UNIT-2

PART-1

DIETARY SUPPLEMENTS AND NUTRACEUTICALS

Points to be covered in this topic

- **Phytochemicals as nutraceuticals**

❑ Phytochemicals as nutraceuticals

A. Carotenoids- α and β-Carotene, Lycopene, Xanthophylls, leutin
B. Sulfides: Diallyl sulfides, Allyl trisulfide.
C. Polyphenolics: Reservetrol
D. Flavonoids- Rutin , Naringin, Quercitin, Anthocyanidins, catechins, Flavones
E. Prebiotics / Probiotics.: Fructo oligosaccharides, Lacto bacillum
F. Phyto estrogens : Isoflavones, daidzein, Geebustin, lignans
G. Tocopherols
H. Proteins, vitamins, minerals, cereal, vegetables and beverages as functional foods: oats, wheat bran, rice bran, sea foods, coffee, tea and the like.

A. Carotenoids-

➢ α -Carotene

✓ Occurrence

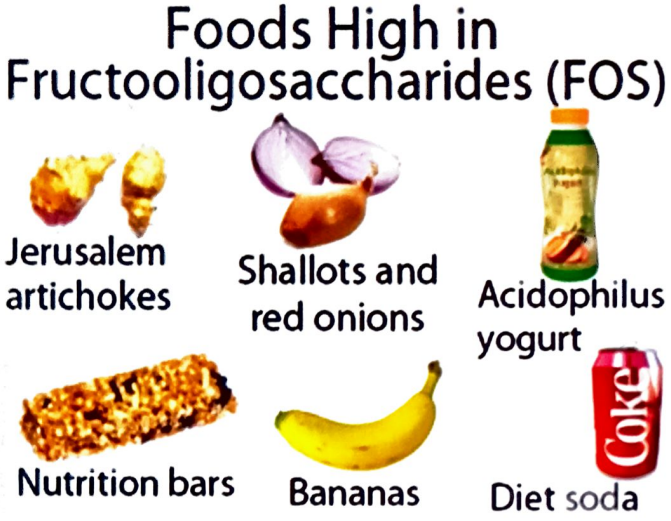
Alpha-carotene occurs **naturally in a variety of fruits, vegetables, and other plant-based foods.** Some of the best dietary sources of alpha-carotene include:

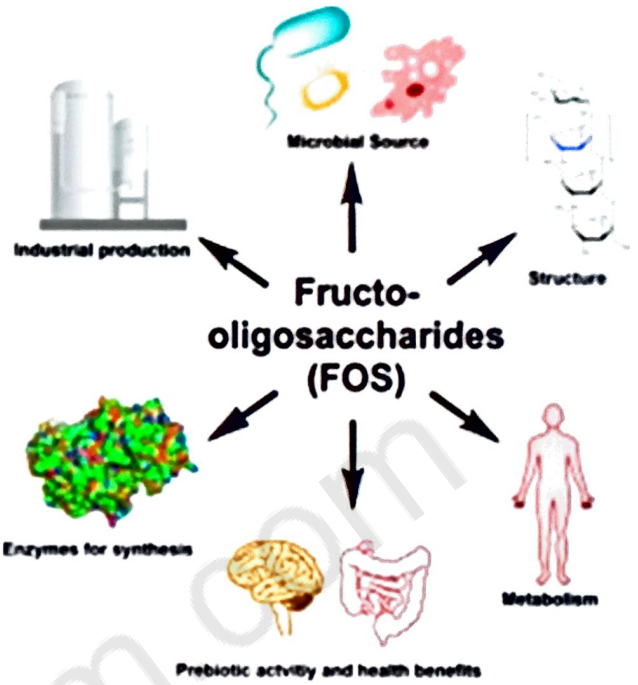
- **Carrots**
- **Sweet potatoes**
- **Pumpkins**
- **Squash**
- **Spinach**
- **Kale**
- **Collard greens**
- **Broccoli**

❑ Phytochemicals as nutraceuticals

E. Prebiotics / Probiotics

➢ Fructo oligosaccharides





✓ Occurrence:

1. Chicory Root: Chicory root is the primary source of fructo-oligosaccharides. It contains a high concentration of inulin, which is a type of fructo-oligosaccharide.

2. Jerusalem Artichoke: Jerusalem artichoke is another significant source of fructo-oligosaccharides. It contains inulin and other fructo-oligosaccharides.

3. Onions and Garlic: Onions and garlic also contain fructo-oligosaccharides, although in smaller amounts compared to chicory root and Jerusalem artichoke.

4. Wheat and Rye: Wheat and rye are grains that contain fructo-oligosaccharides, particularly in the form of inulin.

Alpha-carotene is also found in some **animal products, such as egg yolks and liver.** However, the primary dietary source of alpha-carotene is plant-based foods. The concentration of alpha-carotene in these foods can vary depending on a number of factors, including the **growing conditions, ripeness, and storage conditions of the food.**

✓ Chemical nature

- The molecular formula for alpha-carotene is **C40H56**, and its systematic name is **1,3,3-Trimethyl-2-[3,7,12,16-tetramethyl-18-(2,6,6-trimethyl-1-cyclohexenyl)octadeca-1,3,5,7,9,11,13,15,17-nonaenyl]cyclohexene**.
- The structure can be visualized as **two symmetrical halves, each containing a long hydrocarbon chain with alternating single and double bonds**, and a series of conjugated double bonds in the center.
- Alpha-carotene is typically found in nature as a mixture of **two isomers: all-trans-alpha-carotene and 9-cis-alpha-carotene**. These isomers have slightly different chemical structures due to differences in the arrangement of the double bonds in the molecule.

✓ Medicinal benefit

1.Antioxidant properties: Like other carotenoids, alpha-carotene acts as **an antioxidant in the body, helping to protect cells from damage caused by free radicals**. This may help to **reduce the risk of chronic diseases such as heart disease and certain types of cancer.**

2.Heart health: Some research has suggested that diets **high in alpha-carotene** may be associated with a reduced risk of heart disease.

3.Cancer prevention: Some studies have suggested that alpha-carotene may have cancer-fighting properties. For example, one study found that higher intake of alpha-carotene was associated with a reduced risk of lung cancer.

4.Eye health: Alpha-carotene, along with other carotenoids, may help to reduce the risk of age-related eye diseases such as cataracts and macular degeneration.

