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# Polyphenols in Nature

Mohd. Adil Tahseen*, Adnan Raza**

*(PhD Research Scholar, Shobit University, Saharanpur
adiltahseen987654321000@gmail.com )

** (B.Pharm, S R Institute of Pharmacy, Bareilly
adnanraza9207@gmail.com )

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## Abstract

Phenolic compounds are a broad class of secondary metabolites found in many higher plant organs, including fruits, vegetables, grains, legumes, nuts, and spices. They are also involved in a variety of physiological processes, including stress resistance, plant quality, color, and flavor. The anti-inflammatory, anticarcinogenic, antibacterial, and natural antioxidant properties of phenolic compounds are currently a focus of much research and application. Several types of phenolic compounds share a common chemical structure consisting of an aromatic ring with one or more hydroxyl substituents. Flavonoids, phenolic acids, tannins, stilbenes, and lignans are the primary families of phenolic compounds. The SLE, SFE, UAE, MAE, ESE, and PLE are examples of advanced extraction techniques. While non-conventional technologies can provide greater extraction efficiency in terms of cost, yield, extraction time, and/or selectivity, conventional extraction methods are relatively straightforward and frequently employed for separating plant phenolic chemicals. HPLC is one of the most advantageous analytical techniques, particularly when used in conjunction with extremely sensitive detectors (like MS). All things considered, the scientific community is still very interested in the biological potential of several naturally occurring plant phenolic chemicals. Despite all of those developments, there is still a significant lack of information regarding the phytochemicals that are responsible for the biological potential, their modes of action, how to build therapeutic and preventative dosages, and even whether biochemical interactions occur.

***Keywords:*** Phenolic compounds, Secondary metabolites, Biological Potential, Biochemical Interactions.

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## INTRODUCTION

All plant cells manufacture polyphenols, also known as phenolic compounds (PCs), which are thought to be among the most common secondary metabolites. Their biosynthesis involves the involvement of the acetate-malonate and shikimate pathways. This forms polyphenols with various structures, including flavonoids, phenylpropanoids, and other phenolic oligomeric and polymeric molecules. They already have more than 10,000 members. Their variety influences the biological activity and functional relevance of phenolics. Their interactions with reactive oxygen species, which may be found in both plants and the human body when they enter through food chains, define most of their representatives. Because of their strong biological activity, phenolic compounds are effectively employed as medications and dietary supplements to promote population health. (1)

Antioxidants, structural polymers (lignin), attractants (flavonoids and carotenoids), UV filters (flavonoids), signal chemicals (salicylic acid and flavonoids), and defensive response chemicals (tannins and phytoalexins) are all possible uses for plant phenolic compounds. Phenolic chemicals have a key role in defensive responses, including anti-aging, anti-inflammatory, antioxidant, and anti-proliferative properties, from a physiological perspective. Thus, eating plant foods strong in antioxidant compounds is helpful since it will reduce the occurrence of several chronic illnesses, such as diabetes, cancer, and cardiovascular diseases, by managing oxidative stress. Berries and other fruits with high-glucosidase and low-amylase inhibitory properties may also be considered as potential dietary supplements for managing the first phases of type 2 diabetes-related hyperglycemia. (2)

  

In addition to giving plants their color, plant phenolics are typically engaged in defense against UV rays or hostility from diseases, parasites, and predators. They are an essential component of the human diet as they are found in every plant organ. Plant foods (fruits, vegetables, cereals, olives, legumes, chocolate, etc.) and drinks (tea, coffee, beer, wine, etc.) include phenols, which are widely distributed and largely responsible for the general organoleptic qualities of plant foods. For instance, when phenolics, primarily procyanidin, interact with the glycoprotein in saliva, they contribute to the bitterness and astringency of fruit and fruit juices. (3)

**Classification of Polyphenols**

1. **Phenolic acids**

One important family of polyphenols that are widely utilized in human diets are phenolic acids, which are non-flavonoid polyphenols. The varied family of plant polyphenols are phenolic acids, which are produced via the phenylpropanoid route from shikimic acid, the breakdown of cell wall polymers like lignin during the monolignol pathway, and certain microorganisms. The shikimate or shikimic acid route is responsible for producing the majority of phenolics in bacteria, fungi, and plants by transforming simple carbohydrate molecules—which are produced by the pentose phosphate pathway and glycolysis—into tryptophan and phenylalanine. In a multi-step metabolic process, larger carbohydrate molecules broke down into glucose, which was then transformed into dehydroshikimic and shikimic acids. While shikimic acid changed into phenylalanine, dehydroshikimic acid changed into gallic acid, a basic hydroxybenzoic acid. While tyrosine ammonia lyase (TAL) helps some plants and grasses convert 4-hydroxycinnamic acid, phenylalanine ammonia-lyase (PAL) transforms phenylalanine into trans-cinnamic acid and releases ammonia, which is essential for the synthesis of phenolic acids as well as primary and secondary metabolism. When acid/alkali hydrolysis occurs, the integrated esterified phenolic acids found in plant cell walls are released. When a hydroxyl group is added at the para position, monooxygenase transforms cinnamic acid into p-coumaric acid (employ cytochrome P450 as oxygen binding site). After undergoing hydroxylation and oxymethylation, p-coumaric acid yields ferulic and caffeic acids, respectively. The production of lignins and other phenolics uses these phenolic acids, which have a C6-C3 structure, as an ancestor. Cinnamic acid changed into benzoic acid and its derivatives by losing two carbon atoms. Depending on the amount of fruits, vegetables, and whole grains consumed, such as apples, mangos, berries, plums, cherries, kiwis, citrus fruits, onions, tea, coffee, and flour produced from whole wheat, rice, maize, or oats, a person should consume 200 mg or more of phenolic acids per day. Additionally, phenolic acids can be purchased commercially as dietary supplements, such as green tea or grape seed extract. The supplements are usually offered as antioxidants, but recent studies have shown that fruits, vegetables, and whole grains offer more health advantages than antioxidant supplements. As a result, their extraction company has a lot of room to grow. (4)

| **Phenolic acid** | **Plant** | **Reported activities (5-37)** |
|---|---|---|
| Protocatechuic acid | *Oryza sativa*<br>*Prunus domestica*<br>*Vitis vinifera*<br>*Prunus amygdalus*<br>*Illicium verum*<br>*Rosmarinus officinalis*<br>*Hibiscus sabdariffa*<br>*Ginkgo biloba* | Antibacterial, Antioxidant, Antidiabetic Activity, Anticancer, Antiulcer, Antiaging, Antifibrotic, Antiviral, Anti-inflammatory, Analgesic, and Antiseptic Properties<br>Anti-atherosclerotic and anti-hyperlipidemic Activities<br>Cardiac Activity<br>Hepatoprotective, Nephroprotective Activity, Neurological Effects, Metal Chelating Properties |
| p-hydroxy benzoic acid | *Daucus carota*<br>*Elaeis guineensis*<br>*Vitis vinifera*<br>*Fagara macrophylla*<br>*Paratecoma peroba* | Antimicrobial, Anti-sickling, antialgal, antimutagenic agent, estrogenic, nematicidal agent, antiviral, hypoglycemic agent, antiatherogenic agent, anti-inflammatory agent, Antiplatelet aggregating factor, antioxidant |

