etc*. Popular adulterating compounds are metanil yellow, chalk powder and lead chromate. Consumption of adulterated turmeric products leads to adverse health effects, since these are carcinogenic and toxic (neurotoxic and genotoxic).

Health Benefits

Turmeric is one of the popular folk medicines which has a great history. Ancient Chinese have been using turmeric for more than 1000 years, as a treatment for inflammation and to promote blood circulation. In Ayurveda, turmeric is used to heal ulcers, wounds, insect stings, whooping cough, indigestion, hysteric fit *etc*. Turmeric is used as a skin tonic, as well as a medicine to cure gastritis, chest pains and menstrual difficulties.

From the ancient, ladies apply turmeric on their skins to enhance the beauty of the skin. Scientists have discovered that turmeric can protect epidermal skin cells from UV-B radiations. “Kum-kum” is made from adding slaked lime to turmeric powder and Indians often apply it on forehead to awake the sixth chakra (third eye chackra) of the body (*i.e.*, the energy of the body is stored in seven places along the spine to head which known as “Chakra” and there are 7 Chackras). Married Hindu ladies apply vermillion colored Kum-kum which is also known as “Sindoor”.

Curcumin is composed of antioxidant, antifungal, antibacterial, anti-inflammatory, anti-obesity, antitumor, anti-viral, anti-rheumatic, anti-HIV and hepato protective properties. It has the ability to inhibit lipid peroxidation and curcuminoids have a miraculous power to inhibit cancer in many stages. But unfortunately, curcumin is an organic compound with poor absorption into blood stream. Researchers have found that piperine (phytochemical present in black pepper), enhances the absorption of curcumin into the blood.

Turmeric is used to treat patients suffering from neuro-degenerative problems such as Parkinson’s and Alzheimer’s diseases.

In 2022, Idowu-Adebayo *et al*. reported that “Golden milk”, prepared from turmeric-fortified soya milk samples, exhibited highest protein, iron, zinc, and antioxidant activity.

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Guest Articles

Advanced Applications of Poly (lactic acid)

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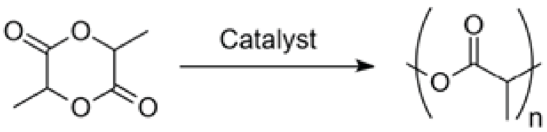
Poly(lactic acid) (PLA) is a biodegradable, compostable and biocompatible polyester. PLA was first synthesized by Wallace Hume Caruthers at DuPont in 1932 via the polycondensation of lactic acid. However, the modern industrial process for PLA synthesis, polymerizes lactide, the cyclic diester of lactic acid (Figure 01). Lewis acid catalysts are used for the ring-opening polymerization (ROP) of lactide. The lactic acid needed to produce lactide is produced through the fermentation of an agricultural feedstock such as corn starch or sugar beet pulp. Poly(lactic acid) along with thermoplastic starch dominate the global biopolymer market.



PLA

Figure 1: Ring-opening polymerization of lactide

Lactide occurs in three isomeric forms, L-lactide, D-lactide and meso-lactide (Figure 02). Due to the presence of stereocenters along the polymer backbone, the stereoregularity or the tacticity of the polymer has a significant impact on thermomechanical properties of PLA. A large body of academic literature has focussed on developing stereoselective catalysts for lactide polymerization. These are often catalysts with ligands of varying complexity attached to a Lewis acidic metal centre. In general, an equimolar mixture of L- and D- lactide (racemic lactide) is used in academic research on stereoselective polymerization. However, in the industrial monomer feedstocks, L-lactide is by far the most abundant stereoisomer present (though some D-lactide and meso-lactide can be present due to racemization) because the natural enantiomer of lactic acid, L-lactic acid is formed in starch fermentation. The industrial polymerization catalyst is usually a simple tin alkoxide salt.