➢ β-Carotene

✓ Occurrence

Beta-carotene is a type of carotenoid, a group of naturally occurring pigments found in plants. It is one of the most common carotenoids in nature and is found in many **fruits and vegetables,** including:

- **Carrots**
- **Sweet potatoes**
- **Spinach**
- **Kale**
- **Broccoli**
- **Red peppers**
- **Mangoes**
- **Apricots**
- **Papayas**
- **Peaches**

Beta-carotene is also found in some **animal products, such as egg yolks and liver.** In plants, beta-carotene serves as a natural pigment that gives **fruits and vegetables their bright orange or yellow color**. In the human body, beta-carotene is converted into **vitamin A, an essential nutrient that plays a role in maintaining healthy vision, skin, and immune function.**

Beta-carotene is also known for its **antioxidant properties**, which may help **protect cells from damage caused by free radicals**.

✓ Chemical nature

Beta-carotene is a type of carotenoid, a group of naturally occurring pigments found in plants. It is chemically classified as a terpenoid, which means it is composed of isoprene units. It has a linear molecular structure consisting of 40 carbon atoms and 56 hydrogen atoms, with 11 conjugated double bonds and two end rings.

Beta-carotene is a provitamin A compound, which means it can be converted by the body into vitamin A.

✓ Medicinal benefit

1.May reduce the risk of certain cancers: Some studies have suggested that diets high in beta-carotene may be associated with a reduced risk of certain types of cancer, such as lung cancer and prostate cancer.

2.May improve cognitive function: Beta-carotene may help to improve cognitive function and protect against age-related cognitive decline.

3.May protect against sun damage: Beta-carotene may help to protect the skin from sun damage and reduce the risk of skin cancer.

4.May improve immune function: Beta-carotene may help to boost the immune system and reduce the risk of infectious diseases.

5.May reduce the risk of heart disease: Some studies have suggested that diets high in beta-carotene may be associated with a reduced risk of heart disease.

➢ Lycopene

✓ Occurrence

- Lycopene is **a bright red carotenoid pigment** that is found in **high concentrations in certain fruits and vegetables,** especially in tomatoes. It is a member of the carotenoid family, which includes other pigments like **beta-carotene and alpha-carotene**.
- In addition to **tomatoes, lycopene is also found in watermelon, papaya, grapefruit, guava, and rosehips**.
- Tomatoes and tomato-based products are the richest dietary sources of lycopene. However, it's **important to note that lycopene is more easily absorbed by the body when it is consumed** with fat, so cooking tomatoes in olive oil.
- Lycopene is **not produced by the human body, so** it must be obtained through diet or supplementation. Studies have suggested that a diet high in lycopene may be associated with several potential health benefits, including a reduced risk of certain **types of cancer, cardiovascular disease, and age-related macular degeneration.**

✓ Chemical Nature

Lycopene is a bright red carotenoid **pigment found in many fruits and vegetables, particularly in tomatoes, watermelon, pink grapefruit, and papaya**. It is a type of **acyclic carotenoid**, which means that it has a **linear molecular structure** rather than a cyclic structure like other carotenoids such as beta-carotene.

Chemically, lycopene is a **tetraterpenoid**, which means that it is composed of **eight isoprene units**. Its molecular formula is **C40H56**, and it has a molecular weight of **536.88 g/mol.** Lycopene has a **long, rigid, and linear molecule with 13 conjugated double bonds**, which gives it its **deep red color and strong antioxidant properties.**

Lycopene is not converted into vitamin A in the body like **beta-carotene,** but it still has several potential health benefits. It is a potent antioxidant that may help to protect against **oxidative damage and inflammation, which are involved in the development of many chronic diseases such as cancer, heart disease, and Alzheimer's disease.**

✓ Medicinal benefits

1.May reduce the risk of cancer: Some studies have suggested that lycopene may help to reduce the risk of certain types of cancer, such as prostate cancer, breast cancer, and lung cancer.

2.May improve heart health: Lycopene may help to improve heart health by reducing inflammation and oxidative stress in the body, lowering blood pressure, and improving cholesterol levels.

3.May protect against sun damage: Lycopene may help to protect the skin from sun damage and reduce the risk of skin cancer.

4.May improve vision: Lycopene may help to improve vision and protect against age-related macular degeneration.

5.May improve male fertility: Some studies have suggested that lycopene may help to improve sperm quality and reduce the risk of infertility in men.

✓ Occurrence

Xanthophylls are a type of **yellow pigment** found in many **plants and algae.** They belong to the group of carotenoids, which are responsible for the bright colors of many fruits and vegetables. Xanthophylls are **chemically similar to other carotenoids, but they have oxygen-containing groups in their structure that give them unique properties.**

Some common sources of xanthophylls include:

1.Leafy green vegetables: Xanthophylls are abundant in leafy green vegetables such as spinach, kale, and collard greens.

2.Yellow and orange fruits and vegetables: Xanthophylls are also found in high amounts in yellow and orange fruits and vegetables, such as corn, pumpkin, and carrots.

3.Egg yolks: Egg yolks are a rich source of xanthophylls, particularly lutein and zeaxanthin.

4.Algae: Some types of algae, such as spirulina and chlorella, contain high levels of xanthophylls.

✓ Chemical nature

- Xanthophylls are a type of oxygen-containing carotenoid pigment found in many **plants, algae, and bacteria**. They are similar in structure to other carotenoids, such as beta-carotene and lycopene, but have additional oxygen atoms.
- The chemical nature of **xanthophylls is characterized by their long polyene chains with alternating single and double bonds, which gives them their characteristic color.** Xanthophylls contain hydrocarbon chains with oxygen-containing functional groups, such as **hydroxyl (-OH) and/or carbonyl (>C=O) groups**.
- The most common xanthophylls found in nature are **lutein, zeaxanthin, and cryptoxanthin.** Lutein and zeaxanthin are commonly found in **green leafy vegetables, such as spinach and kale, as well as in yellow and orange fruits and vegetables, such as corn and orange peppers**.

✓ Medicinal benefits

1.May reduce the risk of age-related macular degeneration: Xanthophylls such as lutein and zeaxanthin are concentrated in the macula of the eye, where they act as antioxidants and help to filter out harmful blue light. Studies have shown that diets high in lutein and zeaxanthin may help to reduce the risk of age-related macular degeneration, a leading cause of blindness in older adults.

2.May improve cognitive function: Some studies have suggested that diets high in lutein and zeaxanthin may be associated with better cognitive function, including improved memory and processing speed.

3.May reduce inflammation: Xanthophylls, such as astaxanthin, have anti-inflammatory properties and may help to reduce inflammation in the body, which is linked to many chronic diseases, including heart disease, diabetes, and cancer.

4.May improve skin health: Some studies have suggested that xanthophylls, such as lutein and zeaxanthin, may help to protect the skin from damage caused by ultraviolet (UV) radiation and improve skin hydration and elasticity.

5.May improve cardiovascular health: Some studies have suggested that diets high in lutein and zeaxanthin may be associated with a reduced risk of heart disease and stroke.