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|---|---|---|
| | *Tabebuia impetiginosa*<br>*Pterocarpus santalinus*<br>*Catalpa bognoniooides*<br>*Vitex negundo*<br>*Areca catechu*<br>*Arabidopsis thaliana* | |
| Vanillic acid | *Angelica sinensis*<br>*Olea europaea*<br>*Psidium guajava* | Antimicrobial, Anti-filarial, Antibacterial, Cardioprotective, Hepatoprotective Prevention of carcinogenesis, inhibition of snake venom activity, apoptosis, inflammation, and minimizing oxidative stress caused by the pathogenesis of cardiovascular diseases |
| Caffeic acid | *Olea europaea*<br>*Coffea arabica*<br>*Solanum tuberosum* | Anticarcinogenic, Antioxidant Activity, Vasorelaxant Effect, Anti-inflammatory and Immunomodulatory, Anti-atherosclerotic Activity, Anti-angiogenic Activity. Enhanced insulin secretion and ameliorated insulin resistance, DM-induced inflammation, and oxidative stress and showed protective effects against nephropathy, neuropathy, and cardiomyopathy. |
| p-Coumaric acid | *Malus domestica*<br>*Pyrus communis*<br>*Solanum lycopersicum*<br>*Zea mays* | Antioxidant, anti-inflammatory, antimutagenic, anti-ulcer, antiplatelet, and anti-cancer activities, mitigating atherosclerosis, oxidative cardiac damage, UV-induced damage to ocular tissues, neuronal injury, anxiety, gout, and diabetes |
| Ferulic acid | *Angelica sinensis*<br>*Cimicifuga racemosa*<br>*Ligusticum chuangxiong* | Anti-Oxidative Effects, Anti-Inflammatory Effects, Anti-Fibrotic Effects, Anti-Cancer, Asthma |
| Syringic acid | *Olea europaea*<br>*Beta vulgaris cicla*<br>*Juglans regia*<br>*Phoenix dactylifera*<br>*Cucurbita pepo*<br>*Raphanus sativus*<br>*Hemidesmus indicus* | Alleviates oxidative stress<br>Modulates oncogenic transcription factors and induces apoptosis in cancer cells<br>Antidiabetic, Neuroprotective activity, Anti-inflammatory activity, Cardioprotective activity, Antiendotoxic activity, Anti-microbial agent |
| Sinapic acid | *Citrus paradisi*<br>*Vaccinium oxycoccus*<br>*Brassica napus* | Antioxidant, Anti-Inflammatory, Anti-Cancer, Hepatoprotective, Cardioprotective, Renoprotective, Neuroprotective, Anti-diabetic, Anxiolytic and Anti-bacterial |
| Gallic acid | *Phyllanthus*<br>*Momordica*<br>*Mentha* | Anti-Inflammatory, Anti-Oxidative, Anti-Tumor, Anti-Bacterial, Anti-Diabetes, Anti-Obesity, Anti-Microbial And Anti-Myocardial Ischemia |
| Chlorogenic acid | *Boehmeria nivea*<br>*Flos Lonicera japonica*<br>*Helianthus annuus* | Anti-Inflammation and Anti-Oxidation<br>Glucose and Lipid Metabolic Homeostasis Modulation<br>Endothelial Protection and Anti-Atherosclerosis, Anti-Allergic Effect, Hypotensive Effects, Hepatoprotection, Neuroprotection, Anticancer Effect, Antiviral and Antimicrobial Effects, Anti-UV-induced photoaging, mitigating systemic lupus erythematosus (SLE)-like symptoms, and suppressing melanogenesis. |

  

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|---|---|---|
| Rosmarinic acid | *Rosmarinus officinalis*<br>*Forsythia koreana*<br>*Ocimum tenuiflorum*<br>*Thymus mastichina* | Antiviral, Antibacterial, Anticancer, Antioxidant, Anti-Aging, Antidiabetic, Cardioprotective, Hepatoprotective, Nephroprotective, Antidepressant, Antiallergic, And Anti-Inflammatory Activities |
| Ellagic acid | *Rubus ursinus*<br>*Quercus pyrenaica*<br>*Rubus idaeus*<br>*Fragaria ananassa*<br>*Terminalia ferdinandiana*<br>*Eucalyptus globulus*<br>*Juglans nigra* | Anti-mycobacterial, Anti-inflammatory, Anti-hyperlipidemic, Hepatoprotective, Treatment of type 2 diabetes mellitus, Neuroprotective in sporadic Alzheimer's disease |

