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An Introduction to Types of Polyphenols and Biological Activities & Commercial Importance of Curcuminoids: A Review

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Abstract:

In this review the authors made some basic literature survey on types of polyphenols, and biological activities of curminoids. This review provides importance of the various type of polyphonols, and importance of curminoinds in commercial scale also.

Keywords: polyphenols, curcumin, antioxidant, curcuminoids.

Introduction:

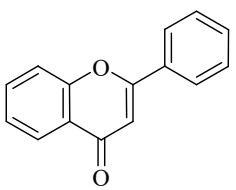
The antioxidant nature of the many phytochemicals is attributed to the phenolic hydroxyl groups present in them. Most anti oxidants contain more than one phenolic hydroxyl group in their structure and are thus called as Polyphenols. Polyphenols are potent natural antioxidants that are found in plants. In modern research, polyphenols have gained a lot of importance because of their use as preventive and therapeutic agents in many diseases. Much work has been presented on the anti oxidant effects of polyphenols. Several epidemiological studies and associated meta-analyses strongly showed that the consumption of these polyphenols offered better protection against chronic diseases such as cancers, cardiovascular diseases, cerebra vascular diseases, diabetes, ageing and neurodegenerative diseases. They are found largely in fruits, vegetables, tea, coffee, chocolates, legumes, cereals, and beverages. They were proved to protect our body from free radical damage, UV radiation and aggression by pathogens. Their addition to the food as coloring & flavoring agents, bitters, astringents, helps to prevent the process of oxidation.

Types of Polyphenols

The Polyphenols are generally accumulated in the outer layer of different parts of a plant.[1] They are categorized as four groups based on the number of phenolic groups and structural elements they contain.[2] They are Flavonoids, Stilbenes, Lignans and Phenolic compounds.

Flavonoids have potential effect on radical scavenging and inflammatory reactions. They are widely found in fruits, vegetables, legumes, red wine, and green tea. Initially, Geissman and Henreiner coined the term flvanoids[3] to cover all such compounds whose structure was based on flavones (**1**).

The other classes of flavonoids which are derived from flavones are flavanones (**2**), flavonols (**3**), dihydroflavonols (**4**), catechins (**5**), Leuco anthocyanidins (Proanthacyanidins) (**6**) and anthocyanidins (**7**). Apart from these, there are also four classes of compounds, which do not possess the basic 2-phenyl chromone (**1**) skeleton but are closely related both chemically and biosynthetically to other flavonoid type of compounds. They are chalcones (**8**), dihydro chalcones (**9**), isoflavones (**10**), aurones (**11**), the neoflavones or 4-phenyl coumarins (**12**). Some of these flavonoids were tested for various biological activities.[4-7]



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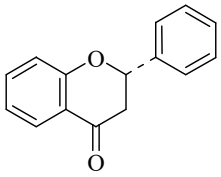

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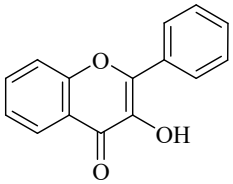

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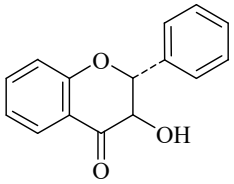

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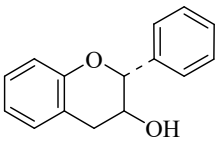

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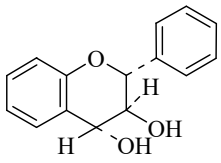

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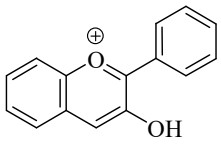

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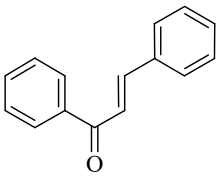

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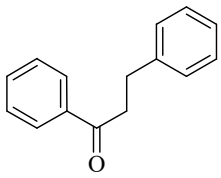

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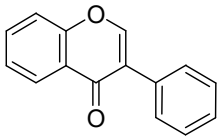

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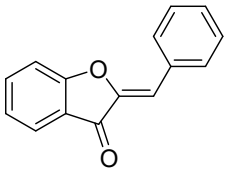

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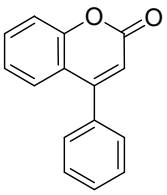


(12)

Stilbenes are found in grapes, red wine, and peanuts. Resveratrol (**13**), Epsilon-Viniferin (**14**), Pterostilbene (**15**), Piceatannol (**16**) are known compounds among the group.

Figure 1. Rich source for flovonoids (www.medindia.net).