➢ Leutin

✓ Occurrence

- Lutein is a type of carotenoid, a group of naturally occurring pigments found in plants. It is a **yellow or orange pigment and is found in high concentrations in dark, leafy green vegetables such as spinach, kale, and collard greens. Other dietary sources of lutein include broccoli, peas, corn, and eggs.**

- Lutein is also found in the **human eye,** particularly in the macula and the retina, where it acts as an antioxidant and helps to **protect the eye from damage caused by blue light and oxidative stress**. This has led to lutein being **studied for its potential benefits in preventing or treating** age-related macular degeneration, a leading cause of blindness in older adults.
- Lutein is also important for **skin health, as it may help to protect the skin from sun damage and improve skin hydration and elasticity**. In addition, some studies have suggested that lutein may have anti-inflammatory and anti-cancer properties.
- Overall, lutein is an important nutrient that can be obtained from a **variety of plant-based foods, particularly dark, leafy green vegetables.**

✓ Chemical nature

- Lutein is a type of carotenoid, a group of naturally occurring pigments found in plants. It is chemically similar to other carotenoids such as beta-carotene, but has a slightly different molecular structure.
- Lutein is a **yellow pigment that is found in high concentrations** in **leafy green vegetables such as spinach, kale, and collard greens, as well as in egg yolks and some fruits such as kiwifruit and grapes**. Lutein is an important nutrient for eye health, as it **helps to filter out harmful blue light and protects the retina from oxidative damage**. In addition to its role in eye health, lutein may also have other potential health benefits, including reducing the risk of heart disease, cognitive decline, and certain types of cancer.
- The chemical structure of **lutein includes a long chain of conjugated double bonds, which gives it its characteristic yellow color and allows it to absorb light in the blue-violet range**. This property of lutein makes it an effective antioxidant and light filter in the eyes.

✓ **Medicinal benefits**

1.Reducing the risk of cardiovascular disease: Some studies have suggested that lutein may help to reduce the risk of cardiovascular disease by reducing inflammation and improving blood vessel function.

2.Improving cognitive function: Lutein may help to improve cognitive function, particularly in older adults. This may be due to its anti-inflammatory effects and its role in protecting the brain from oxidative stress.

3.Protecting skin from UV damage: Lutein may help to protect the skin from UV damage and reduce the risk of skin cancer.

4.Improving symptoms of metabolic syndrome: Lutein may help to improve several markers of metabolic syndrome, including blood sugar levels, blood pressure, and inflammation.

B. Sulfides

➢ Diallyl sulfides

✓ **Occurrence**

- Diallyl sulfides are organic compounds that contain a **sulfur atom and two allyl groups**. They are found naturally in certain members of the **Allium genus of plants, including garlic, onions, shallots, and leeks**.
- Garlic, in particular, is a rich source of diallyl sulfides, including diallyl disulfide (DADS), diallyl trisulfide (DATS), and diallyl tetrasulfide (DATTS). These compounds are formed when garlic is crushed or chopped, which releases an enzyme called alliinase that converts alliin, a sulfur-containing amino acid, into allicin, the precursor to diallyl sulfides.
- Diallyl sulfides have been studied for their potential health benefits. They have been found to have **antioxidant, anti-inflammatory, and antimicrobial properties,** and may have several medicinal benefits, including:

1.Cardiovascular health: Diallyl sulfides may help to lower blood pressure, reduce cholesterol levels, and improve blood flow, which can reduce the risk of heart disease.

2.Cancer prevention: Diallyl sulfides may have anti-cancer properties and may help to prevent the growth and spread of certain types of cancer cells.

3.Immune function: Diallyl sulfides may help to boost the immune system and reduce the risk of infectious diseases.

4.Neuroprotection: Diallyl sulfides may have neuroprotective effects and may help to reduce the risk of neurodegenerative diseases such as Alzheimer's and Parkinson's.

Overall, diallyl sulfides are important bioactive compounds found in garlic and other Allium plants, and may have several potential health benefits.

✓ Chemical Nature

- Diallyl sulfides are a group of organosulfur compounds that contain two **allyl groups (C3H5) attached to a sulfur atom (S).** They are found in various plants in the **Allium genus, such as garlic, onions, and shallots, and are responsible for the pungent odor and flavor of these foods.**
- The most common diallyl sulfide is allicin (diallyl thiosulfinate), which is formed when garlic is crushed or chopped. When allicin is exposed to heat or acid, it decomposes into various sulfur-containing compounds, including diallyl disulfide, diallyl trisulfide, and ajoene.
- Diallyl sulfides have various **chemical and physical properties**, including **high boiling points, low solubility in water, and high reactivity towards other chemicals**. They also have strong odor and flavor, which makes them useful as food additives and flavoring agents.
- Diallyl sulfides have been studied for their potential medicinal benefits, including **antimicrobial, antioxidant, anti-inflammatory, and anticancer effects.** However, more research is needed to fully understand the mechanisms underlying these effects and to determine their **safety and efficacy in humans.**

✓ Medicinal benefits

1.May reduce the risk of cancer: Some studies have suggested that diallyl sulfides may have anti-cancer effects, particularly against cancers of the digestive system, such as stomach, colon, and pancreatic cancer. These compounds may help to inhibit the growth of cancer cells and induce apoptosis (programmed cell death) in cancer cells.

2.May lower cholesterol levels: Diallyl sulfides may help to lower cholesterol levels and improve lipid metabolism, which could reduce the risk of heart disease.

3.May have anti-inflammatory effects: Diallyl sulfides may help to reduce inflammation in the body, which could have benefits for a variety of health conditions, including arthritis and inflammatory bowel disease.

4.May have antibacterial and antiviral effects: Diallyl sulfides may help to inhibit the growth of bacteria and viruses, and may have potential as a natural remedy for infections.

5.May improve blood sugar control: Some studies have suggested that diallyl sulfides may help to improve insulin sensitivity and reduce blood sugar levels, which could benefit people with diabetes.

➢ Allyl trisulfide

✓ Occurrence

- Allyl trisulfide is a naturally occurring **sulfur compound found in several members of the Allium genus, including garlic, onions, and shallots**. It is one of the primary organosulfur compounds responsible for the pungent aroma and flavor of these vegetables.
- When garlic or onions are chopped or crushed, the enzyme alliinase is activated and converts alliin, a sulfur-containing amino acid, into various sulfur-containing compounds, including allyl trisulfide. This process is what gives garlic and onions their distinctive **odor and taste.**

✓ Chemical nature

- Allyl trisulfide is a chemical compound with the molecular formula **C6H10S3**. It is a member of the organosulfur compound family and is typically found in garlic and other members of the Allium genus.
- Allyl trisulfide has a characteristic pungent **odor and taste**, and is responsible for much of the flavor and aroma of garlic. It is a **yellow to brownish-yellow liquid that is soluble in alcohol and ether, but only sparingly soluble in water.**
- The chemical structure of allyl trisulfide consists of a central sulfur atom bonded to three allyl groups. The allyl group is a common functional group in organic chemistry, consisting of a three-carbon chain with a double bond between the first and second carbon atoms.
- Allyl trisulfide has been studied for its potential health benefits, particularly its anti-inflammatory and anticancer properties.