2. **Flavonoids**

The term "flavonoid" refers to a class of around 6500 molecules with a 15-carbon structure. Two phenyl benzopyranones comprise the core structure, and the three-carbon bridge connecting the phenyl groups is frequently cyclized with oxygen. The main groups are anthocyanidins, flavones, isoflavones, flavonols, chalcones, aurones, and flavanones. More differentiation within the distinct classes is feasible depending on the kind and quantity of substituent groups affixed to the rings. In addition to existing as free aglycones and glycosidic conjugates, flavonoids can also exist in various modified forms, as with most plant elements. This change can be considered a crucial defence in plants to prevent cytoplasmic damage and to store the flavonoids securely in the cell vacuole since the glycosylation makes the flavonoid less reactive, more polar, and hence more water-soluble. One or more aglycone hydroxyl groups are joined to sugar in flavonoid O-glycosides via the creation of an O–C acid-labile acetal bond. Although any hydroxyl group can, in theory, be glycosylated, specific locations are preferred; for instance, the 3- and 7-hydroxyls in flavonols and flavanols, the 3- and 5-hydroxyls in anthocyanidins, and the 7-hydroxyl group in flavones, flavanones, and isoflavones are the common glycosylation sites. When microorganisms infect plants, the plants release a special chemical known as "phytoalexin" that protects the plants from the disease organisms. Numerous plant species have been discovered to contain flavonoid molecules called phytoalexins. Most flavonoid phytoalexins were mostly extracted from subterranean components such as seeds, rhizomes, roots, and hypocotyls. Furthermore, many flowering plants, particularly those in the Leguminosae family, are known to be stimulated by specific flavonoids to produce nitrogen-fixing bacteria (*Rhizobium, Azorhizobium, and Bradyrhizobium*). Almost all flavonoid groups are best defined by their ability to function as antioxidants. Flavonoids can disrupt a minimum of three distinct processes that generate free radicals. Because they have lower redox potentials, they can reduce highly oxidizing free radicals by forming less reactive flavonoid radicals. This helps to prevent things like lipid peroxidation, which is one of the main ways that free radicals damage cellular membranes and ultimately cause cell death. The anti-inflammatory, antiallergic, hepatoprotective, antithrombotic, antiviral, and anticarcinogenic properties of flavonoids have also long been known. (38)

| Flavonoids | Plant | Reported activities (39-59) |
|---|---|---|
| Quercetin | *Fagopyrum esculentum*<br>*Brassica oleracea italica*<br>*Camellia sinensis*<br>*Vaccinium macrocarpon* | Cardiovascular Protection, Anticancer, Anti-Ulcer, Anti-Allergy, Anti-Viral, Anti-Inflammatory Activity, Anti-Diabetic, Gastroprotective Effects, Antihypertensive, Immunomodulatory, Anti-Infective. |
| Rutin | *Fagopyrum esculentum*<br>*Ruta graveolens*<br>*Sophora japonica* | Antimicrobial, Anti-Inflammatory, Anticancer, Antidiabetic |

| | | |
|---|---|---|
| Genistein | *Glycine max*<br>*Lupinus* | Anti-Cancer Activity, Antioxidant Activity, Anti-Inflammatory Activity, Antidiabetic, Antibacterial and Antiviral Activity |
| Taxifolin | *Larix sibirica*<br>*Pinus roxburghii*<br>*Cedrus deodara* | Antiviral, Antifungal, Anti-hyperuricemic, Anti-psoriatic, Anti-cataractogenesis, Antiangiogenic, Antihyperglycemic, Antioxidant, Anti-Alzheimer, Hepatoprotective, Anti-inflammatory |
| Fisetin | *Diospyros kaki*<br>*Allium cepa*<br>*Cucumis sativus* | Anti-inflammatory, Antioxidant, Anticarcinogenic, Neuroprotection |
| Hesperidin | *Citrus sinensis*<br>*Citrus limon* | Antioxidant, Anti-Inflammatory, Cardiovascular protective effects, Neuroprotective, Gastroprotective |
| Myricetin | *Myrica nagi* | Nutraceuticals, Antioxidant Properties, Anti-Inflammatory, Analgesic, Antitumor, Hepatoprotective, Antidiabetic effects |
| Luteolin | *Lactuca sativa*<br>*Brassica oleracea acephala* | Antiangiogenic, Antimetastatic, Immunomodulatory, Synergistic Effects of Conventional Anti-Cancer Drugs |

3. **Lignan**

The phenylpropanoid pathway is the source of the family of secondary metabolites known as lignans in plants. Lignans are beneficial in human nutrition and medicine and play a significant role in protecting plants. Legumes, oilseeds, whole grain cereals, and various fruits and vegetables are the main sources of dietary lignans. Edible plant parts that have the highest concentrations of lignans include flax and sesame seeds. The diverse components of around 60 plant families include this class of chemicals, known as lignans, which have the potential to function as bioactive agents against malignant cells. In addition to their cytotoxic properties, they can treat cardiovascular disorders, diabetes, microbial infections, oxidation of live cells as antioxidants, and other significant or minor inflammatory reactions. (60)

| **Lignan** | **Plant** | **Reported activities (61-65)** |
|---|---|---|
| Enterolactone | *Linum usitatissimum* | Protective Against Cancer, Inflammation, Viral Infection, Stroke, And Cardiovascular Diseases. |
| Matairesinol | *Symplocos setchuensis* | Antiangiogenic, Anti-Inflammatory, Antioxidant, Anti-Tumor<br>Potent Inhibitor of Casein Kinase I in Vitro<br>Inhibit HIV replication in H9 lymphocyte cells |
| Liriodendrin | *Boerhaavia diffusa* | Anti-myocardial ischemia, Anti-Arrhythmic, Anti-Oxidant, Anti- Inflammatory |
| Steganacin | *Steganotaenia araliacea* | Antileukemic |

4. **Stilbenes**

Several significant phenolic compounds, including stilbenes, come from plant families such as the Dipterocarpaceae, Vitaceae, Leguminosae, and Gnetaceae. They have a C6-C2-C6 backbone and often have two isomeric variants. Stilbenes are produced as a result of both biotic and abiotic stressors, including oxidation, high temperatures, and microbial infections. A total of 196 plant species and 45 plant groups were found to have 459 naturally occurring stilbene chemicals. The anticancer, antibacterial, antioxidant, anti-inflammatory, anti-degenerative, anti-diabetic, neuroprotective, anti-aging, and cardioprotective properties of stilbenes are also demonstrated by pharmacological research. In stilbene biosynthesis routes, stilbene synthase (STS) is the primary enzyme. Research on stilbenes' therapeutic use identifies limited bioavailability and isomerization as the main obstacles to their advancement as medicinal medications. (66)

| **Stilbenes** | **Plant** | **Reported activities (67-71)** |
|---|---|---|
| Resveratrol | *Polygonum cuspidatum* | Antiangiogenic, Immunomodulatory, Antimicrobial, Neuroprotective, Antidiabetic, Cardioprotective, Hepatoprotective |
| Pterostilbene | *Pterocarpus marsupium* | Anti-inflammatory, Antioxidant, Antitumor |
| Piceatannol | *Passiflora edulis* | Antioxidant, Anti-Inflammatory, Cancer Preventive, Neuroprotective Properties, Managing Hypercholesterolemia, Atherosclerosis, Angiogenesis, And Cardiovascular Diseases. |

