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Phytochemicals As Nutraceuticals: A Review

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ABSTRACT

Nutraceuticals have received good interest due to safety, nutritive and medicinal effects. Such products include dietary supplements to genetically engineered foods, herbal products and processed foods. Plant produces a variety of chemicals known as phytochemicals which maintain or improve health and which can be broadly classified in various categories based on their chemical structure. Foods like grains, fruits, vegetables, beans, and herbs actually contain phytochemicals of nutraceutical importance. Phytochemicals, either alone or in combination, have enormous medicinal potential in prevention and treatment of diseases. It has been noted that many of the phytochemicals of various nutraceuticals are effective on difficult to cure diseases like cancer, diabetes, cardiovascular disorders *etc*. They play important pharmacological effects in our health and possess medicinal activities as anti-inflammatory, antioxidant, hypolipidemic, anticancer, antidiabetic, immune-modulator *etc*. In the present study we have summarized thirty-nine different phytochemicals which have the potential to be used as nutraceuticals; namely as functional foods, dietary supplements, *etc*. We have studied their biological

source, chemical structure, CAS no., mechanism of action, uses, *etc*. and detailed herein. Thus, this is a compressive review of significant importance for health, medicinal and nutritional fields.

Keyword: *Phytochemicals, Nutraceuticals, Food, Medicine, Antioxidant, Health*

1. INTRODUCTION

Today's consumers are worried about their eating habits, health, and way of life. The quality of life has increased as a result of globalisation and economic progress. Life has become fast with Hurry, Worry and curry being the buzz words. Junk food consumption has increased, resulting in several diseases linked to nutritional imbalances. Nutraceuticals have the potential to help regulate them. A nutraceutical is defined as any substance that is a food or part of a food and provides medical or health benefits, including the prevention and treatment of disease. Such products may range from dietary supplements to genetically engineered foods, herbal products and processed foods, which come in a variety of forms, including tablets, capsules, gummies, and powders, as well as drinks and energy bars [1,2]. The major sources of dietary nutrients are cereals, legumes (barley, corn, nuts, oats, rice, sorghum, wheat, beans, and pulses), oilseeds (rapeseed, canola, flaxseed and olive seeds), fruits, vegetables and beverages (fruit juices, tea, coffee, cocoa, beer and wine) [3,4]. A large variety of nutraceuticals have become accessible for self-medication or sale in the last 20 years. There has been a surge in the selling of nutraceuticals due to; adverse effects of synthetic drugs and increased tendency of patients for self-medication.

Clinical trials have been conducted on a variety of nutraceuticals, and the findings of these trials confirm their efficacy as well as their overall safety. The classification of nutraceuticals is based on traditional and non-traditional methods described below (Fig. 1)

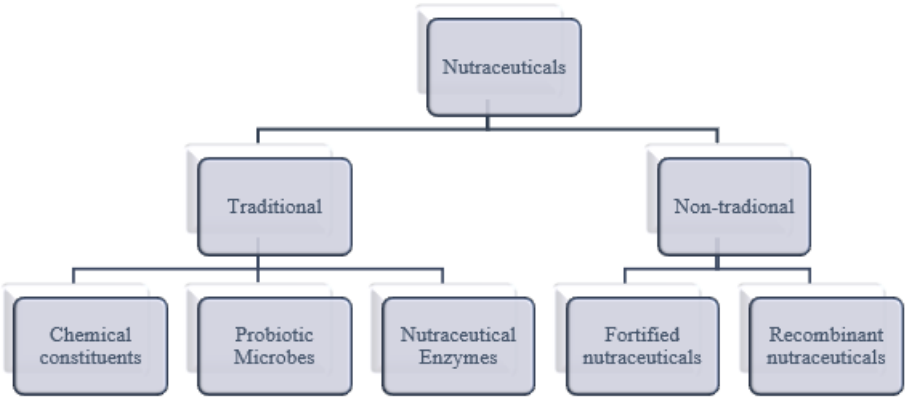


Figure 1: Classification of Nutraceuticals

The nutraceuticals comprise of bioactive phytochemicals that protect or promote health and occur at the intersection of food and pharmaceutical industries. (Fig. 2)

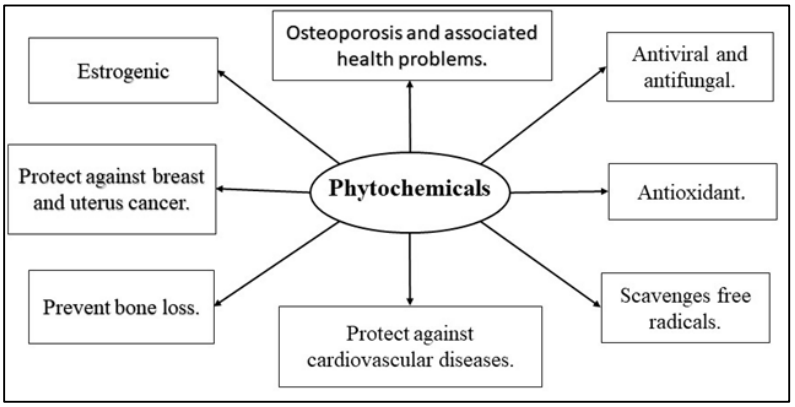


Figure 2: Biological properties of phytochemicals.

IMPORTANCE

From the consumers' point of view, the phytochemicals and nutraceuticals offer many benefits such as;

- Increase the nutritional worth of our food.
- Assist us in avoiding certain medical problems
- Considered to be more "natural" than conventional medication, with less negative side effects.
- May include food for certain populations (e.g., nutrient-dense meals for the elderly).
- Useful to prevent, treat, or cure a condition or disease[5].

Phytochemicals are non-nutritive plant compounds with disease-fighting or disease-preventive effects. These phytochemicals, alone or in combination, offer enormous therapeutic promise in the treatment of a variety of illnesses (Including cancer, coronary heart disease, diabetes, high blood pressure, inflammation, microbial, viral, and parasitic infections, psychotic diseases, spasmodic conditions, ulcers, osteoporosis and other conditions).[6,7]They can be used as aid in the restoration, correction or modification of physiological functioning in humans.Numerous phytochemicals currently are in the market. The available phytochemicals, their source and their potential human health benefits are given below-(Table-1)

Table-1: Important freely available phytochemicals, their sources and health benefits.

COMPONENTS	SOURCES	HEALTH BENEFITS
CAROTENOIDS	Carrots, various fruits	Free radicals that can harm cells are neutralized, and cellular antioxidant defenses are strengthened.
FLAVONOIDS	Tea, apple, broccoli	Acts as antioxidant
PHENOLS	Pears, citrus fruits, vegetables	Help to maintain vision and heart health by boosting cellular antioxidant defenses.
PREBIOTICS/PROBIOTICS	Yogurt, other dairy and non-dairy products	Improve gastrointestinal health and systematic immunity
SULFIDES	Cruciferous vegetables	Helps in maintenance of healthy immune function

Carotenoids and flavonoids are the most extensively studied phytochemicals for their antioxidant functions as well as potential preventive medicinal benefits such as maintaining inflammation balance (diosgenin), reducing the risk of certain cancers (quercetin, rutin, allicin) [8], promoting and maintaining cardiovascular, anti-diabetic (naringenin) [9] as well as neurocognitive, eye, and bone health in humans. Below is general classification of phytochemical categories, their medicinal uses. (Fig. 3)

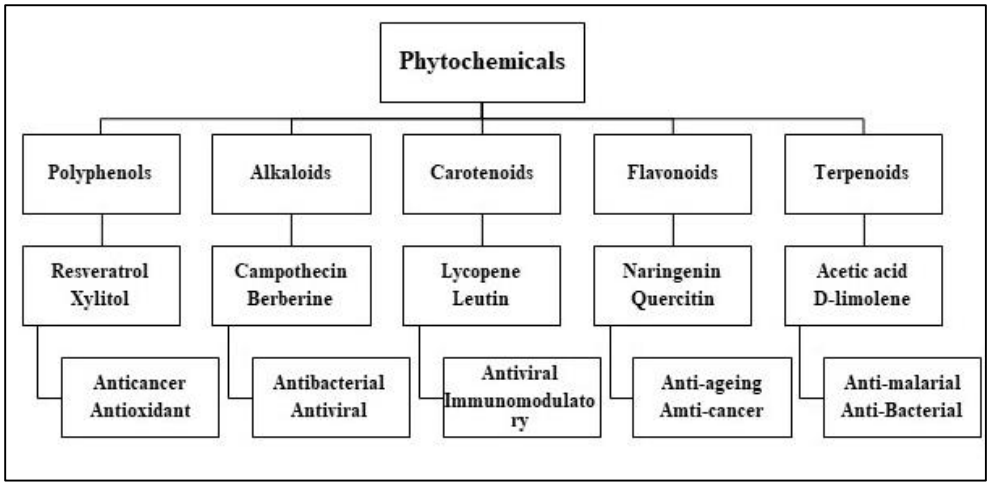


Figure 3: Classification of phytochemicals as nutraceuticals

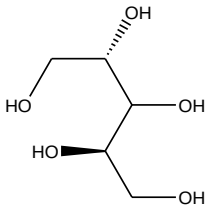
PHYTOCHEMICALS AS NUTRACEUTICALS

The purpose of this study is to examine the comprehensive profiles of phytochemicals that are used as a Nutraceuticals. Therefore, it was decided to study and collect information of different phytochemicals that are used as nutraceuticals with respect to their name, source, common name, geographical source, chemical structure, CAS number, mechanism of action, indications, medicinal uses, their marketed product brands, *etc*.

1 Xylitol [10-13]

Xylitol is a natural sugar alcohol that can be found in a variety of fruits and vegetables. It has a sweet flavour and is frequently substituted for sugar to be used as a sugar alternative in products such as pills, nutritional dietary supplements, confectionaries, toothpastes and chewing gums. However, it isn't always a common household sweetener.

Biological source: Many fruits and vegetables naturally contain xylitol, naturally obtained from birch bark (Family: Betulaceae*)* and corn cob (Family: Poaceae.)

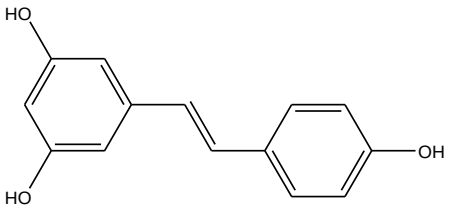
Geographical sources	Trees are found in high altitude areas in India, like Arunachal Pradesh, Darjeeling, Himachal Pradesh, Jammu-Kashmir, Sikkim and Uttaranchal as well as internationally in Russia, Finland and Sweden.
Part of plant	Bark, fruit.
Chemical structure	
Molecular formula	$C_5H_{12}O_5$
IUPAC Name	*(2R,3R,4S)-Pentane-1,2,3,4,5-pentol*
CAS No.	87-99-0
Mechanism of action	After accumulating intracellularly in the microbe, xylitol functions by preventing the growth of the germs found in plaque and saliva.