✓ Medicinal benefits

1.May reduce the risk of cancer: Allyl trisulfide has been shown to have anticancer properties, and may help to prevent the development of certain types of cancer, including stomach, colon, and breast cancer.

2.May improve heart health: Allyl trisulfide may help to improve heart health by reducing inflammation, lowering blood pressure, and improving cholesterol levels.

3.May have antimicrobial properties: Allyl trisulfide has been shown to have antimicrobial properties, and may help to fight bacterial and fungal infections.

4.May protect against liver damage: Allyl trisulfide may help to protect the liver against damage caused by toxins and other harmful substances.

5.May improve cognitive function: Allyl trisulfide may help to improve cognitive function and protect against age-related cognitive decline.

C. Polyphenolics:

➢ Reservetrol

✓ Occurrence

- Resveratrol is an **antioxidant-like compound found in red wine, berries and peanuts.** Much of the human research has used supplements that contain high levels of resveratrol.
- Resveratrol is a phytoalexin, a class of compounds produced by many plants when they are infected by pathogens or physically harmed by cutting, crushing, or ultraviolet radiation.
- Plants that synthesize resveratrol include knotweeds, pine trees including Scots pine and Eastern white pine, grape vines, raspberries, mulberries, peanut plants, cocoa bushes, and Vaccinium shrubs that produce berries, including blueberries, cranberries, and bilberries.

✓ Chemical nature

- Resveratrol (3,5,4′-Trihydroxystilbene) is a natural polyphenol with a stilbene structure. Its chemical structure was characterized in 1940 by Takaoka, who isolated it from the root of Veratrum grandiflorum. However, it has been present in medicinal preparations, such as darakchasava or manakka , for more than 2000 years. Its basic structure consists of two phenolic rings bonded together by a double styrene bond, which forms the 3,5,4′-Trihydroxystilbene (molecular weight 228.25 g/mol). This double bond is responsible for the isometric cis- and trans-forms of resveratrol. It is worth mentioning that the trans-isomer is the most stable from the steric point of view.
- **Resveratrol (3, 5, 4′-trihydroxystilbene) is a nonflavonoid polyphenol that naturally occurs as phytoalexin. It is produced by plant sources such as grapes, apples, blueberries, plums, and peanut.**

✓ Medicinal benefits

- Helps estrogen metabolism
- Supports thyroid function
- Reduces breast cancer risk
- Enhances immune system
- Prevents cardiovascular
- disease
- Reduces incidence of cognitive disorders

D. Flavonoids-

➢ Rutin

✓ Occurrence

1. **Citrus Fruits:** Rutin is present in citrus fruits such as oranges, lemons, grapefruits, and limes. It can be found in both the peel and pulp of these fruits.
2. **Buckwheat:** Buckwheat is a grain-like seed that is particularly rich in rutin. The highest concentrations of rutin are found in the bran and outer layers of buckwheat seeds.
3. **Tartary buckwheat:** a variety of buckwheat, is another significant source of rutin.
4. **Apples:** Rutin is found in the skin of apples. It contributes to the antioxidant and health-promoting properties of apples.
5. **Asparagus:** Asparagus contains rutin, especially in the tips and upper parts of the spears.
6. **Tea:** Rutin is present in tea leaves, particularly in green tea.

✓ Chemical nature

Rutin is a naturally occurring flavonoid in many foods, especially buckwheat, apricots, cherries, grapes, grapefruit, plums, and oranges. It is often used in patients with capillary fragility, varicose veins, bruising, or hemorrhoids. Antioxidant, anti-inflammatory effect, eye health, blood vessel health, anti cancer potential.

✓ Medicinal benefits

- Top rated anti-inflammatory
- Increases collagen production (fight aging)
- Lowers bad cholesterol
- Increases vitamin C absorption
- Help prevents stroke and heart attack
- Treat osteoporosis

➢ Naringin

➢ Occurrence

1. Citrus Fruits: Naringin is abundant in citrus fruits, especially in grapefruits. It is found in the pulp, peels, and seeds of grapefruits and contributes to the bitter taste of the fruit. Bitter oranges, such as Seville oranges, also contain significant amounts of naringin.

2. Other Fruits: Naringin can be found in smaller amounts in other citrus fruits, such as oranges, lemons, and tangerines. However, the concentration of naringin is highest in grapefruits and bitter oranges.

✓ Chemical nature

Naringin is a disaccharide derivative that is (S)-naringenin substituted by a 2-O-(alpha-L-rhamnopyranosyl)-beta-D-glucopyranosyl moiety at position 7 via a glycosidic linkage. It has a role as a metabolite, an antineoplastic agent and an anti-inflammatory agent.

✓ Medicinal benefits

- Hypoglycemic effect
- Neuroprotective effect
- Anti-inflammatory effect
- Anti-diabetic effect
- Hypolipidemic effect
- Antihypertensive
- Anti-oxidant effect

➢ Quercetin

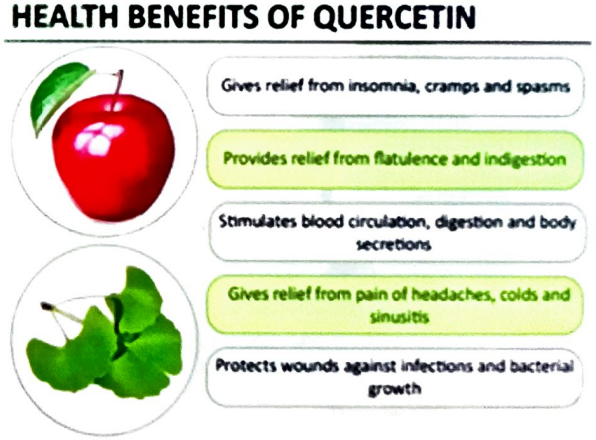
✓ Occurrence:

1. Fruits and Vegetables: Quercetin is found in many fruits and vegetables, particularly in the skins of apples, onions, and berries such as blueberries, cranberries, and cherries. It is also present in **citrus fruits, grapes, tomatoes, and leafy greens like kale and spinach.**

2. Herbs and Spices: Many herbs and spices contain quercetin. Examples include **parsley, dill, capers, lovage, sage, and red chili peppers.**

3. Tea: Quercetin is present **in tea leaves, especially green tea.** It contributes to the health benefits associated with tea consumption.