5. **Coumarins**

Coumarins (1,2-benzopyrone) are significant secondary metabolites that are widely distributed in a variety of species, including bacteria, fungi, and plants. Coumarins and their derivatives have a benzene ring fused with an α-pyrone ring in their basic structure. The formation of simple coumarins, including esculetin, scopoletin, umbelliferone (7-hydroxy coumarin), and 4-hydroxycoumarin (4-HC), is accomplished via the catalysis of hydroxide radicals and methyl groups in various locations. The three categories of complex coumarins that come from the phenylpropanoid routes are pyranocoumarins, furanocoumarins, and pyrone-substituted coumarins. Psoralen and angelicin are examples of furanocoumarins, which have a characteristic molecular structure with a furan ring connected to the coumarin nucleus. Similarly, there are two forms of pyranocoumarins, such as xanthyletin and seselin, based on the positions of the pyran rings. Pyrone-substituted coumarins, including dicoumarol and warfarin, are based on pyranocoumarins and have pyrone ring replacements and modifications. Many biological actions, such as antibacterial, antiviral, antifungal, anti-inflammatory, anticancer, anticoagulant, and antihypertensive properties, have been discovered in coumarin derivatives due to their unique structures. Coumarin derivatives are, therefore regarded as reliable sources for the development of new drugs. For instance, in recent decades, they have been extensively used in the creation of herbal medications. (72)

| **Coumarins** | **Plant** | **Reported activities (73-78)** |
|---|---|---|
| Umbelliferone | Ipomoea mauritiana<br>*Edgeworthia chrysantha* | Antioxidant, antidiabetic, Anti-cancer, Molluscicidal, Anti-inflammatory, sunscreen agent. |
| Esculetin | *Cichorium glandulosum* | Antioxidant, Anti-Proliferative, Cytoprotective |
| Scopoletin | *Viola mandshurica*<br>*Polygala sabulosa*<br>*Hedyotis diffusa*<br>*Artemisia annua* | Antibacterial, Antifungal, Antiparasitic, Anticancer, Anti-Inflammation, Hepatoprotective, Antihyperlipidemic, Antidiabetic, Neuroprotective, Antioxidant, Anti-Angiogenesis, Anti-Hypertensive, Analgesic, Anxiolytic, Immunomodulatory, Anti-Osteoporosis, Anti-Allergic, Anti-Aging, Anti-Gout Activities. |
| Psoralen | *Cullen corylifolium* | Anti-Osteoporotic, Antiviral, Antibacterial, Anti-Tumor, Anti-Inflammatory, Neuroprotective |
| Calanolides | *Calophyllum lanigerum austrocoriaceum* | Anticancer, Anti-HIV, Antimycobacterial, Antiparasitic |

6. **Xanthones**

Xanthone, also known as 9H-xanthen-9-one, is an aromatic oxygenated heterocyclic compound having a dibenzo-γ-pirone scaffold. The biosynthetic processes in higher plants that result in the acetate-derived A-ring (carbons 1–4) and the shikimic acid pathway-derived B-ring (carbons 5–8) determine the number and class of rings A and B. The type of substituents and where they are located on the scaffold determine the minor variations among xanthone derivatives. Several living things, including those that are phylogenetically distant from one another, produce xanthones, which are extensively spread in nature. Natural xanthones, including their reduced derivatives di-, tetra-, and hexahydroxanthones, are around 2000 years old, according to the Dictionary of Natural Products as of January 2016. Nearly 80% of natural xanthones come from plants, making them the most common source of xanthones.

The classification of xanthones has attracted a lot of attention in recent decades, mainly due to the compounds' enormous potential for biologically beneficial medical applications. Their group classification has changed as a result of the wide variety of substituents as well as the discovery and synthesis of new xanthones. Based on their substituents, all other xanthones can be categorized into six main groups: oxygenated xanthones, glycosylated xanthones, prenylated xanthones, xantholignoids, bisxanthones, and various xanthones. Simple xanthones, on the other hand, only have methyl groups attached to their core structure. Different plant organs (leaves, stems, roots, flowers, and fruits) and tissues, as well as those of other animals, biosynthesize and collect these compounds. Plants use the shikimate pathway to produce xanthones, with the acetate (or polyketide) pathway contributing. Many synthesized and naturally occurring xanthone derivatives with a variety of advantageous and diverse pharmacological properties have been documented in the literature. Many authors have claimed that xanthones have anticancer, antimicrobial, antimalarial, anti-HIV, anticonvulsant, anticholinesterase, antioxidant, and anti-inflammatory properties. They have also been linked to an inhibitory activity on various enzymes, such as intestinal P-glycoprotein, a-glucosidase, topoisomerase, protein kinase C, miRNA, acyl-CoA: cholesterol acyltransferase, xanthine oxidase, and aromatase. Cytotoxic effects have already been shown for all xanthone groups. The antioxidant properties of oxygenated xanthones with simple substituents like hydroxyl, methoxy, or methyl groups were linked to anti-obesity, antifungal, antibacterial, hepatoprotective, and cancer chemopreventive actions involving targets like tyrosinase, monoaminoxidase (MAO), P-glycoprotein (P-gp), protein kinase C (PKC), and tyrosinase. The most effective lignoids, in addition to xanthonolignoids, were identified to be 3,4-dihydroxy xanthone derivatives with synthesis intermediates of 3,4-dihydroxy-2-methoxyxanthone and 2,3-dihydroxy-4-methoxyxanthone, which in leukemia cell lines showed potential antiproliferative and apoptotic activities. Initially thought to have potential for treating melanoma, 1,2-dihydroxyxanthone is the most promising antioxidant due to its chelating qualities, stability, phototoxicity, cytotoxic effect on a human keratinocyte cell line, and modulatory effects on THP-1 macrophage cell line activity. As of today, thousands of natural xanthone derivatives have been isolated from Amaranthaceae, Anacardiaceae, Annonaceae, Asteraceae, Clusiaceae, Eriocaulaceae, Fabaceae, Filicineae, Gentianaceae, Guttiferae, Hypericaeae, Moraceae, Leguminosae, Loganiaceae, and Polygalaceae families. (79, 80)

| **Xanthones** | **Plant** | **Reported activities (81-85)** |
|---|---|---|
| Mangostin | *Garcinia mangostana* | Antibacterial, Antifungal, Antimalarial, Anticarcinogenic, Antiatherogenic Activities. Neuroprotective Properties In Alzheimer's Disease (AD) |
| Garcinone E | *Garcinia mangostana* | Anticancer |
| Gambogic acid | *Garcinia hanburyi* | Anti-Cancer, Anti-Inflammatory, Antioxidant, Anti-Bacterial |
| Swertianolin | *Lavandula angustifolia* | Neuromodulators targeting epilepsy, depression, and anxiety |
| Mangiferin | *Mangifera indica* | Antioxidant, Anti-Inflammatory, Neuroprotective, Cardioprotective, Nephroprotective, Hepatoprotective, Anti-Diabetic, Anti-Asthmatic, Gastroprotective, Immunomodulatory, Anti-Cancer, And Hypocholesterolemic |