Uses	Stimulates the immune system, digestion, lipid and bone metabolism. Helps in glycaemic and obesity control. Anticancer. Prevent tooth decay.
Marketed products	Organic Xylitol, Nature's Sweetener, 16 oz (454 g) (by Zint) Dry Mouth Moisturizing Gum with Xylitol (by Act) Happydent White, Xylitol Sugar free, Chewing Gum (by Perfetti Van Melle India Pvt. ltd.)

2. RESVERATROL [14-16]

Resveratrol belongs to the polyphenol type of phytochemicals. They're considered to work as antioxidants, protecting the body from damage that can increase the risk of cancer and heart disease.

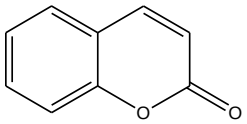
Biological source: Resveratrol is a natural polyphenol found in plants such as grapes (*Vitis vinifera*), cranberry (*Vaccinium macrocarpon*), and peanut (*Arachis hypogaea*), family Vitaceae.It may be found in the skin of red grapes, as well as peanuts, red wine, berries, and other foods and berries.

Geographical sources	N.E India, USA, Canada, Chile, Spain, Ukraine, France.
Part of plant	Seeds, fruits.
Chemical structure	
Molecular formula	$C_{14}H_{12}O_3$
IUPAC Name	*5-[(E)-2-(4-hydroxyphenyl)ethenyl]benzene-1,3-diol*
CAS No.	501-36-0
Mechanism of action	Resveratrol is a histone deacetylase inhibitor, which inhibits cancer cell proliferation by triggering cell cycle arrest, apoptosis, and mitotic cell death.
Uses	Antioxidant. Anticancer. Anti-diabetic. Helps in Neurodegenerative Diseases.
Marketed products	Resveratrol Grapeseed Ext Red Wine Ext - 60 Veg caps (by Zenith Nutrition) Now Foods, Resveratrol, 200 mg, 120 Veg Capsules (by Now Foods) Natural Resveratrol-255mg, 60 capsule Rejusure resveratrol & ferulic acid facial oil- 30ml (by Rejusure)

3. COUMARIN [17-20]

Coumarin sare naturally occurring volatile phytochemicals that may be found in a variety of plants. Coumarins possess anti-oxidant, analgesic, anti-inflammatory, and antimutagenic properties, according to studies

Biological source: They are found in *Cinnamomum* which is a genus of the family *lauraceae*. It is also found in sweet clover (Family: Fabaceae), lavender oil, woodruff (*Galium odoratum*, Family:Rubiaceae), and Tonka beans (*Dipteryx odorata,* Family: Fabaceae).

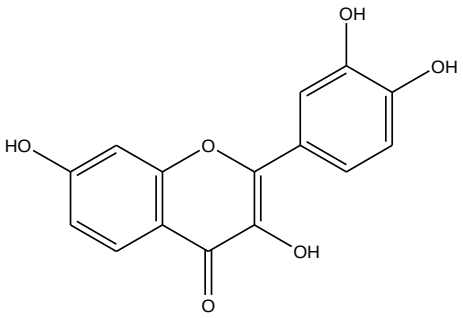
Geographical sources	Sri Lanka, the neighbouring Malabar Coast of India and Myanmar (Burma) and is also cultivated in South America and the West Indies.
Part of plant	Fruits, flowers, roots, seeds, leaves, and stems.
Chemical structure	
Molecular formula	$C_9H_6O_2$
IUPAC Name	2H-1-Benzopyran-2-one
CAS NO.	91-64-5
Mechanism of action	Coumarin method of action is based on the competitive antagonism of vitamin K, which prevents the synthesis of prothrombin and so inhibits coagulation in the body.
Uses	Anticoagulant. Anti-inflammatory. Anticancer. Anti-diabetic**.**
Marketed products	Tendocel capsules (by D.R. Johns Lab Pharma) Dipodem Tablet (by Meridian Enterprises Pvt Ltd, India) Lympedim 200mg Tab (by Pharm Products Pvt Ltd, India)

4. FISETIN [21-29]

Fisetin has shown great promise as a useful natural anti-cancer agent and has been evaluated for its potential inhibitory role against cancer in several *in-vitro* and *in-vivo* studies. The AKT/m-TORpathway is known to play a central role in various cellular processes that contribute to the malignant phenotype. Accordingly, inhibition of this signalling cascade has been a focus of recent therapeutic studies**.**

Biological source: Fisetin is found abundantly in vegetables, fruits, teas and Ancardiaceae plants (*Rhus succedanea*) ranging from 0.1 to 539 μg/g concentrations.

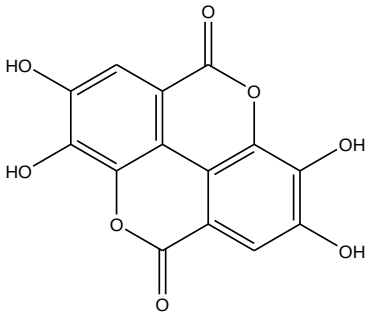
Geographical sources	China, U.S.A., Mexico and Egypt.

Part of plant	Fruits and vegetables.
Chemical structure	
CAS no.	528-48-3
IUPAC Name	3, 3′, 4′, 7-Tetrahydroxyflavone.
Molecular formula	$C_{15}H_{10}O_6$
Mechanism of action	Fisetin altered the expression of cyclooxygenase 2 (COX2) thereby suppressed the secretion of prostaglandin E2 ultimately resulting in the inhibition of epidermal growth factor receptor (EGFR) and NF-κB in human colon cancer cells HT29.
Uses	Anticancer. Antioxidant. Neuroprotection. Anticonvulsant. Antipsychotic.
Marketed Product	Fisetin with Novusetin, 100 mg, 30 Veggie Caps (by Doctor's Best) Life Extension, Bio- Fisetin, 30 Vegetarian Capsules (by iHerb) Fisetin Supplement with Novusetin&Bacognize, 125mg of Fisetin Per Capsule – Fisetin Complex with Bacognize - 30 Capsules (by sunergetic products)

5. ELLAGIC ACID [30-32]

Phenolic phytochemicals such as ellagic acid are important components of fruits and vegetables and are partly responsible for their beneficial health effects against oxidation-linked chronic diseases such as cancer and cardiovascular diseases. It is believed that these phytochemicals function either by countering the negative effects of oxidative stress by directly acting as an antioxidant or by activating/inducing cellular antioxidant enzyme systems. These models are limited in explaining the more comprehensive antioxidant-related functions of phytochemicals in maintaining specific cellular homeostasis which contributes to its preventive mode of action and beneficial effects across diverse biological systems and cell types.

Biological source: The actual content of ellagic acid varies from plant to plant, with different concentrations being described depending on the source. Raspberries (Family: Rosaceae) probably contain the highest concentration while cloudberries (*Rubuschamaemorus*), blackberries (*Rubus* sp.), and strawberries (*Fragaria ananassa*, Rosaceae). Seeds, such as pecans and walnuts (*Juglans regia*, Juglandaceae), and beverages such as cognac and oak-aged red wine obtained from grapes (*Vitis vinifera*, Vitaceae) also present relevant levels. Other fruits with high levels of acid are pomegranates (*Punicagranatum*, Lythraceae), persimmons (*Diospyros kaki*,Ebenaceae), peaches (*Prunus persica*, Rosaceae), and plums (*Prunus domestica* and other species and subspecies from the genus *Prunus*, Rosaceae).

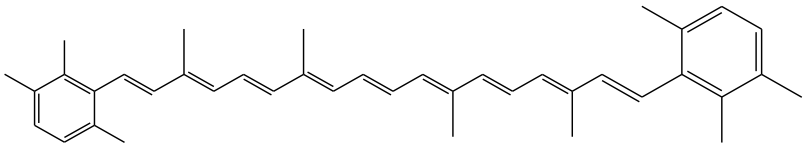
Geographical sources	Ellagic acid is found in oak species mostly of the North American varieties
Part of plant	Seeds, and fruits, especially berries
Chemical structure	
CAS no.	476-66-4
IUPAC Name	2,3,7,8-Tetrahydroxy[1]benzopyrano[5,4,3-*cde*][1]benzopyran-5,10-dione
Molecular formula	$C_{14}H_6O_8$
Mechanism of action	The transcription factor NF-B, has been shown to be a critical regulator of COX-2 expressionproduction of COX-2 on mRNA mainly through the inhibition of ROS production, which in turn inhibits NF-kB, activation. In their study, COX-2 on mRNA expression was also blocked by meloxicam ellagic acid may inhibit carrageenan-induced acute inflammation by blocking the COX-2 receptor, as is the case with both diclofenac and meloxicam in parallel, prostaglandin E2 (a metabolite of COX-2) is considered to be one of the strongest mediators in the inflammatory response.
Uses	Antioxidant. Antibacterial. Antiviral. Anti-diabetic. Gastroprotective. Antihyperlipidemic. Antidepressant.
Marketed Product	Pomegranate (Ellagic Acid) Extract capsules (by Fortune Health Care) Trexgenics Pomegranate (Bioactive 40% Ellagic acid) Seed Extract 500 mg Antioxidant, Skin Care, Blood circulation, Cardiovascular Health Support (60 Vcaps) (by Trexgenics)

6. A- CAROTENOID[33-35]

Fat-soluble plant pigments the carotenoids, are extensively studied micronutrient phytochemicals for their potential health benefits. It is noteworthy that specific carotenoids may be responsible for different protective effects against certain diseases.

Biological source- orange and yellow vegetables like carrots and winter squash are rich sources of α- carotene and β-carotene. Spinach is also a rich source of β-carotene, although the chlorophyll in spinach leaves hides the yellow-orange pigment.