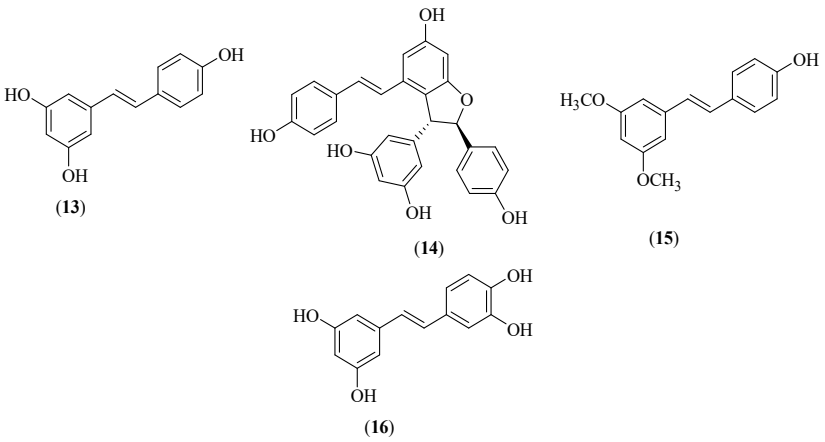
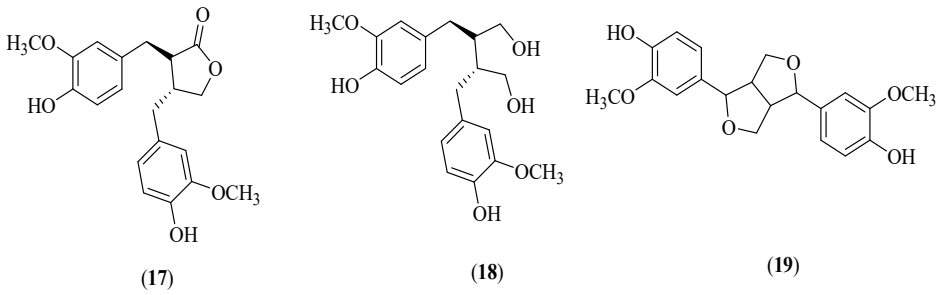


Figure 2. Rich sources for Resveratrol (www.preventdisease.com).

Lignans are found in seeds like flax, linseed, legumes, cereals, grains, fruits, algae, and certain vegetables.Matairesinol (**17**), Secoisolariciresinol (**18**), Pinoresinol (**19**)are known compounds among the group.

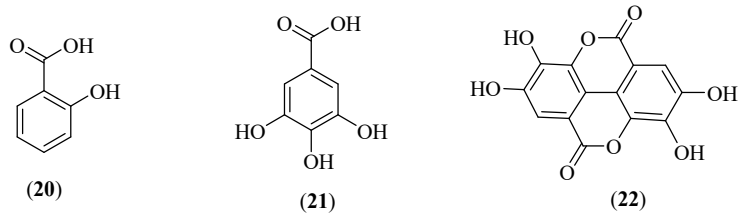


(**17**) (**18**) (**19**)

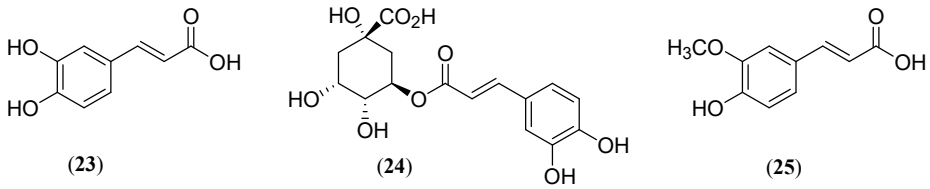
Figure 3. Rich source for Lignans from legume (www.foodrevolution.org**).**

Phenolic compounds are found in coffee, tea, cinnamon, blueberries, kiwis, plums, apples, cherries. They are further classified as hydroxybenzoic acids, hydroxycinnamic acids.Salicylic acid (**20**), Gallic acid (**21**), Ellagic acid (**22**) belongs to the class of hydroxylbenzoic acids. Caffeic acid (**23**), Chlorogenic acid (**24**) and ferulic acid (**25**) are known compounds among the hydroxycinnamic acids group.

Feruloyl compounds are mainly found in turmeric and mushrooms. Curcumin (**26**) and hispolon (**27**) are feruloyl derivatives.



(**20**) (**21**) (**22**)



(**23**) (**24**) (**25**)

Figure 4.*White willow* natural source for salicylic acid (www.biolib.com).