## CONCLUSION

The most prevalent secondary metabolites found in nature are phenolic compounds, usually referred to as polyphenols. They have an aromatic ring with one or more free hydroxy substituents or functional derivatives such as glycosides, ethers, and esters. The antioxidant, antibacterial, anti-inflammatory, anticancer, and cardiovascular protective properties of phenolic compounds have drawn particular interest. Everyday dietary phenolic compounds come from a range of foods and drinks, including fruits (citruses, grapes, berries), vegetables (onions, broccoli, and cabbage), and beverages (coffee, tea, and wine). They are in charge of a variety of food qualities, including color, astringency, taste, and odor. Furthermore, several studies show that eating vegetables can improve metabolic markers typically linked to non-communicable disorders, including obesity, diabetes, and hypertension.

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**REFERENCES**
1. Natalia V Zagoskina, Maria Y Zubova, Tatiana L Nechaeva, Varvara V Kazantseva, Evgenia A Goncharuk, Vera M Katanskaya, Ekaterina N Baranova, Maria A Aksenova Polyphenols in Plants: Structure, Biosynthesis, Abiotic Stress Regulation, and Practical Applications (Review) Int J Mol Sci. 2023; 24(18):13874.
2. Derong Lin, Mengshi Xiao, Jingjing Zhao, Zhuohao Li, Baoshan Xing, Xindan Li, Maozhu Kong, Liangyu Li, Qing Zhang, Yaowen Liu, Hong Chen, Wen Qin, Hejun Wu, Saiyan Chen An Overview of Plant Phenolic Compounds and Their Importance in Human Nutrition and Management of Type 2 Diabetes Molecules. 2016; 21(10): 1374.
3. Jin Dai, Russell J Mumper Plant Phenolics: Extraction, Analysis and Their Antioxidant and Anticancer Properties Molecules. 2010; 15(10):7313–7352.
4. Naresh Kumar, Nidhi Goel Phenolic acids: Natural versatile molecules with promising therapeutic applications Biotechnol Rep (Amst). 2019; 24: e00370.
5. Sahil Kakkar, Souravh Bais A Review on Protocatechuic Acid and Its Pharmacological Potential ISRN Pharmacol. 2014; 2014: 952943.
6. Rohini Manuja, Shikha Sachdeva, Akash Jain, Jasmine Chaudhary A Comprehensive Review on Biological Activities of P-Hydroxy Benzoic Acid and Its Derivatives Int. J. Pharm. Sci. Rev. Res. 2013; 22(2): 109-115
7. Pallavi Dandekar, Kailas L. Wasewar Experimental investigation on extractive separation of vanillic acid Chemical Data Collections 2020; 30: 100564
8. Özcan, M.M., Matthäus, B. A review: benefit and bioactive properties of olive (*Olea europaea* L.) leaves. Eur Food Res Technol 2017; 243: 89–99.
9. Rosa Martha Pérez Gutiérrez, Sylvia Mitchell, Rosario Vargas Solis Psidium guajava: A review of its traditional uses, phytochemistry, and pharmacology Journal of Ethnopharmacology 2008; 117 (1): 1-27
10. Noor Ariefandie Febrianto, Fan Zhu Coffee bean processing: Emerging methods and their effects on chemical, biological and sensory properties Food Chemistry 2023; 412: 135489
11. Hanjo Hellmann, Aymeric Goyer, Duroy A Navarre Antioxidants in Potatoes: A Functional View on One of the Major Food Crops Worldwide Molecules. 2021; 26(9): 2446.
12. Espíndola KMM, Ferreira RG, Narvaez LEM, Silva Rosario ACR, da Silva AHM, Silva AGB, Vieira APO and Monteiro MC Chemical and Pharmacological Aspects of Caffeic Acid and Its Activity in Hepatocarcinoma. Front. Oncol. 2019; 9:541
13. Silva H and Lopes NMF Cardiovascular Effects of Caffeic Acid and Its Derivatives: A Comprehensive Review. Front. Physiol. 2020; 11: 595516