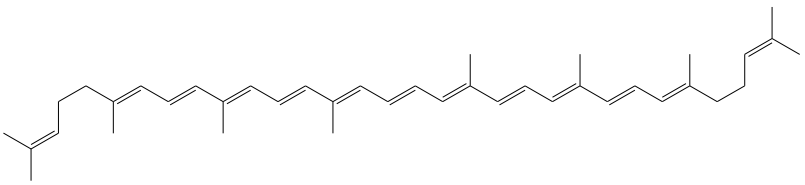
Geographical sources	Ireland and the UK
Part of plant	roots, stems, leaves, flowers, and fruit

Chemical structure	
Molecular formula	$C_{40}H_{56}$
IUPAC Name	1,3,3-Trimethyl-2-[(1E,3E,5E,7E,9E,11E,13E,15E,17E)-3,7,12,16-tetramethyl-18-(2,6,6-trimethylcyclohexen-1-yl)octadeca-1,3,5,7,9,11,13,15,17-nonaenyl] cyclohexene
CAS No.	36-88-4
Mechanism of action	Cancer chemoprevention by dietary carotenoids involves several mechanisms, including effects on gap junctional intercellular communication, growth factor signalling, cell cycle progression, differentiation-related proteins, retinoid-like receptors, antioxidant response element, nuclear receptors, AP-1 transcriptional complex, the Wnt/β-catenin pathway and inflammatory cytokines.
Uses	Anti-inflammatory effects help to protect cells from damage. Anti-carcinogenic.
Marketed products	Caroten all, Mixed Carotenoids Complex (by Jarrow formulas) Natural Beta Carotene, 7,500 mcg (25,000 IU), 90 Softgels (by Now foods) GNC Beta Carotene 6 mg - 100 Softgel Capsules (by Guardian Healthcare Services Pvt. Ltd.)

7. LYCOPENE [36-38]

Lycopene is a carotenoid that gives red colour to plants and fruits. Lycopene serves as an antioxidant due to its chemical structure, which is the basis for its health-promoting qualities. Lycopene appears to be a universal therapy for a variety of ailments. Lycopene's nutraceutical impact has been documented for many years in cancer patients, infertility patients, metabolic syndrome patients, and liver disease patients.

Biological source: Fruits and vegetables that are high in lycopene include autumn olive (*Elaeagnus umbellate*, Elaeagnaceae), tomatoes (*Solanum lycopersicum*, Solanaceae*)*, watermelon (*Citrullus lanatus*, Cucurbitaceae). Tomatoes are exceptionally high in this compound, accounting for 80-90 percent of all carotenoid-containing foods. Marine haloarchaea belonging to the Haloferacaceae family may also synthesize lycopene.

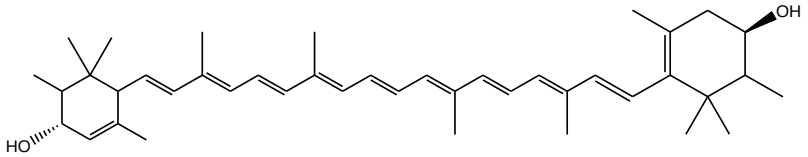
Geographical sources	China, USA, Italy, Turkey, India and Egypt
Part of plant	Fruits.
Chemical structure	
Molecular formula	C40H56
IUPAC Name	(6E,8E,10E,12E,14E,16E,18E,20E,22E,24E,26E)-2,6,10,14,19,23,27,31-Octamethyldotriaconta-2,6,8,10,12,14,16,18,20,22,24,26,30-tridecaene

CAS No.	502-65-8
Mechanism of action[37]	Lycopene is a powerful antioxidant, and this is clearly one of the most significant mechanisms of lycopene activity. Lycopene can do this by trapping singlet oxygen and reducing mutagenesis.
Uses	Lycopene is a potent antioxidant that has a long list of health benefits, including sun protection, improved heart health, and a reduced risk of certain cancers, to treat osteoporosis, Down syndrome and Alzheimer's disease.
Marketed products	Lycogem forte capsule (by Aureate healthcare) HealthVit Lycopene 10000 mcg Capsule 60's (by Health Vit) 21st Century, Lycopene, 25 mg, 60 Tablets (by iHerb) Lycopene 30mg - 60 Veg. Capsules (by HealthyHey Foods, India)

8. LUTEIN [39-41]

Lutein is one of the key nutrients for maintaining crucial human physiological functioning and is a carotenoid with reported anti-inflammatory properties. Human body cannot produce lutein and hence it must be obtained from dietary sources.

Biological source: It is found in green leafy vegetables e.g., kale *(Brassica oleracea*, Brassicaceae*)*, spinach (*Spinacia oleracea,* Amaranthaceae), broccoli, and lettuce and egg yolks.

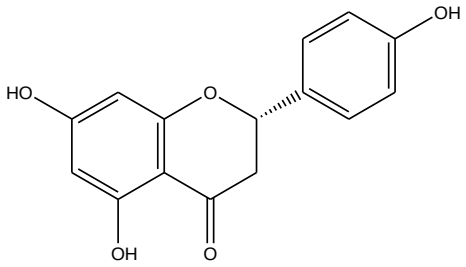
Geographical sources	The majorly it is found in India (Karnataka, Punjab, Uttar Pradesh, Tamil Nadu, and Andhra Pradesh), Nepal.
Part of plant	Leaves.
Chemical structure	
Molecular formula	C40H56O2
IUPAC Name	β, ε-Carotene-3,3′-diol
CAS No.	127-40-2
Mechanism of action	As Lutein is antioxidant it scavenges reactive oxygen species directly, preventing them from causing damage to DNA and protein molecules.
Uses	Suppress inflammation. Defend against free radicals and oxidative stress. Improve your visual contrast sensitivity. Improves cardiac health.
Marketed products	Eye: **Relief tablets (by** Naturamore) Eye Shield with Lute-gen Plus, 30 capsules (by TrueBasics)

	Lutein 12 mg with Zeaxanthin - Support Eye Health - 60 Veg. Capsules (by HealthyHey Foods, India) BlueEyeProtect Natural Lutein and Zeaxanthin - Protection from Blue Light and Eye Health - 100mg (60 Veg. Capsules)

9. NARINGENIN [42-48]

Naringenin is naturally occurring flavonoid which has a wide range of biological effects on human health, including lowering lipid peroxidation biomarkers and protein carbonylation, increasing antioxidant defences, modulating immune system activityand anti-inflammatory properties.

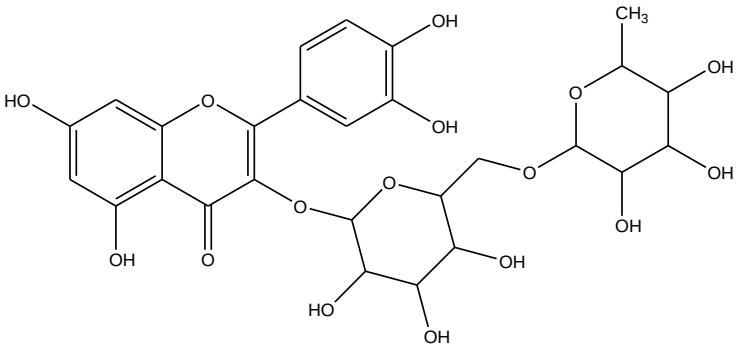
Biological source: Naringenin has been discovered in a wide range of plants and fruitsincluding grapefruit (*Citrus paradisi*) water mint (*Mentha aquatica*- Lamiaceae) as well as in beans, flavanone family. It is also present in several edible fruits such as citrus and tomatoes.

Geographical sources	India (Assam, Kerala, Bangalore and Tripura), Florida, Arizona, California and Texas.
Part of plant	Fruit
Chemical structure	
Molecular formula	$C_{15}H_{12}O_5$
IUPAC Name	(2S)-4′,5,7-Trihydroxyflavan-4-one
CAS No.	480-41-1
Mechanism of action	Naringenin exhibited anti-inflammatory properties via inhibiting tumour necrosis factor (TNF). This decreased the synthesis of inflammatory mediators (IL-6, IL-1, TNF) and nitric oxide by blocking COX-2.
Uses	Anti-obesity. Anti-HCV Activity. Anti-inflammatory. Anti-diabetic.
Marketed products	Swanson Naringin 500 Milligrams 60 Capsules (by Swanson) NutriBiotic, Grapefruit Seed Extract, 250 mg, 60 Capsules (by NutriBiotic). Vital Herbs Naringin Powder (by Vital Herb)

10. RUTIN [49-53]

Rutin is a kind of plant pigment with anti-inflammatory and antioxidant properties and is present in a variety of fruits and vegetables. It might also provide some protection against cancer and other disorders.

Biological source:It is found in Buckwheat *(Fagopyrum esculentum,* Polygonaceae)Japanese pagoda tree (*Styphnolobiumjaponicum,*Fabaceae).Rutin may be found in buckwheat, Japanese pagoda trees, and Eucalyptus.

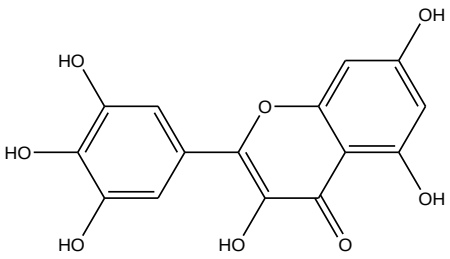
Geographical sources	India (Jammu and Kashmir, Uttarakhand, Himachal Pradesh), China.
Part of plant	Fruits, leaves, flowers.
Chemical structure	
Molecular formula	$C_{27}H_{30}O_{16}$
IUPAC Name	3′,4′,5,7-Tetrahydroxy-3-[α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranosyloxy] flavone
CAS NO.	153-18-4
Mechanism of action	The aglycone of rutin exerts a protective effect by binding free radicals during reperfusion injury of ischemic tissues. Rutin can act as an anti-inflammatory agent because of the binding of free radicals that prevents the induction of inflammatory cytokine transcription factors.
Uses	Antioxidant to treat osteoarthritis. Anti-inflammatory. Anticancer. Antidiabetic. Anti-bacterial. Anti-fungal. Neuroprotective property.
Marketed products	Rutin powder (by Himrishi Herbals) Rutin, 450 mg, 100 Veg Capsules (by Now Foods) SolgarRutin 500 mg - 100 Tablets (by Solgar)

11. MYRICETIN [54-56]

Myricetin is a flavonoid obtained from plants that is widely known for its nutraceutical properties. It's a vital element in a variety of foods and beverages. It exhibits multiple central nervous system-related functions, and numerous studies have shown that the molecule may be useful in the prevention of disorders like Parkinson's and Alzheimer's.

Biological source: Myricetin is found in a variety of foods, including blueberry leaves, rose petals (*Rosa damascena*) Rosaceae, chia seeds, pistachio extract (*Pistacia lentiscus*) Anacardeceae, grape seed extract, cruciferous vegetables, garlic, and black tea (*Camellia sinensis*) Theaceae.

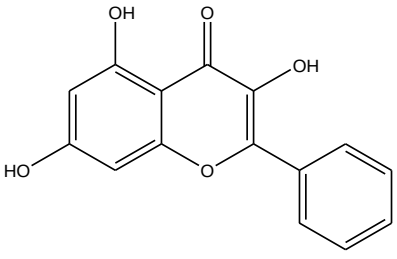
Geographical sources	Bulgaria, India, Southern France and Turkey to Iraq.
Part of plant	Seeds, leaves, flower.