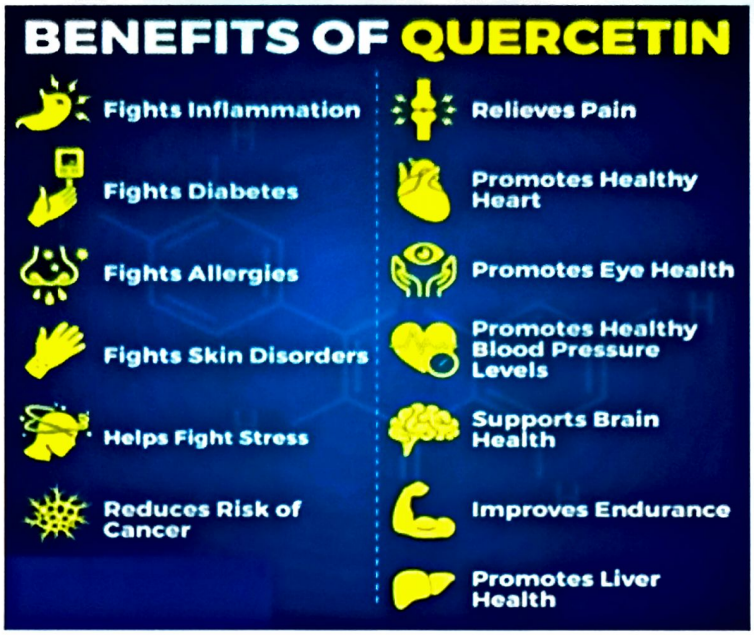
4. Grains and Legumes: Quercetin can also be found in certain grains like **buckwheat and in legumes such as lentils and black beans.**



✓ Chemical nature

Quercetin is a pentahydroxyflavone having the five hydroxy groups placed at the **3-, 3'-, 4'-, 5- and 7-positions**. It is one of the most abundant flavonoids in edible vegetables, fruit and wine. It has a role as an **antibacterial agent, an antioxidant, a protein kinase inhibitor, an antineoplastic agent.**

✓ Medicinal benefits



➢ Anthocyanidins

✓ Occurrence:

1. Fruits: Anthocyanidins are commonly found in a wide range of fruits, such as berries (blueberries, strawberries, raspberries, blackberries), cherries, grapes, pomegranates, cranberries, and blackcurrants. The color of these fruits is due to the presence of anthocyanidins.

2. Vegetables: Some vegetables also contain anthocyanidins, although in smaller amounts. Examples include purple cabbage, purple potatoes, purple sweet potatoes, red onions, and eggplants.

3. Flowers: Anthocyanidins contribute to the vibrant colors of many flowers, such as roses, pansies, irises, and tulips.

✓ Chemical nature

- They are "nature's colors," responsible for providing the beautiful red-orange to blue-violet hues present in many leaves, flowers, vegetables, and fruits, especially berries.
- Anthocyanins are the glycosylated forms of anthocyanidins (aglycones). These compounds are formed by a flavylium cation backbone hydroxylated in different positions (generally on carbons C3, C5, C6, C7 and C3', C4′, C5′) to give rise to different anthocyanidins

✓ Medicinal benefits

- Improve brain function
- Anti-inflammatory
- Regulate blood sugar
- Support heart health

➢ Catechins

✓ Occurrence:

1. Tea: Catechins are abundant in tea leaves, particularly in green tea. They are present in varying amounts depending on the tea variety and processing methods. Green tea contains higher levels of catechins compared to black tea, as black tea undergoes oxidation that transforms catechins into other compounds.

2. Other Foods: While tea is the primary source of catechins, small amounts can also be found in certain fruits, such as apples, pears, and berries like strawberries and blackberries. Cacao beans, which are used to make chocolate, also contain catechins.

✓ Chemical nature

Catechin is a flavan-3-ol, a type of secondary metabolite providing antioxidant roles in plants. It belongs to the subgroup of polyphenols called flavonoids. Except where otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa).

✓ Medicinal benefits

- Antioxidant activity.
- Anticarcenogenic.
- Antiatherogenic.
- Function as enzyme-
- Antibacterial.
- Antibioctic
- Antidiabetic.

➢ Flavones

✓ Occurrence:

1. Herbs and Spices: Flavones are commonly found in herbs and spices. Examples include parsley, thyme, basil, mint, rosemary, and celery seeds. These herbs and spices are often used as culinary ingredients and contribute to their distinct flavors and aromas.

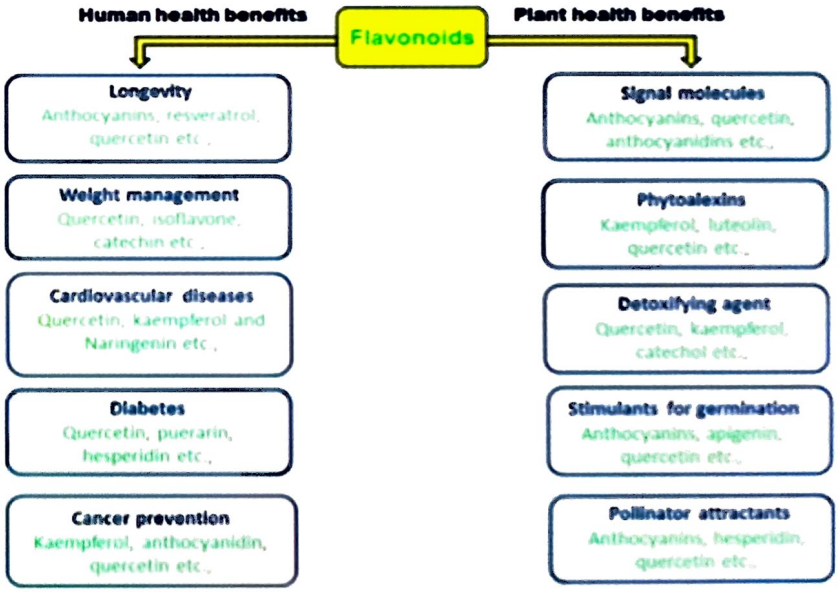
2. Vegetables: Some vegetables contain flavones, although usually in smaller amounts compared to herbs and spices. Examples include celery, bell peppers, and chili peppers.

3. Fruits: While flavones are more abundant in herbs and spices, they can also be found in certain fruits, such as oranges and grapefruits. However, the concentration of flavones in fruits is generally lower compared to other subclasses of flavonoids, such as flavonols or anthocyanins.

✓ Chemical nature

Flavones and flavonols (flavus—Latin for yellow) are present in plant and fungi as secondary metabolites and are naturally yellow in color. Chemical structure has a 15-carbon skeleton, with two phenyl rings (A and B) and one heterocyclic ring (C); abbreviated as C6–C3–C6.