14. Iman Akhlaghipour, Arya Nasimi Shad, Vahid Reza Askari, Amirhosein Maharati, Vafa Baradaran Rahimi How caffeic acid and its derivatives combat diabetes and its complications: A systematic review Journal of Functional Foods 2023; 110: 105862
15. Jiri Patocka, Kanchan Bhardwaj, Blanka Klimova, Eugenie Nepovimova, Qinghua Wu, Marco Landi, Kamil Kuca, Martin Valis, Wenda Wu *Malus domestica*: A Review on Nutritional Features, Chemical Composition, Traditional and Medicinal Value Plants (Basel). 2020; 9(11):1408.
16. Hong, SY., Lansky, E., Kang, SS. *et al.* A review of pears (*Pyrus* spp.), ancient functional food for modern times. BMC Complement Med Ther 2021; 21: 219.
17. Edward J Collins, Cressida Bowyer, Audrey Tsouza, Mridula Chopra Tomatoes: An Extensive Review of the Associated Health Impacts of Tomatoes and Factors That Can Affect Their Cultivation Biology (Basel). 2022; 11(2): 239.
18. Tajamul Rouf Shah, Kamlesh Prasad, Pradyuman Kumar Maize—A potential source of human nutrition and health: A review Cogent Food & Agriculture 2016; 2: 1166995
19. Kehan Pei, Juanying Ou, Junqing Huang, Shiyi Ou p-Coumaric acid and its conjugates: dietary sources, pharmacokinetic properties and biological activities J Sci Food Agric 2016; 96: 2952–2962
20. Yiman Zhai, Tingyu Wang, Yunmei Fu, Tong Yu, Yan Ding, Hongguang Nie Ferulic Acid: A Review of Pharmacology, Toxicology, and Therapeutic Effects on Pulmonary Diseases Int J Mol Sci. 2023; 24(9): 8011.
21. Purushothaman J R, Rizwanullah M Ferulic Acid: A Comprehensive Review. Cureus 2024; 16(8): e68063
22. Magda Gamba, Peter Francis Raguindin, Eralda Asllanaj, Francesco Merlo, Marija Glisic, Beatrice Minder, Weston Bussler, Brandon Metzger, Hua Kern, Taulant Muka Bioactive compounds and nutritional composition of Swiss chard (*Beta vulgaris* L. var. *cicla* and *flavescens*): a systematic review Crit Rev Food Sci Nutr. 2021; 61(20): 3465-3480.
23. Sharma, M., Sharma, M. & Sharma, M. A comprehensive review on ethnobotanical, medicinal and nutritional potential of walnut (Juglans regia L.). Proc.Indian Natl. Sci. Acad. 2022; 88: 601–616
24. Mohamed Ali Al-Farsi, Chang Yong Lee Nutritional and functional properties of dates: a review Crit Rev Food Sci Nut. 2008; 48(10):877-87.
25. Maria Batool, Muhammad Modassar Ali Nawaz Ranjha, Ume Roobab, Muhammad Faisal Manzoor, Umar Farooq, Hafiz Rehan Nadeem, Muhammad Nadeem, Rabia Kanwal, Hamada AbdElgawad, Soad K Al Jaouni, Samy Selim, Salam A Ibrahim Nutritional Value, Phytochemical Potential, and Therapeutic Benefits of Pumpkin (Cucurbita sp.) Plants (Basel). 2022; 11(11): 1394.
26. Srinivasulu Cheemanapalli, Ramgopal Mopuri, Ramanjaneyulu Golla, Anuradha C.M., Suresh Kumar Chittaa Syringic acid (SA) – A Review of Its Occurrence, Biosynthesis, Pharmacological and Industrial Importance Biomedicine & Pharmacotherapy 2018; 108: 547–55
27. Pandi, A., Kalappan, V.M. Pharmacological and therapeutic applications of Sinapic acid—an updated review. Mol Biol Rep 2021; 48: 3733–3745
28. Onakpoya, I., O'Sullivan, J., Heneghan, C., & Thompson, M. The effect of grapefruits (*Citrus paradisi*) on body weight and cardiovascular risk factors: A systematic review and meta-analysis of randomized clinical trials. Critical Reviews in Food Science and Nutrition, 2016; 57(3): 602–612.
29. Boris V Nemzer, Fadwa Al-Taher, Alexander Yashin, Igor Revelsky, Yakov Yashin Cranberry: Chemical Composition, Antioxidant Activity and Impact on Human Health: Overview Molecules. 2022; 27(5):1503.
30. Nadia Raboanatahiry, Huaixin Li, Longjiang Yu, Maoteng Li Rapeseed (Brassica napus): Processing, Utilization, and Genetic Improvement Agronomy 2021; 11(9): 1776
31. Jinrong Bai, Yunsen Zhang, Ce Tang, Ya Hou, Xiaopeng Ai, Xiaorui Chen, Yi Zhang, Xiaobo Wang, Xianli Meng Gallic acid: Pharmacological activities and molecular mechanisms involved in inflammation-related diseases Biomedicine & Pharmacotherapy 2021; 133: 110985

32. Vi Nguyen, Elaine G Taine, Dehao Meng, Taixing Cui, Wenbin Tan Chlorogenic Acid: A Systematic Review on the Biological Functions, Mechanistic Actions, and Therapeutic Potentials Nutrients. 2024; 16(7):924.
33. Zizhen Yang, Zhijian Tan, Fenfang Li, Xiangdong Li An effective method for the extraction and purification of chlorogenic acid from ramie (Boehmeria nivea L.) leaves using acidic ionic liquids Industrial Crops and Products 2016; 89: 78-86
34. Sun, Y., Ding, S., Huang, H. et al. Ionic liquid-based enzyme-assisted extraction of chlorogenic acid from Flos Lonicera Japonicae . Bioresour. Bioprocess. 2017; 4: 45
35. Sergio González-Pérez, Karin B. Merck, Johan M. Vereijken, Gerrit A. van Koningsveld, Harry Gruppen, Alphons G. J. Voragen Isolation and Characterization of Undenatured Chlorogenic Acid Free Sunflower (*Helianthus annuus*) Proteins J. Agric. Food Chem. 2002; 50 (6): 1713–1719
36. Muhammad Nadeem, Muhammad Imran, Tanweer Aslam Gondal, Ali Imran, Muhammad Shahbaz, Rai Muhammad Amir, Muhammad Wasim Sajid, Tahira Batool Qaisrani, Muhammad Atif, Ghulam Hussain, Bahare Salehi, Elise Adrian Ostrander, Miquel Martorell, Javad Sharifi-Rad, William C. Cho, Natália Martins Therapeutic Potential of Rosmarinic Acid: A Comprehensive Review Appl. Sci. 2019; 9(15): 3139
37. Golmei P, Kasna S, Roy KP, Kumar S. A Review on Pharmacological Advancement of Ellagic Acid. Journal of Pharmacology and Pharmacotherapeutics. 2024;15(2):93-104.
38. Corradini, Eleonora, Foglia, Patrizia, Giansanti, Piero, Gubbiotti, Riccardo, Samperi, Roberto and Laganà, Aldo Flavonoids: chemical properties and analytical methodologies of identification and quantitation in foods and plants Natural Product Research 2011; 25 (5): 469 — 495
39. Alexander Victor Anand David, Radhakrishnan Arulmoli, Subramani Parasuraman Overviews of Biological Importance of Quercetin: A Bioactive Flavonoid Pharmacogn Rev. 2016; 10(20):84–89.
40. Fan Zhu Buckwheat proteins and peptides: Biological functions and food applications Trends in Food Science & Technology 2021; 110: 155-167
41. Rahamat Unissa Syed, Sivakumar Sivagurunathan Moni, Mohammed Khaled Bin Break, Weam M. A. Khojali, Mohammed Jafar, Maali D. Alshammari, Karim Abdelsalam, Soha Taymour, Khetam Saad Mutni Alreshidi, Manal Mohamed Elhassan Taha, Syam Mohan Broccoli: A Multi-Faceted Vegetable for Health: An In-Depth Review of Its Nutritional Attributes, Antimicrobial Abilities, and Anti-inflammatory Properties Antibiotics 2023; 12(7): 1157
42. Sabu M Chacko, Priya T Thambi, Ramadasan Kuttan, Ikuo Nishigaki Beneficial effects of green tea: A literature review Chin Med. 2010; 5: 13.
43. Boris V Nemzer, Fadwa Al-Taher, Alexander Yashin, Igor Revelsky, Yakov Yashin Cranberry: Chemical Composition, Antioxidant Activity and Impact on Human Health: Overview Molecules. 2022; 27(5):1503.
44. Beatriz Gullón, Thelmo A. Lú-Chau, María Teresa Moreira, Juan M. Lema, Gemma Eibes Rutin: A review on extraction, identification and purification methods, biological activities and approaches to enhance its bioavailability Trends in Food Science & Technology 2017; 67: 220-235
45. Shenglin Hou Genistein: Therapeutic and Preventive Effects, Mechanisms, and Clinical Application in Digestive Tract Tumor Evid Based Complement Alternat Med. 2022; 2022: 5957378.
46. Seok Tyug Tan, Seok Shin Tan, Chin Xuan Tan Soy protein, bioactive peptides, and isoflavones: A review of their safety and health benefits PharmaNutrition 2023; 25: 100352
47. Javad Sharifi-Rad, Cristina Quispe, Muhammad Imran, Abdur Rauf, Muhammad Nadeem, Tanweer Aslam Gondal, Bashir Ahmad, Muhammad Atif, Mohammad S Mubarak, Oksana Sytar, Oxana Mihailovna Zhilina, Ekaterina Robertovna Garsiy, Antonella Smeriglio, Domenico Trombetta, Daniel Gabriel Pons, Miquel Martorell, Susana M Cardoso, Ahmad Faizal Abdull Razis, Usman Sunusi, Ramla Muhammad Kamal, Lia Sanda Rotariu, Monica Butnariu, Anca Oana Docea, Daniela Calina Genistein: An Integrative Overview of Its Mode of Action, Pharmacological Properties, and Health Benefits Oxid Med Cell Longev. 2021; 2021: 3268136.