Chemical structure	
Molecular formula	C15H10O8
IUPAC Name	3,3′,4′,5,5′,7-Hexahydroxyflavone
CAS NO.	529-44-2
Mechanism of action	Myricetin inhibits UVB-induced keratinocyte mortality and lowers malondialdehyde levels, which rise after UVB exposure, according to a mechanism-based study. Myricetin's ability to decrease UVB-induced H_2O_2 production in keratinocytes can be attributed to its anti-oxidant capability, which enhances free radical scavenging.
Uses	Antidiabetic. Anti-oxidant. Anti-cancer. Anti-inflammatory effects. Activity against CNS Disorders.
Marketed products	DHM1000 Dihydromyricetin (DHM) Tablets (by Double woods) Natural Dihydromyricetin 400mg, 120 Capsules (by Naturebell) Dihydromyricetin as Hovenia Dulcis Extract 400 mg-120 capsules (by Nusapure)

12. GALANGIN [57-61]

Galangin a flavonolpossessesas a variety of biological activities at non-toxic concentrations in organisms.

Biological source: A flavonoid derived from medicinal herbs including *Alpiniaofficinarum*, *Alnus pendula* and *Plantago major*, a resinous substance from honeybees.

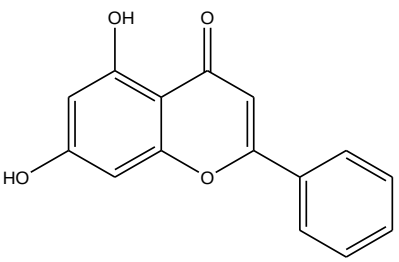
Geographical sources	The semi-smooth skin is light brown to tan, firm, hard, and is covered in darker brown rings.
Part of plant	Leaves, roots, and rhizomes.
Chemical structure	
CAS no.	548-83-4

IUPAC Name	(4*H*-1-benzopyran-4-one-3,5,7-trihydroxy-2-phenyl and 3,5,7-trihydroxyflavone
Molecular formula	$C_{15}H_{10}O_5$
Mechanism of action	The predominant anti-Hepatocellular carcinoma (HCC) effects are: anti-genotoxic activity against environmental and dietary carcinogens; anti-proliferative effects through the reversal of the Warburg effect in HCC; cell cycle arrest in the G0/G1 phase; induction of apoptosis through the stimulation of reactive oxygen species (ROS), endoplasmic reticulum (ER) stress, and the mitochondrial-dependent apoptosis pathway; induction of autophagy; inhibition of angiogenesis, metastasis, and multidrug resistance (MDR); and synergistic effects with other chemotherapeutic drugs.
Uses	Anti-genotoxic activity. Mouthwashes. Antiviral. Anti-proliferative activities.
Marketed products	Premium International Seeds &Berrie (by Happilo) Galangal, Galangin, 90 VCaps, Green Organic Supplements (by Green Organic Supplements) Hildegard's Original Galangal with Fennel: Natural High Blood Pressure Reducers. 60 Capsules (by Hildegard Von Bingen)

13. CHRYSIN [62-68]

Chrysin belongs to the group of natural polyphenols and shows a wide range of biological activities, including the prevention of oxidative stress, inflammation, neurodegeneration and carcinogenesis. Being a part of the human diet, chrysin is considered to be a promising compound to be used in the prevention of many diseases, including cancers, diabetes and neurodegenerative diseases such as Alzheimer's or Parkinson's. Nevertheless, due to the low solubility of chrysin in water and under physiological conditions, its bioavailability is low.

Biological source: Chrysin (5,7-dihydroxyflavone) belongs to natural polyphenols, which are found among others in honey propolis and various medicinal plants and fruits such as bitter melon (*Momordica charantia*) or the wild Himalayan pear (*Pyrus pashia*).

Geographical sources	Asia, Africa.
Part of plant	Fruitsandflowers.
Chemical structure	

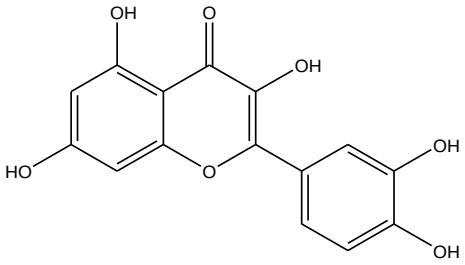
CAS no.	480-40-0
IUPAC Name	5,7-Dihydroxy-2-phenyl-4*H*-chromen4-oneand5,7-dihydroxyflavone.
Molecular formula	$C_{15}H_{10}O_4$
Mechanism of action[66]	Chrysin plays significant role to reduce inflammation of immune system to reduce damage produce through macrophages, neutrophils and other immune-inflammatory responses.
Uses	Anticancer. Anti-inflammatory. Antidiabetic. Neuroprotective. Cardiovascular health. Antiasthmatic. Antiviral.
Marketed Product	Chrysin 500, 30 Vegan Capsules (by MRM Nutrition) Chrysin, 500 mg, 30 Capsules (by Jarrow Formulas) Naturally Complete Chrysin for Men and Women 2 oz. Pump Bottle (by Radiant Laboratories)

14. LUTEOLIN [69-78]

Luteolin is a flavonoid which is part of our daily nutrition in relatively low amounts (less than 1 mg/day). Nevertheless, some epidemiological studies suggest an inverse correlation between Luteolin intake and the risk of some cancer types. Luteolin displays specific anti-inflammatory and anti-carcinogenic effects, which can only partly be explained by its anti-oxidant and free radical scavenging capacities.

Biological source-Luteolin is one of the most common flavonoids present in edible plants. For example, it has been found in carrots (*Daucus carota*), peppers (*Capsicum annuum*), celery (*Apiumgraveolens*), olive oil (*Olea europaea*), peppermint (*Mentha piperita*), thyme (*Thymus vulgaris*), rosemary (*Rosmarinus officinalis*), oregano (*Origanum vulgare*), lettuce (*Lactuca sativa*), Perilla leaves (*Perilla frutescens*), pomegranate (*Punicagranatum*), artichoke (*Cynara scolymus*), chocolate (*Theobroma cacao*), rooibos tea (*Aspalathuslinearis*), buckwheat sprouts (*Fagopyrum esculentum*), turnip (*Brassica napus*), capers (*Capparis spinosa*) and cucumber (*Cucumis sativus*). Luteolin has also been identified in lemon, beets, Brussels sprouts, cabbage, cauliflower, chives, fennel, hornwort, horseradish, kohlrabi, parsley, spinach and green tea.Plants with high luteolin content have been used ethnopharmacologically to treat inflammation-related symptoms. Both isolated luteolin and extracts from luteolin-rich plants have been studied using various models and exhibited anti-inflammatory activity.

Geographical sources	South and South-eastern Asia
Part of plant	Fruits

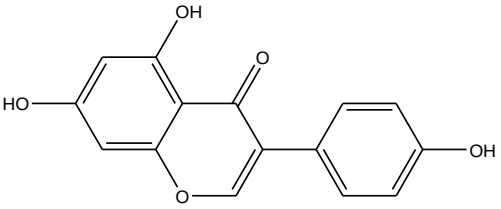
Chemical structure	
CAS no.	491-70-3
IUPAC Name	2-(3,4-Dihydroxyphenyl)-3,5,7-trihydroxy-4H-1-benzopyran-4-one.
Molecular formula	$C_{15}H_{10}O_6$.
Mechanism of action	Mechanism of luteolin (Lut)-triggered TNF-α-induced cancer cell apoptosis. Free p-NF-κBtranslocates to the nucleus to mediate the transcriptional activation of genes. Luteolin can suppress the activity of NF-κB translocation, activating the TNF-α-induced apoptosis pathway. The generation of ROS caused by treatment with luteolin plays a marginal role in suppressing NF-κB, further enforcing JNK activation. ROS activate the AMPK signaling pathway, which interacts with the NF-κB pathway, thereby inhibiting NF-κB DNA-binding activity.
Uses	Anti-oxidant. Tumour cell proliferation. Anti-cancer. Anti-inflammatory. Antiallergic.
Marketed Product	Luteolin Complex capsules,30 veggie capsules(by Swanson) Brain Elevate capsules100mg (by Now foods) Luteolin 100-100mg, 60 Servings (by Senolyfe)

15. GENISTEIN [79-85]

Genistein is a soy derived isoflavanoid compound with multitude health benefits. This compound is found to be a potent agent in both prophylaxis and treatment of cancer and various other chronic diseases. Ranging from its antioxidant activity to its effect on various cancer types, genistein has been a compound of interest in a number of studies carried out so far.

Biological source: Genistein aglycone is an isoflavone found at low concentrations in soybeans but at high concentrations in certain soy-derived food. In contrast, genistein, the glucoside form of the aglycone genistein, is much more abundant in the unprocessed soybean.

Geographical sources	Asian countries, Western countries.
Part of plant	Seeds.

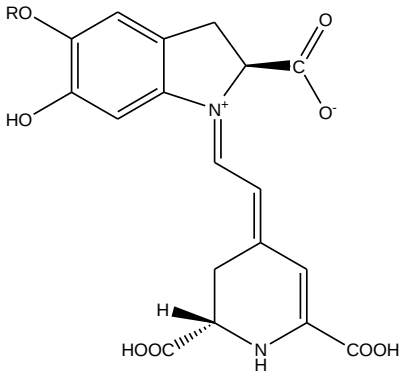
Chemical structure	
CAS no.	446-72-0
IUPAC Name	5,7-Dihydroxy-3-(4-hydroxyphenyl).
Molecular formula	$C_{15}H_{10}O_5$
Mechanism of action	Genistein acts as an inhibitor of the tyrosine-specific protein kinases of the epidermal growth factor (EGF) receptor and also inhibited the activity of topoisomerases. Genistein potentially inhibits proliferation of various cancer cells and induces cell differentiation and apoptosis. It also exhibits antiangiogenic and antioxidant activities that are important for cancer prevention. One of the most important advantages of genistein is its low toxicity in comparison with many current chemotherapeutic drugs.
Uses	Antioxidant. Maintain blood pressure. Anti-browning.
Marketed Product	Full Spectrum Soy 1000 tablets (by Planetary Herbals) Soy Isoflavones, 10 mg (by Natrol) Genistein Soy Complex 1000 Mg, 120 Tablets (by, Source Naturals)

16. BETACYANIN [86-89]

Betacyanin is a pigment that can be used as a natural pigment for food and as an alternative to synthetic dyes because it has an attractive colour. Other than that, it also dissolves easily in water, and has high antioxidant activity so it is safer for the body when consumed.

Biological source: Betacyanin is found in plants such as in red dragon fruit (*Hylocereuspolyrhiyus*), beets (*Beta vulgaris*), cactus fruit (*Opuntia elatior*), and in Inflorescence *Celosia*.