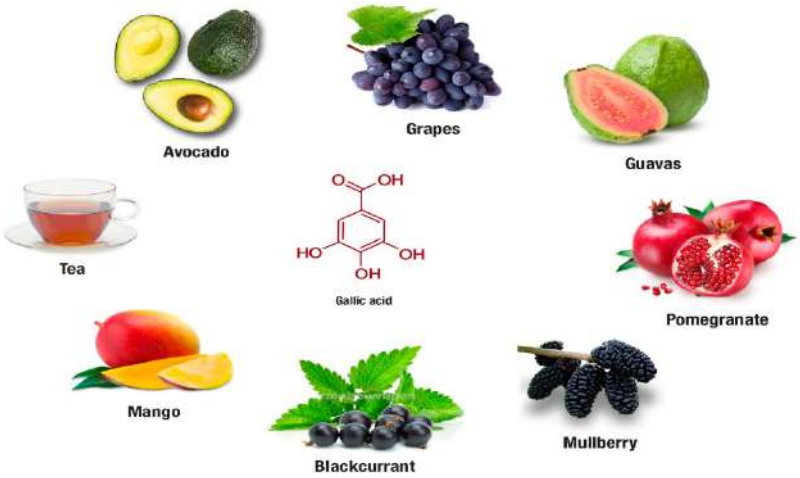
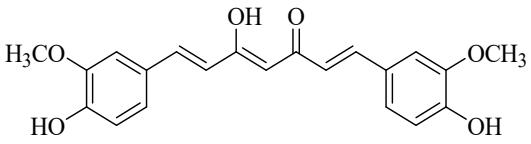
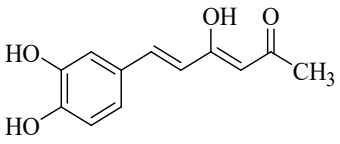


Figure 5. Rich sources for Gallic acid (www.organicfacts.net).

Figure6. Chlorogenic acid from green coffee seeds (www.yourhealthremedy.com).



(**26**)



(**27**)

Curcuminoids

From ancient times turmeric powder has been used as a coloring and flavoring agent in curries and mustards. In India it also has been used to maintain oral hygiene.[8] It has traditionally been used for medical purposes for many centuries in countries such as India and China for treatment of jaundice and other liver ailments.[9,10]Turmeric is one of the most popular medicinal herbs, with a wide range of pharmacological activities such as anti-oxidant,[11]anti-protozoal,[12]anti-venom activities.[13]anti-microbial,[14]anti-malarial,[15] anti-inflammatory,[16]anti-proliferative,[17] anti-angioge nic,[18]anti-tumor[19]and anti-aging[20]properties. It has also been used to treat ulcers, parasitic infections, various skin diseases, anti-immune diseases and curing the symptoms of colds and flus.[21]

Figure 7.Curcuminoids from rhizomes of *C. longa* (www.turmeric.com)

The yellow colouring matter of the turmeric is curcumin. It is the active ingredient of the turmeric and is extracted from the rhizomes of C. longa, a plant in the Zingiberaceae family. It was first discovered about two centuries ago when Vogel and Pelletier reported the isolation of a curcumin from rhizomes of C. longa.[22]It was characterized by Milobedeska*et al*.,[23] and first synthesized by Lampe *et al*.[24]

The pharmacological activity of turmeric has been attributed mainly to curcuminoids consists of curcumin (CUR) (**28**) and two related compounds demethoxy curcumin (DMC) (**29**) and bis demethoxycurcumin (BDMC) (**30**).[25]CUR itself appears as a crystalline compound with a bright orange-yellow color. Curcuminoids are commonly used as coloring agent in foods. World Health Organization (WHO) stated the acceptable daily intake of curcuminoids as a food additive in the range of 0-3 mg/kg. Curcuminoids and turmeric products have been characterized as safe by the Food and Drug Administration (FDA) in USA. Curcuminoids have achieved the potential therapeutic interest to cure immune related metabolic diseases and cancer due to a vast number of biological targets and virtually has no side effects.[21, 26]

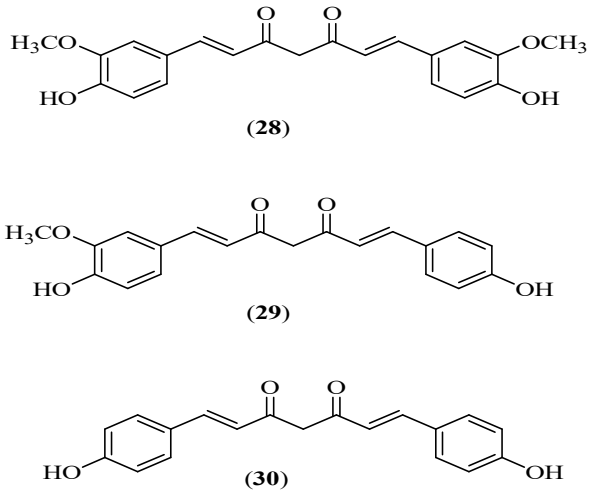


Figure 8. Structures of Curcumin, demethoxycurcumin, bis demethoxycurcumin.