48. Abhijit Das, Ratna Baidya, Tania Chakraborty, Akash Kumar Samanta, Souvik Roy Pharmacological basis and new insights of taxifolin: A comprehensive review Biomedicine & Pharmacotherapy 2021; 142: 112004
49. Naghma Khan, Deeba N Syed, Nihal Ahmad, Hasan Mukhtar Fisetin: A Dietary Antioxidant for Health Promotion Antioxid Redox Signal. 2013; 19(2):151–162.
50. Shubham Jain, G. Ranganna, Sipra Mohapatra, Manjunath Rathod, Homeshvari, Deepak S. Kore, Saransh Saxena, Anushi A Comprehensive Review on Persimmon (Diospyros kaki): Botanical, Horticultural, and Varietal Perspectives Int. J. Environ. Clim. Change, 2023; 13 (11): 4437-4457
51. Manpreet Kaur & Parveen Sharma Recent advances in cucumber (Cucumis sativus L.), The Journal of Horticultural Science and Biotechnology, 2022; 97 (1): 3-23
52. Manoj Kumar, Mrunal D. Barbhai, Muzaffar Hasan, Sneh Punia, Sangram Dhuma, Radha, Nadeem Rais, Deepak Chandran, R. Pandiselvam, Anjineyulu Kothakota, Maharishi Tomar, Varsha Satankar k, Marisennayya Senapathy, T. Anitha, Abhijit Dey, Ali A.S. Sayed, Farouk M. Gadallah, Ryszard Amarowicz, Mohamed Mekhemar Onion (Allium cepa L.) peels: A review on bioactive compounds and biomedical activities Biomedicine & Pharmacotherapy 2022; 146: 112498
53. Narender Singh, Divyanshu, Sonu Saini, Navneet Nagpal, Monu Yadav, Atul Tuli, Maajid Mohi Ud Din Malik, Nitish Bhatia Pharmacological and Therapeutic Potential of Hesperidin- A Comprehensive Review Eur. Chem. Bull. 2023, 12(8): 4499-4537
54. Sheetal N. Khandla, Milan S. Vala, Bharat B. Maitreya A Review: Phytochemical Constituents, Medicinal Uses And Economical Value Of Orange Peels (Citrus sinensis L Osbeck) IJCRT 2020; 8 (5): 1340-1354
55. Marta Klimek-Szczykutowicz, Agnieszka Szopa, Halina Ekiert Citrus limon (Lemon) Phenomenon—A Review of the Chemistry, Pharmacological Properties, Applications in the Modern Pharmaceutical, Food, and Cosmetics Industries, and Biotechnological Studies Plants (Basel). 2020; 9(1): 119.
56. Nazia Afroze, Sreepoorna Pramodh, Arif Hussain, Madiha Waleed, Kajal Vakharia A review on myricetin as a potential therapeutic candidate for cancer prevention 3 Biotech. 2020; 10(5): 211.
57. Hardeep Singh Tuli, Prangya Rath, Abhishek Chauhan, Katrin Sak, Diwakar Aggarwal, Renuka Choudhary, Ujjawal Sharma, Kanupriya Vashishth, Sheetu Sharma, Manoj Kumar, Vikas Yadav, Tejveer Singh, Mukerrem Betul Yerer, Shafiul Haque Luteolin, a Potent Anticancer Compound: From Chemistry to Cellular Interactions and Synergetic Perspectives Cancers (Basel). 2022; 14(21): 5373.
58. Min Shi, Jingyu Gu, Hanjing Wu, Abdur Rauf, Talha Bin Emran, Zidan Khan, Saikat Mitra, Abdullah S M Aljohani, Fahad A Alhumaydhi, Yahya S Al-Awthan, Omar Bahattab, Muthu Thiruvengadam, Hafiz A R Suleria Phytochemicals, Nutrition, Metabolism, Bioavailability, and Health Benefits in Lettuce—A Comprehensive Review Antioxidants (Basel). 2022; 11(6): 1158.
59. Neela Satheesh, Solomon Workneh Fant Kale: Review on nutritional composition, bio-active compounds, anti-nutritional factors, health-beneficial properties and value-added products Cogent Food & Agriculture 2020; 6: 1811048
60. Minky Mukhija, Bhuwan Chandra Joshi, Partha Sarathi Bairy, Anurag Bhargava, Archana N Sah Lignans: a versatile source of anticancer drugs Beni Suef Univ J Basic Appl Sci. 2022; 11(1): 76.
61. Mukund P Sibi, Quinlyn T. Waulters, Waidath Bio-Sawe, Russell Hofmann Overview of Enterolactone Biological Properties and Total Synthesis ARKIVOC 2018; 4: 76-93
62. Jhilam Pramanik, Akash Kumar, Bhupendra Prajapati A review on flaxseeds: Nutritional profile, health benefits, value added products, and toxicity eFood 2023; 4 (5): 114
63. Takamasa Yokoyama, A Maiko Okano, A Toshiro Noshita, B Shinji Funayama, B Kenzo Ohtsuki Characterization of ()-Matairesinol as a Potent Inhibitor of Casein Kinase I in Vitro Biol. Pharm. Bull. 2003; 26(3) 371—374
64. Qin Wu, Yuhua Wang, Qingfang Li Matairesinol exerts anti-inflammatory and antioxidant effects in sepsis-mediated brain injury by repressing the MAPK and NF-κB pathways through up-regulating AMPK Aging (Albany NY). 2021; 13(20): 23780–23795