Geographical sources	Europe and parts of Asia and America.
Part of plant	Fruit, flowers.

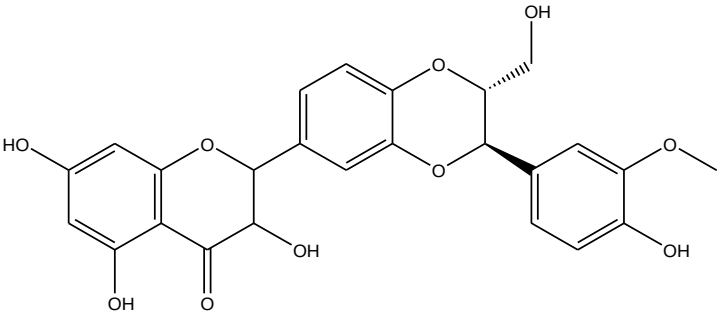
Chemical structure	
CAS no.	7659-95-2
IUPAC Name	3,4,5-Trihydroxy-6-(hydroxymethyloxan-2-yl]oxy-2,3-dihydroindol-1-ium-2-carboxylate
Molecular formula	$C_{24}H_{26}N_2O_{13}$
Mechanism of action	The antioxidant property of betanin and betanidin is due to inhibition of lipid peroxidation. Betalains interact with peroxynitrate*in vitro*. Peroxynitrate which causes the most potent nitrosylative oxidant damage to DNA. When incubated with betalain reduces the damage having potency more than vitamin C (VC) and almost equal the potency to blueberry anthocyanins. In this process carboxyl group of the cyclo-dopa group becomes nitrosylated and de-attaching itself from the betalamic acid. Preclinical studies show that betalain in a dose of 300–600 mg/kg was most potent inhibitor of lipid peroxidation showing high antioxidant activity by its electron donating capacity and its ability to defuse the highly reactive radical targeting the cell membranes.
Uses	Urine bleeding. Dysentery. Diarrhoea, blurred vision. Urinary tract infection. Inflammation.
Marketed Product	Beet root 500 mg (by Nature's way) Beet root Extract 1 kg (by Nature's way) Bountiful Beets, Whole Food Beet Extract, Cherry Flavor, 10.6 oz (300 g) (by Country Farms)

17. SILYMARIN [90-93]

Silymarin from the milk thistle herb (*Silybum marianum*) is used viral hepatitis,metabolic syndrome, fatty liver disease hypertension, hepatitis B and hepatitis silymarin, a mixture of flavonolignans from medicinal plant *Silybum marianum*, is used in supportive treatment of liver diseases of different etiology due to its hepatoprotective activity, which is considered to involve antioxidative and the membrane stabilizing facts. The liver plays an important role in regulation of metabolism of plasma lipoproteins, and liver injury is often reflected as a secondary dyslipoproteinacmia, which may lead to the development of atherosclerosis, particularly when associated with hypercholesterolaemia.

Biological source: *S. marianum* is an annual/biennial herbaceous medicinal plant of the largest and widespread family Asteraceae (about 23,000 species and 1535 genera are identified), with the English name of milk thistle or Mary's thistle.

Geographical sources	Europe, Africa, China, India and Australia.

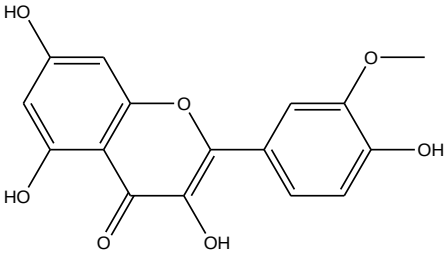
Part of plant	Fruits.
Chemical structure	
CAS no.	65666-07-1
IUPAC Name	3,5,7-Trihydroxy- 2-[(2R,3R)-3-(4-hydroxy-3-methoxyphenyl)-2-(hydroxymethyl) -2,3-dihydrobenzo[b] [1,4] dioxin-6-yl] chroman-4-one
Molecular formula	$C_{25}H_{22}O_{10}$
Mechanism of action	The mechanisms of action of silymarin are not completely understood, but a variety of mechanisms have been proposed. Silymarin is reported to have antioxidant properties, by increasing superoxide dismutase activity in erythrocytes and lymphocytes Counteraction of the CYP2E1 stimulation by chronic alcohol consumption could partly explain the beneficial effects of silymarin seen in alcoholic liver disease, but there is no evidence of P450 2E1 involvement by silymarin.
Uses	Viral hepatitis. Metabolic syndrome. Faty liver disease. Hypertension. hepatitis B.
Marketed Product	Milk Thistle Extract (by Prorganic) High Strength Milk Thistle with 35000 Mg (by Now foods) Milk Thistle 25:1 (Silymarin Marianum) - 600mg Extract 120 Veg. Capsules (by HealthyHey Nutrition) Milk Thistle Extract Silymarin 800Mg/Serve 120 Veg Capsules (by Himalayan Organics)

18. ISORHAMNETIN [94-100]

Isorhamnetin is one of the most important active ingredients in the fruits of *Hippophae rhamnoides* and the leaves of *Ginkgo biloba* L., which possesses extensive pharmacological activities.

Biological source: It is found *in P. rhoeas* L. leaves berries, onion, broccoli, kale, cabbage, buckwheat, tea, and red wine.

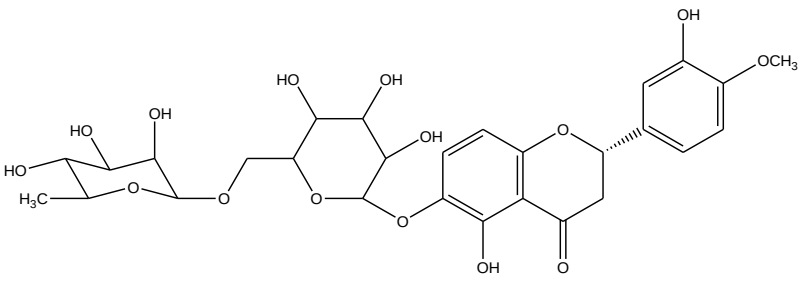
Geographical sources	European *countries*
Part of plant	Fruits, leaves.

Chemical structure	
Molecular formula	$C_{16}H_{12}O_7$
IUPAC Name	3,5,7-Trihydroxy-2-(4-hydroxy-3-methoxyphenyl) chromen-4-one
CAS No.	480-19-3
Mechanism of action	The pharmacological action and mechanism of Isorhamnetin is currently a major research area. It has been reported that Isorhamnetin is cytotoxic to H9C2 cardiomyocytes and mouse primary hepatocytes and induces DNA damage in HepG2 cells.
Uses	Antioxidant Anticancer Antimicrobial Antiviral
Marketed products	Life Extension 30 Vegetarian Capsules (by Life)

19. HESPERIDIN [101-108]

Hesperidin, a flavanone glycoside biphenolic compound is abundant in citrus fruits such as oranges and lemons, having an ability to cross the blood–brain barrier.

Biological source: It is most commonly found in citrus fruits such as oranges, limes, and lemons, contain the highest levels of hesperidin.

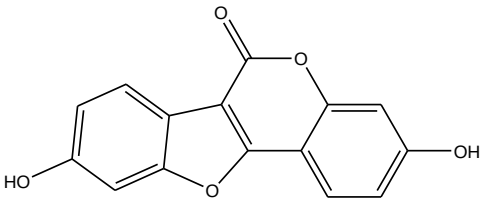
Geographical sources	Asian countries
Part of plant	Fruits.
Chemical structure	
Molecular formula	$C_{28}H_{34}O_{15}$.
IUPAC Name	3, 5, 7-Trihydroxyflavanone-7-rhamnoglucoside.

CAS No.	520-26-3
Mechanism of action	Hesperidin interacts with numerous recognized cellular targets and inhibits cancer cell proliferation by inducing apoptosis and cell cycle arrest.
Uses	Antioxidant. Anti-inflammatory. Anti-carcinogenic. Antioxidant. Anticancer.
Marketed products	Citrus bioflavonoids plus hesperidin 650 mg-90 capsules (by Natural factors) HY-C -250 tablets (by Solgar) Hesperidin Methyl Chalcone 500 mg, 60 Count(by Doctor's Best) Diosmin 450mg Hesperidin 50 mg, Horse Chestnut Seed, Butchers Broom Extract - Natural citrus bioflavonoids - 30 vegetarian tablets (by Variclose Store)

20. COUMESTROL [109-113]

Coumestrol is a phytoestrogen useful in the treatment of carcinogenesis, neurological problems, and autoimmune illnesses.

Biological source: Found naturally in Soybeans (*Glycine max*, Fabaceae) alfalfa sprouts (*Medicago sativa*, Fabaceae), sunflower seeds (*Helianthus annuus*) and legumes all contain coumestrol, a natural organic substance that belongs to the class of phytochemicals known as coumestans. It is also found naturally in soybeans, legumes, brussel, sprouts and spinach.

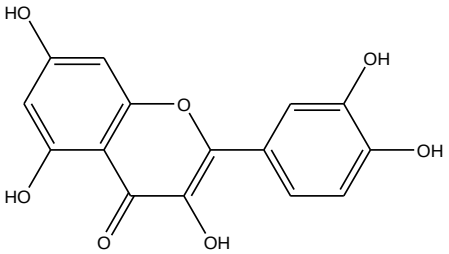
Geographical sources	India, Ukraine, Argentina and Russia.
Part of plant	Seeds, flowers and leaves.
Chemical structure	
Molecular formula	C15H8O5
IUPAC Name	3,9-Dihydroxy-6H- [1] benzofuro[3,2-c][1] benzopyran-6-one
CAS NO.	479-13-0
Mechanism of action	There is no clear molecular mechanism for coumestrol's anticancer action in breast carcinoma. As a result of the investigation of coumestrol's copper-dependent cytotoxic effect in human breast cancer MCF-7 cells. The copper chelator neocuproine and ROS scavengers prevented coumestrol from inhibiting proliferation and inducing apoptosis in MCF-7 cells. Coumestrol therapy resulted in DNA fragmentation, p53/p21 up regulation, cell cycle arrest in the G1/S phase, mitochondrial membrane depolarization, and activation of caspases 9/3.

Uses	Anti-cancer. Anti-estrogenic. Inhibiting proliferation and inducing apoptosis.
Marketed products	Dyn Naturals Cinnamon Dalchini Chakka (by Dyn Naturals) Cassia oil, 30ml (by Moksha Lifestyle) Alpha Chemika 4-hydroxycoumarin 25gm POWDER (by Alpha Chemika)

21. QUERCETIN [114-117]

Quercetin and its derivatives are naturally occurring phytochemicals with promising bioactive effects. The antidiabetic, anti-inflammatory, antioxidant, antimicrobial, anti-Alzheimer's, antiarthritic, cardiovascular, and wound-healing effects of Quercetin have been extensively investigated, as well as its anticancer activity against different cancer cell lines has been recently reported.