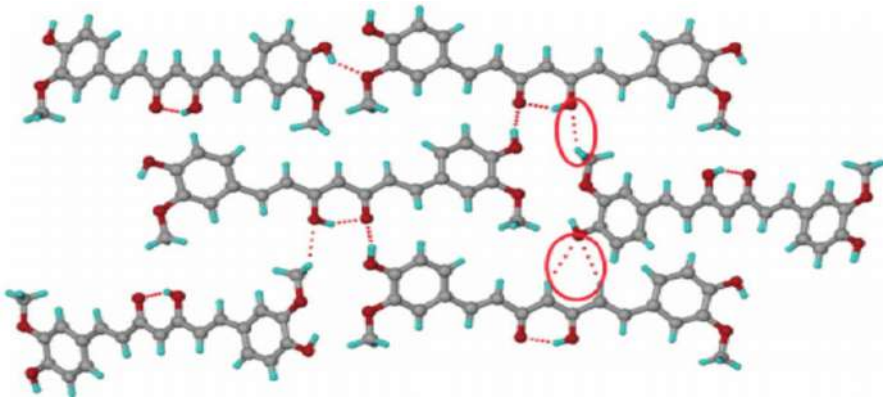


Figure 9. Hydrogen bonding and molecular packing in curcumin Form 1 (known crystal structure) (www.researchgate.net).

Curcumin shows many pharmacological applications from ancient ayurveda to modern medicine because of its high biological activity.[27] Curcumin, a constituent of turmeric, has anti-inflammatory, anti-carcinogenic, and chemo-preventive effects as evidenced in several animal tumor models. Curcumin has potent antioxidant, antitumor and anticancer properties. The molecule is known to possess multiple biological activities like wound healing, antifertility, anti-bacterial, anti-fungal, anti-protozol, anti-viral, anti-fibrotic and antivenom.[28]

Few important examples from recent literature that underscore the importance of curcumin as a therapeutic and nutraceutical compound are entitled below.

Dutta *et al.,*[30]reported that curcumin shows antioxidant activity.Srinivasan *et al*.,[31] reported that curcumin is also an effective hypolipidimic agent. Srinivasan *et al*.,[32] reported that curcumin act as anti-diabetic food adjunct. Elizabeth *et al.,*[33] reported, curcumin is a good scavenger of reactive oxygen species.Curcumin is a potent singlet oxygen quencher at physiological or pharmacological concentrations.[34]Jiao, *et al.,*[35] reported that curcumin is an effective chemo-preventive compound. The mechanism of action of curcumin is complex and likely multi-factorial. It

modulates proteins involved in iron metabolism in cells and tissues and act as a good chelator for iron.Sidhu *et al*.,[36] reported that tissue repair and wound healing are complex processes. Curcumin has very effective wound healing activity, examined in rats and guinea pigs.

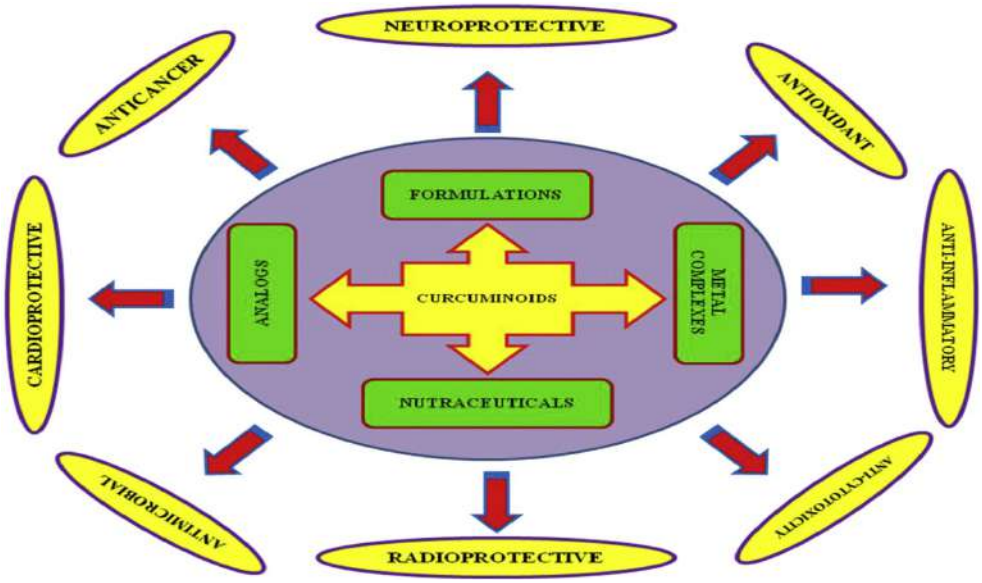


Figure 10.Multiple biological activities of Curcuminoids and their derivatives.[29]