65. S M Kupchan, R W Britton, M F Ziegler, C J Gilmore, R J Restivo, R F Bryan Steganacin and steganangin, novel antileukemic lignan lactones from Steganotaenia araliacea J Am Chem Soc. 1973; 95(4): 1335-6.
66. Tekleab Teka, Lele Zhang, Xiaoyan Ge, Yanjie Li, Lifeng Han, Xiaohui Yan Stilbenes: Source plants, chemistry, biosynthesis, pharmacology, application and problems related to their clinical Application-A comprehensive review Phytochemistry. 2022; 197: 113128.
67. Akash Vikal, Rashmi Maurya, Shuvadip Bhowmik, Satyam Khare, Sarjana Raikwar, Preeti Patel, Balak Das Kurmi Resveratrol: A comprehensive review of its multifaceted health benefits, mechanisms of action, and potential therapeutic applications in chronic disease Pharmacological Research - Natural Products 2024; 3: 100047
68. Dong-Geng Wang, Wen-Ying Liu, Guang-Tong Chen A simple method for the isolation and purification of resveratrol from Polygonum cuspidatum Journal of Pharmaceutical Analysis 2013; 3 (4): 241-247
69. Peijun Liu, Weihua Tang, Kali Xiang, Guangcai Li Pterostilbene in the treatment of inflammatory and oncological diseases Front Pharmacol. 2024; 14: 1323377.
70. Juan Zhang, Siyu Tao, Guige Hou, Fenglan Zhao, Qingguo Meng, Shenpeng Tan Phytochemistry, nutritional composition, health benefits and future prospects of Passiflora: A review Food Chemistry 2023; 428: 136825
71. Hala I. Al-Jaber, Ashok K. Shakya, Mahmoud A. Al-Qudah, Lina M. Barhoumi, Hana E. Abu-Sal, Hazem S. Hasan, Nezar Al-Bataineh, Sultan Abu-Orabi, Mohammad S. Mubarak Piceatannol, a comprehensive review of health perspectives and pharmacological aspects Arabian Journal of Chemistry 2024; 17 (9): 105939
72. Yusong Zou, Yuxi Teng, Joy Li, Yajun Yan Recent advances in the biosynthesis of coumarin and its derivatives Green Chemical Engineering 2024; 5 (2): 150-154
73. Ofentse Mazimba Umbelliferone: Sources, chemistry and bioactivities review Bulletin of Faculty of Pharmacy, Cairo University 2017; 55 (2): 223-232
74. Almesh Kadakol, Nisha Sharma, Yogesh Anant Kulkarni, Anil Bhanudas Gaikwad Esculetin: A phytochemical endeavor fortifying effect against non-communicable diseases Biomedicine & Pharmacotherapy 2016; 84: 1442-1448
75. Wu, H.K., Su, Z., Yili, A. *et al.* Isolation of esculetin from *Cichorium glandulosum* by high-speed countercurrent chromatography. Chem Nat Compd 2007; 43: 109
76. Gao X-Y, Li X-Y, Zhang C-Y, Bai C-Y Scopoletin: a review of its pharmacology, pharmacokinetics, and toxicity. Front. Pharmacol. 2024; 15:1268464
77. Ren Y, Song X, Tan L, Guo C, Wang M, Liu H, Cao Z, Li Y and Peng C A Review of the Pharmacological Properties of Psoralen. Front. Pharmacol. 2020; 11: 571535
78. by Lutfun Nahar, Anupam Das Talukdar, Deepa Nath, Sushmita Nath, Aman Mehan, Fyaz M. D. Ismail, Satyajit D. Sarker Naturally Occurring Calanolides: Occurrence, Biosynthesis, and Pharmacological Properties Including Therapeutic Potential Molecules 2020; 25(21): 4983
79. Camilla Badiali, Valerio Petruccelli, Elisa Brasili, Gabriella Pasqua Xanthones: Biosynthesis and Trafficking in Plants, Fungi and Lichens Plants (Basel). 2023;12(4): 694.
80. Kurniawan, Y.S.; Priyangga, K.T.A.; Jumina; Pranowo, H.D.; Sholikhah, E.N.; Zulkarnain, A.K.; Fatimi, H.A.; Julianus, J. An Update on the Anticancer Activity of Xanthone Derivatives: A Review. Pharmaceuticals 2021; 14: 1144
81. Ming-Hui Wang, Kuo-Jun Zhang, Qin-Lan Gu, Xiao-Ling Bi, Jin-Xin Wang Pharmacology of mangostins and their derivatives: A comprehensive review Chin J Nat Med. 2017; 15(2): 81-93.
82. Wei, D., Wang, L., Lei, S., Zhang, H., Dong, C., Ke, Y., Liu, X. Identification of natural compound garcinone E as a novel autophagic flux inhibitor with anticancer effect in nasopharyngeal carcinoma cells. Pharmaceutical Biology 2023; *61*(1), 839–857.
83. Yuling Liu, Yingchong Chen, Longfei Lin, Hui Li Gambogic Acid as a Candidate for Cancer Therapy: A Review Int J Nanomedicine. 2020; 15: 10385-10399.

84. Shashank M Patil, Khalid Awadh Al-Mutairi, Nagma Firdose, Ramith Ramu, Reshma Mary Martiz, Ashwini P Pharmacoinformatics based screening discovers swertianolin from Lavandula angustifolia as a novel neuromodulator targeting epilepsy, depression, and anxiety South African Journal of Botany 2022; 149: 712-730
85. Jangra, A., Arora, M.K., Kisku, A. et al. The multifaceted role of mangiferin in health and diseases: a review. ADV TRADIT MED (ADTM) 2021; 21: 619–643.