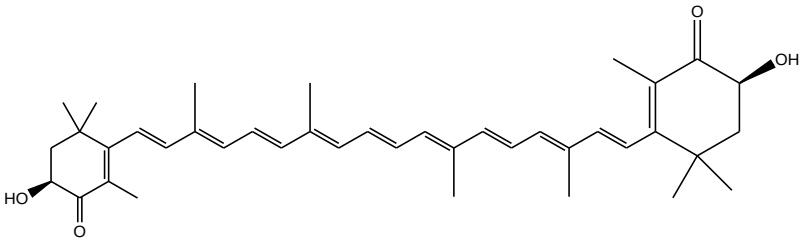
Biological source: It is found in some plant pigment is a potent antioxidant flavonoid and more specifically a flavonol, found mostly in onions, grapes, berries, cherries, broccoli, and citrus fruits.

Geographical sources	Sichuan area of Northern China.
Part of plant	fruits, vegetables, leaves, seeds, and grains; capers, red onions
Chemical structure	
Molecular formula	$C_{15}H_{10}O_7$
IUPAC Name	2-(3,4-Dihydroxyphenyl)-3,5,7-trihydroxychromen-4-one
CAS No.	117-39-5
Mechanism of action[116]	Several studies in-vitro using different cell lines have shown that quercetin inhibits lipopolysaccharide (LPS)-induced tumor necrosis factor α (TNF-α) production in macrophages and LPS-induced IL-8 production in lung A549 cells.
Uses	Help reduce swelling. Kill cancer cells, control blood sugar. Help prevent heart disease.
Marketed products	TurmBright Lozenges (by Kshipra health solution) Quercetin capsules (by NOW Foods) Quercetin 100mg- 60 Veg Capsules (by Biotrex Nutraceuticals)

22. ASTAXANTHIN [118-120]

Astaxanthin is an antioxidant, which can improve the way the immune system functions. People use astaxanthin for many purposes, including Alzheimer disease, athletic performance, aging skin, muscle soreness from exercise, and many others.

Biological source: Astaxanthin is found in algae, yeast, salmon, trout, krill, shrimp and crayfish. Astaxanthin from various microorganism sources include commercial astaxanthin which are mainly from Phaffia yeast, haematococcus and through chemical synthesis.

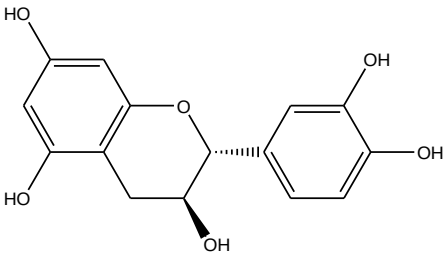
Geographical sources	Indonesia, Asia.
Part of plant	Fruits
Chemical structure	
Molecular formula	$C_{40}H_{52}O_4$
IUPAC Name	(6S)-6-Hydroxy-3-[(1E,3E,5E,7E,9E,11E,13E,15E,17E)-18-[(4S)-4-hydroxy-2,6,6-trimethyl-3-oxo-1-cyclohexenyl]-3,7,12,16-tetramethyloctadeca-1,3,5,7,9,11,13,15,17-nonaenyl]-2,4,4-trimethyl-1-cyclohex-2-enone
CAS No.	472-61-7
Mechanism of action	Astaxanthin protects cell membranes against RONS and oxidative damage. Due to its chemical structure, its polar groups overlap the polar regions of the cell membrane, while the central non-polar region of the molecule fits into the inner non-polar region of the membrane.
Uses	Astaxanthin is used in skin homeostasis for its photo protective, antioxidant, and anti-inflammatory effects.
Marketed products	Astaxanthin Collagen All-in-One Gel (by DHC) Astaxanthin 4 mg 60 Capsules (by HealthVit.) Plant Based Astaxanthin Supplements, 60 Veg Capsules (by Health Veda Organics Private Limited) Natural Astaxanthin, Vegan, 30 Softgels-Pack of 2 (by Origins Nutra)

23. CATECHIN [121-124]

It is a flavan-3-ol, a type of secondary metabolite providing antioxidant roles in plants.In cancer and associated illnesses, catechin impacts the molecular pathways involved in angiogenesis, extracellular matrix breakdown, cell death control, and multidrug resistance.

Biological source[122]**:** Catechin is found in a variety of foods, including green tea, red wine, beer, cacao liquor, chocolate, and cocoa, as well as plants, fruits (such as apples, blueberries, and strawberries), green tea, red wine, beer, cacao liquor and chocolate. High catechin content is reported to be present in fresh tea leaves (*Camellia sinensis*) Theaceae.

Geographical sources	In India (Assam, Tripura, Arunachal Pradesh, Himachal Pradesh, Karnataka, Sikkim, Nagaland, Uttarakhand, Manipur, Mizoram, Meghalaya.), USA, China, Egypt and Mexico.
Part of plant	Leaves.

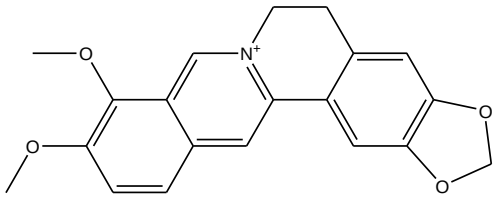
Chemical structure	
Molecular formula	C15H14O6
IUPAC Name	(2R,3S)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol
CAS No.	7295-85-4
Mechanism of action	In vitro, tea catechins are excellent scavengers of reactive oxygen species, and their effects on transcription factors and enzyme activity suggest that they may also act as indirect antioxidants.
Uses	Catechins are used as materials to promote health Anticancer. Antidiabetic. Antimicrobial.
Marketed products	Green Tea Extract 400mg -100 Veg caps (by Now Foods) Reshape Natural Health Supplement Tablets (by Reshape) Natural Potent Green Tea Extract 500 Mg (by Simply Herbal) Nature's Answer, Green Tea Extract-30 ml (by Nature's Answer)

24. BERBERINE [125-135]

Berberine-containing plants have been traditionally used in different parts of the world for the treatment of inflammatory disorders, skin diseases, wound healing, reducing fevers, affections of eyes, treatment of tumours, digestive and respiratory diseases, and microbial pathologies.The phytochemical berberine, a constituent of certain herbs used in traditional Chinese medicine, has long been in use in China as a well-documented therapy for type 2 diabetes.1 2 Mechanistic studies demonstrates that, like metformin, it activates AMP-activated kinase (AMPK); this is thought to be the chief basis of its utility in diabetes.

Biological source: Goldenseal (*Hydrastis canadensis*), Oregon grape (*Berberis aquifolium*), bayberry (*Berveris vulgaris*), coptis (*Coptischinensis*), and tree turmeric (*Berberis aristata*).

Geographical sources	South America and Asia; Europe, Africa and North America.
Part of plant	Roots, rhizomes, stems, and bark.

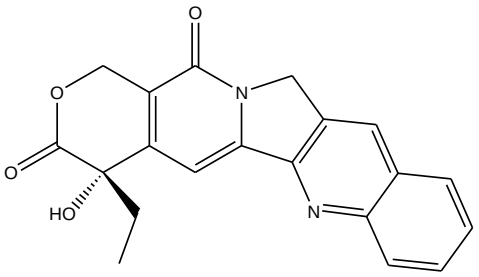
Chemical structure	
CAS no.	2086-83-1
IUPAC Name	5,6-Dihydro-9,10-dimethoxybenzo[*g*]-1,3-benzodioxolo[5,6-a] quinolizinium
Molecular formula	$C_{20}H_{18}NO^{+}_{4}$
Mechanism of action	Berberine shows the anti-inflammatory activities in the intestinal lumen by regulating their transcription and therefore ameliorating pro-inflammatory cytokine-induced intestinal epithelial damage, which is mediated mainly through activation of AMPK and inhibition of transcription factor activator protein 1 (AP1) and NF-κB.
Uses	Urinary disorders. Antimicrobial. Treat diarrhoea. Diabetes. Anti-inflammatory. Hypolipidemic.
Marketed products	Berberine Arista (by Health hey) Berberine 500 mg Veg Capsule Berberine-500 (by Origins Nutra) Good Health Berberine Natural Extracts (500mg X 60 Veg Capsule) (by SushrutAyurved Industries)

25. CAMPTOTHECIN [136-139]

Camptothecin (CPT) is an alkaloid was discovered in the early 60's after a systematic screening of natural products by the National Cancer Instituteand has potent antitumor activity.

Biological source: Camptothecin is an alkaloid first isolated from the stem wood of the tree *Camptotheca acuminata* (Nyssaceae)

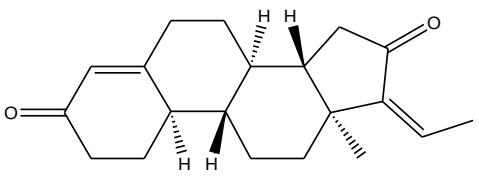
Geographical sources	Madikeri forests of Kodagu (Coorg) district in Karnataka, Southern China.
Part of plant	Stem.

Chemical structure	
Molecular formula	C20H16N2O4
IUPAC Name	(S)-4-ethyl-4-hydroxy-1H-pyrano[3',4':6,7]indolizino[1,2-b] quinoline-3,14-(4H,12H)-dione
CAS No.	7689-03-4
Mechanism pf action	Camptothecin inhibits topoisomerase. It binds to the topoisomerase I and DNA complexes, forming a ternary complex that is stabilised. This hinders re-ligation of DNA.
Uses	**Antitumor.** Anticancer.
Marketed products	Macvestin Total Sachet 10 gm (by Macleods pharmaceuticals ltd) Campto Injection, 2 ml (by RG impex) Campto 40mg Injection 2ml (by Pfizer Limited)

26. GUGGULSTERONE [140-141]

Guggulsterone is the active component of gugulipid. This preparation is derived from the gum resin (guggulu) of the tree *Commiphora mukul*. This gum resin has been used for centuries in Ayurvedic medicine to treat obesity, arthritis, and hyperlipidemia.

Biological source:Guggalsterone is a gum resin obtained by incision of the bark of *Commiphora mukul* (Burseraceae).