✓ Medicinal benefits



UNIT-2

PART-2

DIETARY SUPPLEMENTS AND NUTRACEUTICALS

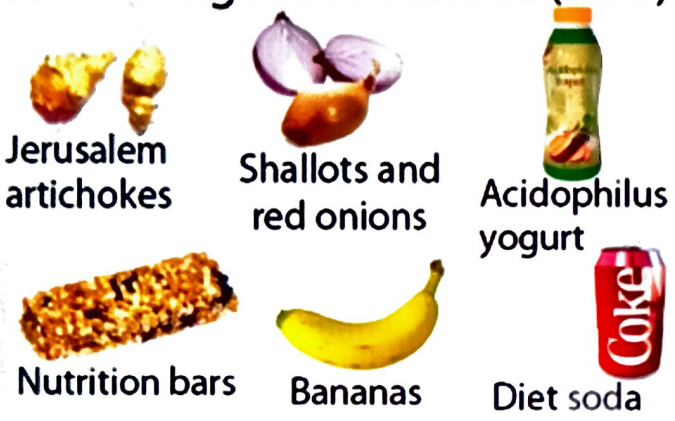
Points to be covered in this topic

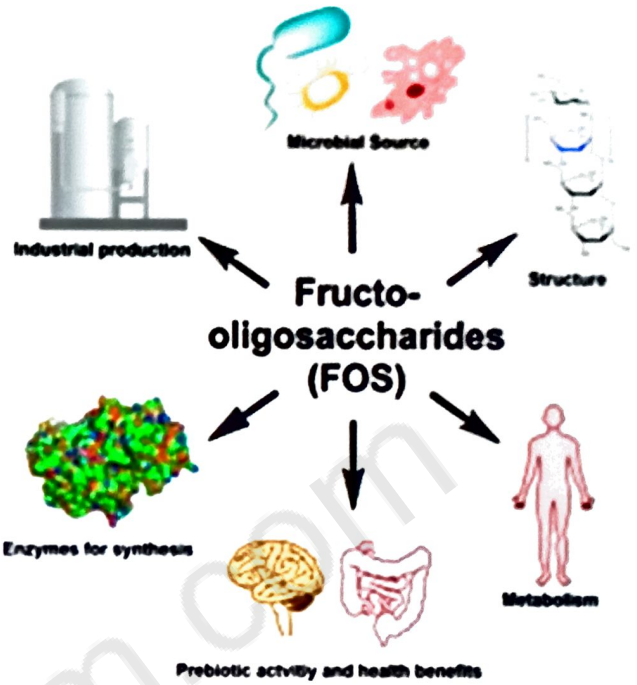
- **Phytochemicals as nutraceuticals**

❑ Phytochemicals as nutraceuticals

E. Prebiotics / Probiotics

➢ Fructo oligosaccharides





✓ Occurrence:

1. Chicory Root: Chicory root is the primary source of fructo-oligosaccharides. It contains a high concentration of inulin, which is a type of fructo-oligosaccharide.

2. Jerusalem Artichoke: Jerusalem artichoke is another significant source of fructo-oligosaccharides. It contains inulin and other fructo-oligosaccharides.

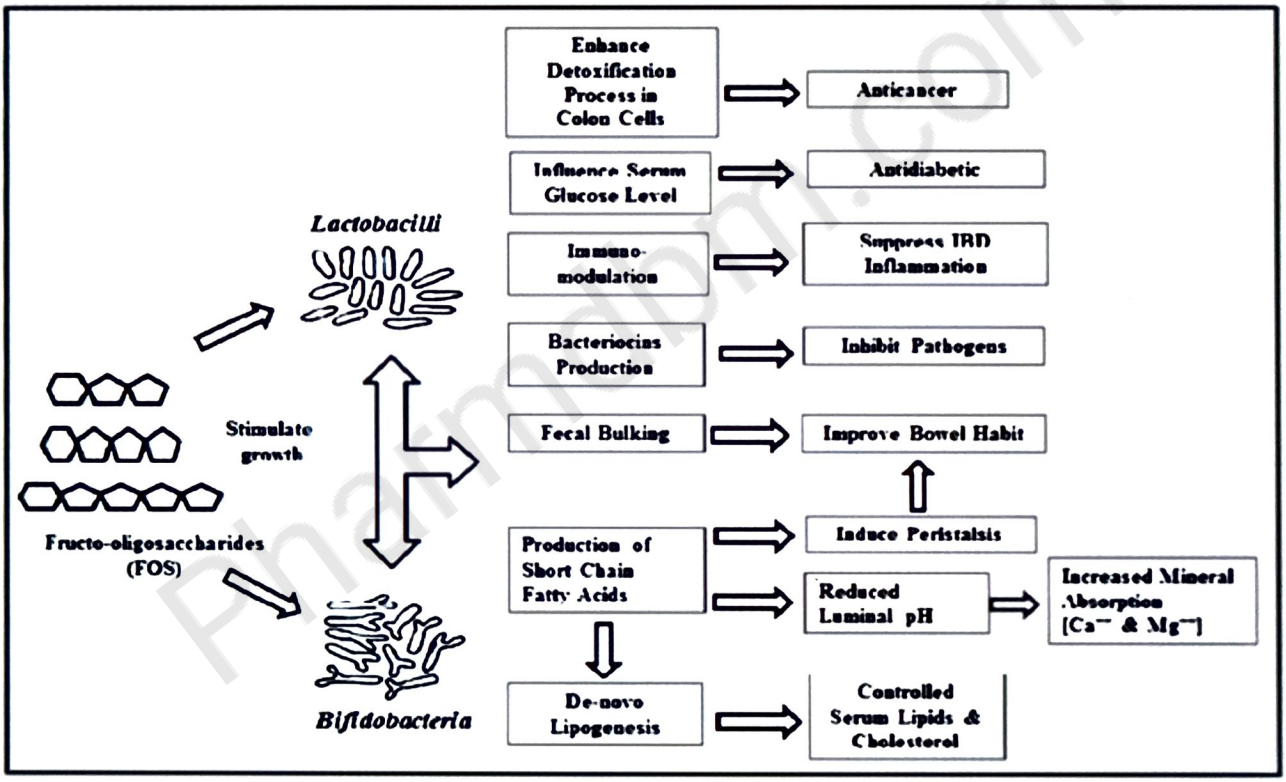
3. Onions and Garlic: Onions and garlic also contain fructo-oligosaccharides, although in smaller amounts compared to chicory root and Jerusalem artichoke.