Aggarwal and Sung reported that curcumin is one of the most promising candidates of natural origin having anti-inflammatory activity with no side effects.[37]Neuroprotective effects and medicinal use in Alzheimer's disease (AD).[38-40]Neuroprotective activity: CUR, DMC and BDMC are significantly suppressed nitric oxide production by LPS-activated microglia and the relative potency was DMC > BDMC > CUR .[41-43]Ataie *et al*.,[39]Agarwal *et al*.,[44] and Mehla*et al*.,[45] reported that curcumin decrease oxidative stress. Loprest*iet al*.,[46] reported that curcumin decrease depressive disorder.Villaflores*et al*.,[47] Ahmed *et al*.,[48-50] were reported that curcumin act as anti Alzheimer's agent.

Several studies have demonstrated the anti-cancer,[51-58] anti-bacterial,[59] anti-malarial,[60,61]anti-tumor,[62-65]anti-oxidant,[66-69] cardio protective,[70] radio protective,[71,72] anti-inflammatory,[73,74] antiviral,[75] anti-fungal[76] and anti-arthritic properties[77,78]of curcumin.

Apart from the thorough academic and research exploration of different activities of curcumin, it also gained commercial importance and many reputed commercial formulations available now worldwide (**Figure11**).

Figure 11. Formulation products of Curcumin (www.googleimg.com).

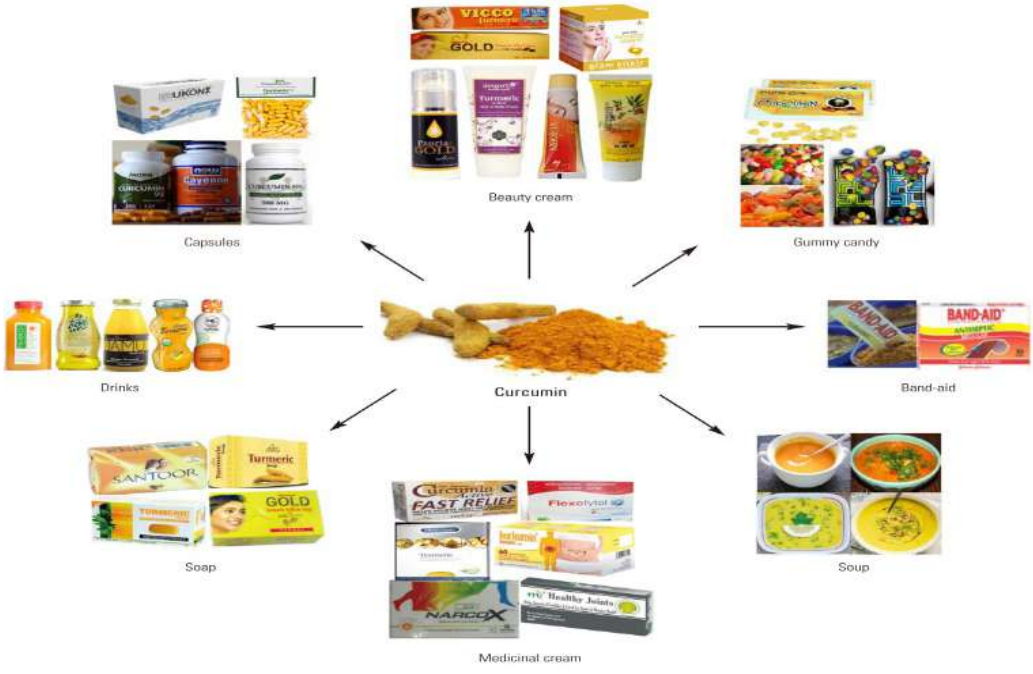


Figure 12. Commercial products of Curcumin (www.googleimg.com)

Conclusion:

This review enlightens the structural classification of polyphenols and most importantly very useful for authors working on curcuminoids in both synthetic approach and biological concerns as curcumin is well known for its health benefits since from olden days. The biological applications of curcuminoids were updated up to 2017.

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