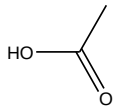
Geographical sources	India.
Part of plant	Bark.
Chemical structure	
Molecular formula	$C_{21}H_{28}O_2$
IUPAC Name	(8R,9S,10R,13S,14S,17Z)-17-Ethylidene-10,13-dimethyl-1,2,6,7,8,9,11,12,14,15-decahydrocyclopenta[a]phenanthrene-3,16-dione
CAS No.	39025-24-6

Mechanism of action[141]	Guggulsterone inhibits LPS- or IL-1b-induced ICAM-1 gene expression, NF-κB transcriptional activity, IκB phosphorylation/degradation, and NF-κB DNA-binding activity in IEC and strongly blocked IKK activity.
Uses	Aritirheumatic. Antiseptic. Demulcent and emmenagogue.
Marketed products	Arogyavardhini Gutika (Dabur) and Abana Diakof (by Himalaya Drug Company). Trexgenics Guggul 500mg Veg. Capsules (by Trexgenics)

27. ACETIC ACID [142-144]

Acetic acid, systematically named ethanoic acid, is an acidic, colourless liquid and organic compound.

Biological source: Natural sources of acetic acid include apples, grapes, pineapple, strawberries, and oranges. Aside from that, acetic acid can be found in vinegar.

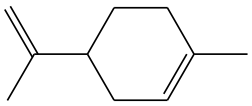
Geographical sources	Mainland China, USA, Italy, Korea, Turkey.
Part of plant	Fruit and vegetables
Chemical structure	
Molecular formula	CH_3COOH
IUPAC Name	Ethanoic acid
CAS No.	64-19-7
Mechanism of action[144]	Acetic acid is effective against microorganisms in patients with acute diffuse external otitis.
Uses	Antiseptic. Antibiotic. Prevent infection and kill bacteria.
Marketed products	Glyco 12% Cream (by Micro labs ltd.) White Vinegar-370ml (by Neo foods)

28. D-LIMONENE [145-148]

D-limonene is one of the most common terpenes in nature. D-limonene is listed in the Code of Federal Regulations as generally recognized as safe (GRAS) for a flavouring agent and can be found in common food items such as fruit juices, soft drinks.

Biological source: The principal sources of d-limonene are the oils of orange, grapefruit and lemon. It is the main volatile constituent of citrus peel oil, and the collected volatile portion of oil is usually referred to as d-limonene in the trade.

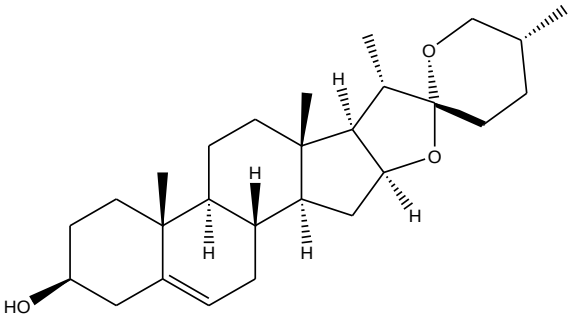
Geographical sources	Asian countries, China and Italy
Part of plant	Rind of citrus fruits

Chemical structure	
Molecular formula	$C_{10}H_{16}$
IUPAC Name	1-Methyl-4-(prop-1-en-2-yl)cyclohex-1-ene
CAS No.	5989-27-5
Mechanism of action	Being a solvent of cholesterol, d-limonene has been used clinically to dissolve cholesterol-containing gallstones. Because of its gastric acid neutralizing effect and its support of normal peristalsis, it has also been used for relief of heartburn and gastroesophageal reflux.
Uses	D-limonene such use for antioxidant, antidiabetic, anticancer, anti-inflammatory, cardioprotective, gastroprotective, hepatoprotective, immune modulatory, anti-fibrotic, anti-genotoxic *etc*.
Marketed products	d-limonene cold-pressed orange peel extract (by Swanson) Healer limonene oil (by Now supplements) D-Limonene 100% Food Grade Citrus Solvent 4oz D-limonene Orange Oil (by Florida Laboratories, Inc)

29. DIOSGENIN [149-152]

Diosgenin is a well-known steroidal sapogenin which originated by the hydrolysis of the saponin dioscin, is classically used in traditional medicine against a variety of medical conditions.

Biological source: Diosgenin, a steroidal sapogenin, occurs abundantly in plants such as *Dioscoreaalata (*Dioscoreaceae), *Smilax China (*Smilacaceae)**,** and *Trigonellafoenum graecum* (Fabaceae).

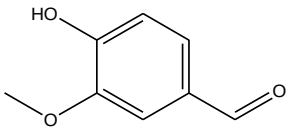
Geographical sources	USA, England and India.
Part of plant	Tubers
Chemical structure	
IUPAC Name	(25R)-Spirost-5-en-3β-ol
Molecular formula	$C_{27}H_{42}O_3$
CAS NO.	512-04-9

Mechanism of action	Diosgenin suppresses tumour metastasis via modulating the epithelial-mesenchymal transition and the actin cytoskeleton, as well as lowering matrix barrier breakdown and suppressing angiogenesis.
Uses	Antioxidant. Anticancer. Anti-inflammatory. Anticoagulant.
Marketed products	Wild Yam Root, 425 mg, 100 Vegan Capsules (by Nature's Way) Wild Yam Root Extract Drops - 50 Ml (by Hawaiian wilds) Wild Yam Root Extract (16% Diosgenin) - 450 mg (100 Capsules) (by TerraVita)

30. VANILLIN [153-155]

Vanillin is the main chemical compound of the extract of the vanilla bean. It is extensively used flavour compound valuable in the food and pharmaceutical industries.

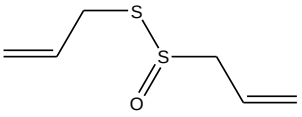
Biological source: Vanilla (Vanilla Pods) consists of the cured fully grown but unripe fruits of *Vanilla fragrans* (Salis.), belonging to family Orchidaceae.

Geographical sources	Indonesia, China, Mexico and Japan
Part of plant	Pods
Chemical structure	
Molecular formula	$C_8H_8O_3$
IUPAC Name	4-Hydroxy-3-methoxybenzaldehyde
CAS No.	121-33-5
Mechanism of action	Vanillin is primarily a membrane-active compound, resulting in the dissipation of ion gradients and the inhibition of respiration, the extent to which is species-specific. These effects initially do not halt the production of ATP.
Uses	Vanillin, a main component of vanilla, use to antioxidant, anti-inflammatory, anticancer, and neuroprotective effects in animal and test-tube research.
Marketed products	Vanillin powder (by Purix) Vanillin powder (by Farmown)

31. ALLICIN [156-157]

The studies on phytochemical, nutraceutical profiles and potential medicinal values of *Allium sativum* (Lilliaceae) on bacterial meningitis were evaluated against bacterial meningitis pathogens.

Biological source: *Allicin* is an organosulfur compound obtained from *garlic*, a species in the family Alliaceae.

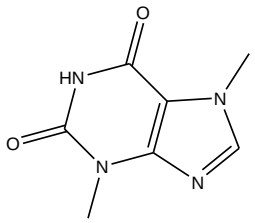
Geographical sources	*Allicin* is found in most regions of the world except the tropics and New Zealand and Australia.
Part of plant	Pungent linear leaves and flowers with six petals.
Chemical structure	
CAS NO.	8000-78-0
IUPAC Name	3-Prop-2-enylsulfinylsulfanylprop-1-ene
Molecular formula	$C_6H_{10}OS_2$
Mechanism of action	Garlic's ability to lower the blood pressure is multifactorial and includes: increasing the availability and activities of nitric oxide, inhibiting ACE thereby reducing a number of pathways that are known to decrease plasma volume and vasoconstriction.
Uses	Used to treat several ailments including fevers, diabetes, rheumatism, intestinal worms, colic, flatulence, dysentery, liver disorders, tuberculosis, facial paralysis, high blood pressure, and bronchitis. Antimicrobial. Anticancer.
Marketed products	Allium cepa 200 (by SBL Pvt. Ltd.) Garlic Tablet-500mg (by Merlion Naturals) Zhou Extra Strength Odorless Garlic with Allicin, Powerful Immune System Support, Blood Pressure and Cholesterol, 90 CT (by Zhou Nutrition Store) HeartLife 100% Natural Allicin Supplement, 60 Vegetarian Capsules (byHeartLife)

32. THEOBROMINE [158-159]

It is the primary methylxanthine in chocolate. Theobromine is the primary bitter-tasting alkaloid found in cocoa and chocolate

Biological source: It present in tea, coffee, cocoa and chocolate.

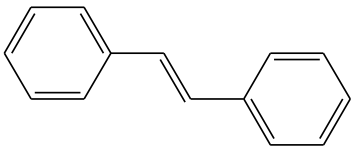
Geographical sources	It is found in Asian countries.
Part of plant	Seed.

Chemical structure	
CAS NO.	83-67-0
IUPAC Name	3,7-Dimethyl-3,7-dihydro-1H-purine-2,6-dione
Molecular formula	$C_7H_8N_4O_2$
Mechanism of action	The main mechanisms of action are inhibition of phosphodiesterases and blockade of adenosine receptors.
Uses	Vasodilator. Heart stimulant.
Marketed products	Theobromine Cocoa Extract 99% - 60 400mg VegiCaps (by Barlowe's Herbal Elixirs) Theobromine 400mg, 90 Vegetarian Capsules (by Nutricost) Theobromine Powder (250 Grams - 8.8 oz) (by BulkSupplements Store)

33. STILBENE [160-161]

It is a phenolic compound that contains two phenyl groups connected by a 2-carbon methylene bridge.

Biological source: found in berries including blueberry, cowberry, lingo berry, and acacia berry.

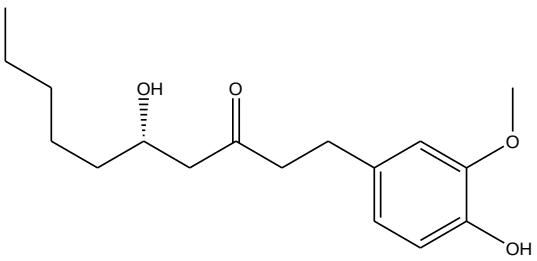
Geographical sources	Found in Europe, Asia and Africa
Part of plant	Fruits.
Chemical structure	
CAS NO.	103-30-0
IUPAC Name	1,2-Diphenylethylene
Molecular formula	$C_{14}H_{12}$
Mechanism of action	Stilbene is the second identified type III PKS that catalyses the sequential condensation of 4-coumaroyl-CoA with three C_2 units from malonyl-CoA to generate .Although STS and CHS apparently use the same condensation mechanism up to the common tetraketide intermediate, they catalyse different ring-closure reactions.

Uses	Anticancer. Anti-inflammatory. Antineoplastic. Antioxidant.
Marketed products	Pteromax capsules (by Biotivia) Pterostilbene 150mg 180 Veggie Caps (by NusaPure Store) Pterostilbene 50 mg - 60 Veggie Caps (by Jarrow Formulas)

34. ***GINGEROLS [162-163]***

Gingerols are phenolic compounds. Several Gingerols of various chain lengths (n6 to n10) are present in ginger, with the most abundant being 6-gingerol.