4. Wheat and Rye: Wheat and rye are grains that contain fructo-oligosaccharides, particularly in the form of inulin.

✓ Chemical nature

- Fructooligosaccharides consist in linear chains of d-fructose units linked by β(2 → 1)-glycosidic bonds, having a terminal d-glucosyl unit linked to a fructose molecule by an α(2 → 1)-bond.
- Fructooligosaccharides (FOSs) are non-digestible carbohydrates with functional and physiological attributes like low sweetness, non-carcinogenicity, low caloric value, prebiotic, hypolipidemic and hypocholestrolemic properties.

✓ Medicinal benefits



➢ Lacto bacillum

✓ Occurrence:

1. Human Body: Lactobacillus species are part of the natural microbiota of various body sites, including the gastrointestinal tract, oral cavity, and urogenital tract. They play a crucial role in maintaining the balance of the microbiota and supporting overall health.

2. Fermented Foods: Lactobacillus species are widely used in the production of fermented foods, where they contribute to the fermentation process and provide characteristic flavors and textures. Examples of fermented foods that contain Lactobacillus include yogurt, cheese, sauerkraut, pickles, kimchi, and sourdough bread.

3. Environment: Lactobacillus can also be found in environmental niches such as soil, plants, and water.

✓ Medicinal benefits

- Improves growth performance
- Feed conversion efficiency
- Nutrient utilization
- Intestinal microbiota
- Gut health and regulates immune system in pigs.
- Treat or prevent diarrhea

F. Phyto estrogens

➢ Isoflavones

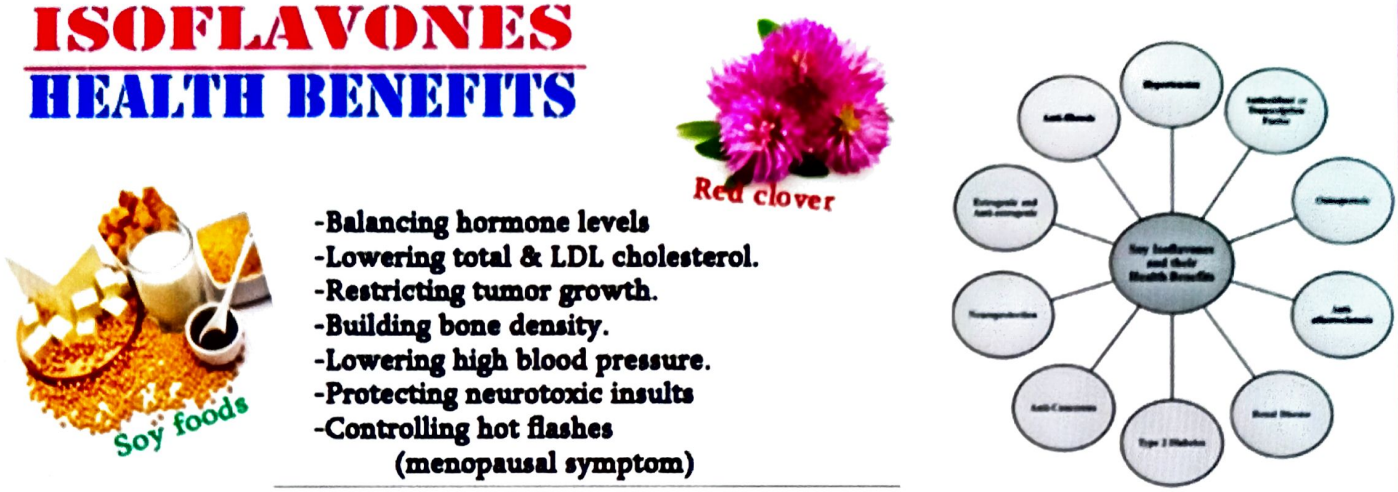
✓ Occurrence:

Isoflavones are a class of phytoestrogens, which are naturally occurring compounds found in certain plants. They are most commonly found in legumes, particularly soybeans and soy products, but can also be found in other plants like chickpeas, lentils, red clover, and kudzu root.

✓ Chemical nature

- Isoflavones are characterized by a 3-phenyl-chromen-4-one skeletal structure with diverse substituents, such as glycoside, hydroxyl, or methoxyl groups.
- Genistein ($C_{15}H_{10}O_5$) is a naturally occurring compound that structurally belongs to a class of compounds known as isoflavones.

✓ **Medicinal benefits**

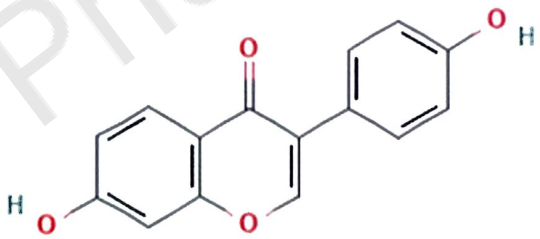


➢ Daidzein

✓ Occurrence:

Daidzein is primarily found in soybeans and soy-based foods, including soy milk, tofu, tempeh, and soy protein isolates. It is also present in other legumes like chickpeas, lentils, and red clover.

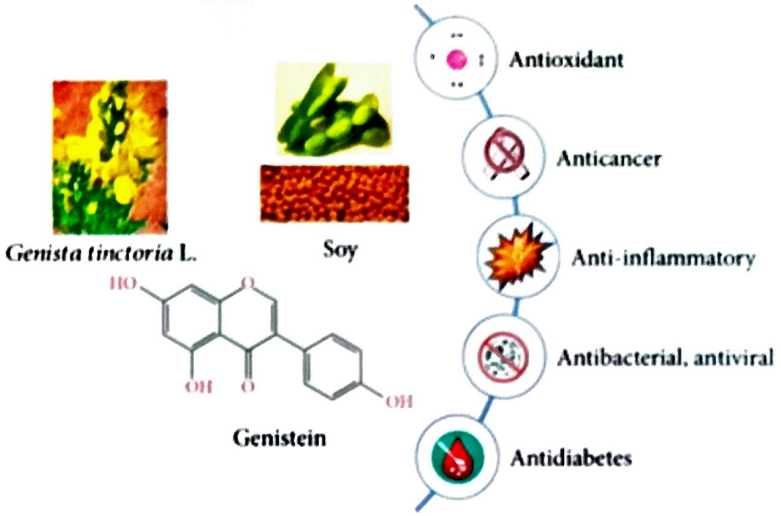
✓ Chemical nature



✓ Medicinal benefits

Daidzein puts forth shielding effects against a great number of diseases, especially those associated with the control of estrogen, such as breast cancer, diabetes, osteoporosis, and cardiovascular disease.

➢ Genistein



✓ Occurrence:

Genistein is primarily found in soybeans and soy products, such as **soy milk, tofu, tempeh, and soy protein isolates**. It is also present in other legumes like **chickpeas, lentils, and red clover**. Additionally, some herbs like Pueraria lobata (kudzu) and Sophora japonica (Japanese pagoda tree) contain genistein.