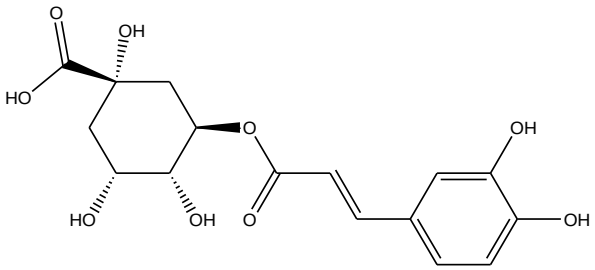
Biological source: Gingerols are the most abundant pungent compounds in fresh roots, and found in ginger. (*Zingiber officinale*, Zingiberaceae).

Geographical sources	Found in Asian, America and Europe.
Part of plant	Roots.
Chemical structure	
CAS NO.	23513-14-6
IUPAC Name	(5S)-5-Hydroxy-1-(4-hydroxy-3-methoxyphenyl) decan-3-one
Molecular formula	$C_{17}H_{26}O_4$
Mechanism of action[163]	Ginger has antioxidant activity through inhibiting free radicals and oxidative stress, and it has anti-inflammatory activity through inhibiting nuclear factor κB and COX1. Ginger modulates the genetic pathways such as apoptosis, activates the tumor suppressor gene, and inhibits VEFG that shows antitumor activity.
Uses	Antioxidant. anti-inflammatory
Marketed products	Super Gingerols 400 mg Per Day - Ginger Root Extract Standardised to 20% Gingerols (by super smart Store) Phytocopeia Ginger Root Capsules (by Phytocopeia) Ginger Extract 5% Gingerols - 100 Veg Capsules (by Health hey nutrition) Jeju root energy mask- ginger (25ml) (by Innisfree)

35. CHLOROGENIC ACID [164-166]

(CGA) are a predominant class of phenolic acids.

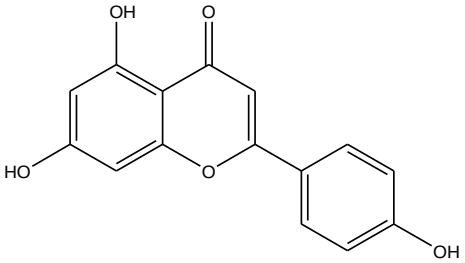
Biological source: It is a compound found in a wide variety of foods and beverages, including fruits, vegetables, olive oil, spices, wine, and coffee.

Geographical sources	Found in Asia, America and Europe.
Part of plant	Fruits
Chemical structure	
CAS NO.	327-97-9
IUPAC Name	(1S,3R,4R,5R)-3-[(E)-3-(3,4-Dihydroxyphenyl) prop-2-enoyl] oxy-1,4,5-trihydroxycyclohexane-1-carboxylic acid
Molecular formula	$C_{16}H_{18}O_9$
Mechanism of action	The mechanism of CGA in reducing blood lipids was most likely associated with the inhibition of absorption and transformation of lipids and with the inhibition of intestinal absorption and hepatic biosynthesis of cholesterol.
Uses	Antioxidant Anti-apoptic.
Marketed products	MyrhaVeerhraAyurveduc Tablet (by Gynoveda) Pure Green Coffee Bean Extract - Green Coffee Extract with 50% Chlorogenic Acid (by Nature Berg) NatureWise Green Coffee Bean 800mg Max Potency Extract 50% Chlorogenic Acids (by Nature Berg)

36. APIGENIN [167-174]

Apigenin is being used by humans in the form of plant extract for the treatment of a number of disorders and inflammatory conditions, until its discovery as a core compound. Apigenin, chemically known as 4′, 5, 7-trihydroxyflavone is a yellow crystalline powder belonging to the flavone class, that is the aglycone of several naturally occurring glycosides. It is insoluble in water but soluble in organic solvents. Numerous pharmacological activities, including anti-inflammatory, anti-toxicant, anti-cancer, etc

Biological source: A variety of plants such as parsley, celery, onions, oranges, chamomile, maize, rice, tea, wheat sprouts, some grasses *etc* are known to synthesis apigenin and its derivatives.

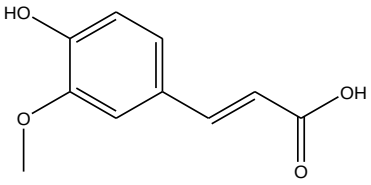
Geographical sources	Asia and Africa.
Part of plant	Fruitsandflower.
Chemical structure	
CAS no.	520-36-5
IUPAC Name	4′,5,7-Trihydroxyflavone, 5,7-dihydroxy-2-(4-hydroxyphenyl)-4H-1-benzopyran-4-one)
Molecular formula	$C_{15}H_{10}O_{5.}$
Mechanism of action	The anti-diabetic properties of apigenin may be attributed to its capacity to inhibit α-glucosidase activity, increase secretion of insulin, to interact with and neutralize reactive oxygen species (ROS) in the cell, which together contribute to the prevention of diabetic complications. Apigenin has also shown the ability to supply moderate nitric oxide (NO) to endothelial cells, thereby limiting the risk of endothelial cell injury and dysfunction from hyperglycaemia.
Uses	Anti-cancers. Rheumatoid Arthritis. Type 1 Diabetes. Anti-toxicant.
Marketed Product	Apigenin Healthy Sleep Support 50 mg. - 120 Capsules (by Double wood supplement) Apigenin 50mg, 180 Capsules, (by Deal Supplement) Liposomal apigenin 500mg Softgels – Optimal (by Cenffitio)

37. FERULIC ACID [175-178]

Ferulic acid has low toxicity and possesses many physiological functions, including anti-inflammatory, antimicrobial, anticancer (for instance lung, breast, colon and skin cancer), anti-arrhythmic, and antithrombotic activity, and it also demonstrated antidiabetic effects and immunostimulant properties.

Biological source: Ferulic acid is commonly found in commelinid plants (rice, wheat, oats, and pineapple), grasses, grains, vegetables, flowers, fruits, leaves, beans, seeds of coffee.

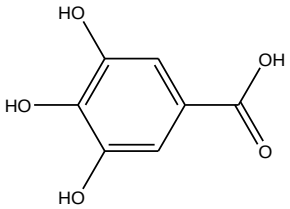
Geographical sources	Japan, Asia, Europe and China.
Part of plant	Commonly found in seeds of plant such as rice, wheat and oats.

Chemical structure	
Molecular formula	$C_{76}H_{52}O_4$
IUPAC Name	(E)-3-(4-Hydroxy-3-methoxyphenyl)prop-2-enoic acid
CAS No.	537-98-4
Mechanism of action	The mechanism of ferulic acid is the ability to form stable phenoxyl radicals, by the reaction of the radical molecule with the molecule of antioxidant. This makes it difficult to initiate a complex reaction cascade leading to the generation of free radicals.
Uses	Antioxidant, it's primarily used to fight off free radicals, which play a role in age-related skin issues, including age spots and wrinkles.
Marketed products	Vitamin C + E + Ferulic 16% (by FOXY) Vitamin C 15%, E & Ferulic Acid Professional Face Serum, 20ml (by St.Botanica) Paula's Choice Boost C15 Super Booster, 15% Vitamin C with Vitamin E & Ferulic Acid, Skin Brightening Serum, 0.67 Ounce (by Paula's Choice Boost store) Pure Ferulic Acid Powder (by Bos Essentials)

38. GALLIC ACID [179-181]

Gallic acid is a phenolic acid with antioxidant, antimicrobial, and potentially even anti-obesity properties.

Biological source: Gallic acid is found in the leaves of bearberry, in pomegranate root bark, gallnuts, witch hazel, sumac, tea leaves, oak bark, and many other plants.

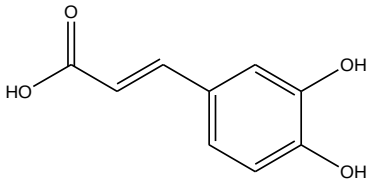
Geographical sources	North America, China, India and Japan
Part of plant	Tea leaves, oak bark.
Chemical structure	
Molecular formula	$C_7H_6O_5$
IUPAC Name	3,4,5-Trihydroxybenzoic acid
CAS No.	149-91-7
Mechanism of action	Gallic acid has been found to induce apoptosis of cancer cells via the mitochondria-mediated pathways and to show selective toxicity for cancer cells without harming normal cells. Gallic acid has also been reported to exhibit anti-invasive and anti-metastatic activities in various cancer cells.

Uses	Gallic acid is a very important common antioxidant tea formulation, known as an Ayurvedic herb. Apart from its phytochemical role, gallic acid is also used in tanning, ink dyes, and the manufacture of paper.
Marketed products	Acidumgallicumdilution (by SBL Pvt. Ltd.) Citrus Bioflavonoids Plus Hesperidin, 650 mg, 90 Capsules (by Natural Factors) Gallic Acid Spray 1.7 oz,(by Valtrexx Bio)

39. CAFFEIC ACID [182-185]

Caffeic acid (CA) is a phenolic compound synthesized by all plant species and is present in foods such as coffee, wine, tea, and popular medicines such as propolis.

Biological source: Caffeic acid (CA) is a polyphenol produced through the secondary metabolism of vegetables, coffee beans, fruits, potatoes, carrots and propolis, and constitutes the main hydroxycinnamic acid found in the diet of humans.

Geographical sources	America, China, India and Japan.
Part of plant	Bark beans and fruits.
Chemical structure	
Molecular formula	$C_9H_8O_4$
IUPAC Name	(E)-3-(3,4-Dihydroxyphenyl)prop-2-enoic acid
CAS No.	331-39-5
Mechanism of action	CA can act by preventing the production of ROS (reactive oxygen species), inducing DNA oxidation of cancer cells, as well as reducing tumour cell angiogenesis, blocking STATS (transcription factor and signal translation 3) and suppression of MMP2 and MMP-9 (collagen IV metalloproteases).
Uses	Use for besides acting as a carcinogenic inhibitor, it is also known to possess antioxidant and antibacterial activity. Ability to increase collagen production and capacity to prevent premature aging of the skin.
Marketed products	Caffeic acid powder (by Quality products lab) Nescafe Classic 100% Pure Instant Coffee (byNestle)

SUMMARY

From this review work it is clear that many phytochemicals are playing important role in the nutraceuticals. These compounds are present in various fruits, foods and are very easily available. Chemically these phytochemicals belong to various classes of phytochemicals like glycosides, alkaloids, polyphenols, terpenoids, tannins, xanthophylls, *etc*. Marketed products are available for these phytochemicals and their demand is increasing day by day. These Phytochemicals will definitely help to improve health of human beings

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