✓ Chemical nature

Genistein is a **7-hydroxyisoflavone** with additional hydroxy groups at positions 5 and 4'. It is a **phytoestrogenic isoflavone with antioxidant properties**. It has a role as an **antineoplastic agent, a tyrosine kinase inhibitor.**

Genistein is a **natural isoflavone primarily found in soybeans and soybean-enriched products.** Many studies have reported a wide range of biological effects such as antioxidant, antiangiogenic, anthelmintic, and anticancer activity.

✓ Medicinal benefits

Genistein is claimed to exert many beneficial effects on health, such as **protection against osteoporosis, reduction in the risk of cardiovascular disease, alleviation of postmenopausal symptoms and anticancer properties**

G. Tocopherols

✓ Occurrence:

Tocopherols are found in a wide range of plant-based sources, including:

1. Vegetable Oils: Tocopherols are particularly abundant in vegetable oils such as sunflower oil, safflower oil, wheat germ oil, soybean oil, corn oil, and olive oil.

2. Nuts and Seeds: Certain nuts and seeds contain tocopherols, including almonds, peanuts, hazelnuts, and sunflower seeds.

3. Whole Grains: Whole grains like wheat germ, oats, and barley can also contain tocopherols.

4. Leafy Greens: Some leafy green vegetables, such as spinach and Swiss chard, contain small amounts of tocopherols.

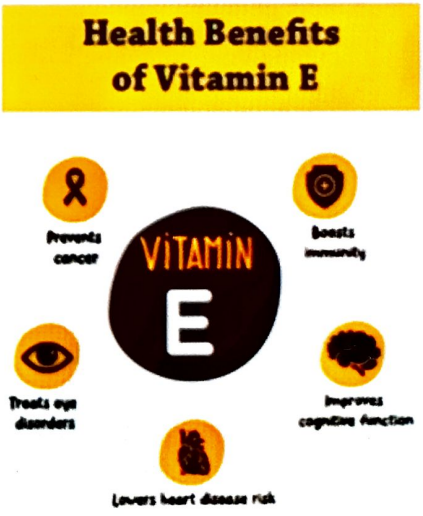
5. Fortified Foods: Tocopherols can also be added to certain fortified food products, such as breakfast cereals and nutritional supplements.

✓ Chemical nature

Vitamin E is a fat-soluble vitamin with several forms, but alpha-tocopherol is the only one used by the human body. Its main role is to act as an antioxidant, scavenging loose electrons—so-called "free radicals"—that can damage cells.

✓ Medicinal benefits

It helps your nerves and muscles work well, prevents blood clots, and boosts your immune system so it can fight off infections from germs.



H. Proteins, vitamins, minerals, cereal, vegetables and beverages as functional foods: oats, wheat bran, rice bran, sea foods, coffee, tea

Functional foods are foods that provide additional health benefits beyond **basic nutrition**. They are typically fortified with specific nutrients or contain natural components that have beneficial effects on the body. **Proteins, vitamins, minerals, cereals, vegetables, and beverages** can all be incorporated as functional foods. Here's a breakdown of each category:

1. Proteins: Functional foods can include protein-rich options that offer added benefits. For **example, protein bars or shakes fortified with vitamins and minerals are popular choices among fitness enthusiasts.** These products can aid in **muscle recovery, provide sustained energy, and support overall well-being.**

2. Vitamins: Functional foods can be enriched with various vitamins to address specific nutritional needs. This can include fortified **cereals, bread, or dairy products that contain added vitamins such as vitamin D, vitamin B12, or folic acid.** These additions help supplement daily vitamin intake and promote overall health.

3. Minerals: Certain functional foods may also be fortified with essential minerals like **iron, calcium, or zinc.** For instance, calcium-fortified orange juice or iron-fortified cereals can help meet dietary requirements and support bone health or prevent iron deficiency.

4. Cereal: Cereals can be enhanced with additional nutrients to provide functional benefits. This includes **whole-grain cereals fortified with fiber, B vitamins, and antioxidants to support heart health and digestion.** Some cereals may also contain added omega-3 fatty acids, which are beneficial for brain function.

5. Vegetables: Functional foods can include vegetables that are processed or prepared in a way that preserves their beneficial properties. For **instance, freeze-dried vegetables or vegetable**-based snacks can offer a convenient and nutritious way to consume essential **vitamins, minerals, and antioxidants found in vegetables.**

6. Beverages: Functional beverages are a popular category of functional foods. These can include fortified **juices, smoothies, or energy drinks that contain added vitamins, minerals, or herbal extracts.** Some beverages are designed to provide specific benefits, such as immune-boosting properties, cognitive enhancement, or improved hydration.

It's important to note that the functional benefits of these foods may vary depending on the specific product and its formulation.

✓ Oats

Oats are widely recognized as a functional food due to their numerous health benefits. Here are some specific ways in which oats can be considered a functional food:

1. Heart health: Oats are **rich in soluble fiber, particularly beta-glucan.** This type of fiber has been shown to **help lower cholesterol levels, specifically LDL cholesterol** (often referred to as "bad" cholesterol). By incorporating oats into your diet, you can promote heart health and reduce the risk of cardiovascular diseases.

2. Blood sugar control: The soluble fiber in oats also plays a role in **regulating blood sugar levels. Beta-glucan forms a gel-like** substance in the digestive tract, which slows down the absorption of glucose and promotes **more stable blood sugar levels.**

3. Digestive health: Oats are a **good source of dietary fiber**, which supports a healthy digestive system. The fiber in oats adds bulk to the stool, aiding in regular bowel movements and preventing constipation. It also promotes the growth of beneficial **gut bacteria, supporting gut health and overall digestion.**

4. Weight management: Oats are a filling and satisfying food due to their high fiber content. Including oats in your meals can help you feel fuller for **longer, reducing the likelihood of overeating or snacking on unhealthy foods.** The slow digestion of oats also helps stabilize blood sugar levels, which can further contribute to better appetite control and weight management.

5. Nutrient density: Oats contain various essential nutrients, including **vitamins (such as vitamin B1, B5, and folate) and minerals (such as manganese, phosphorus, and magnesium).** These nutrients play important roles in **energy production, bone health, and overall well-being.**

6. Antioxidant properties: Oats contain a range of **antioxidants, including avenanthramides, which have been shown to have anti-inflammatory and anti-itching properties.** These antioxidants help protect cells from **oxidative stress and may have potential benefits for skin health.**

When consuming oats as a functional food, it's important to choose minimally processed forms such as whole oats or steel-cut oats, as they retain more of their nutrients and fiber compared to highly processed instant oats. Incorporate oats into your diet by enjoying oatmeal, overnight oats, oat-based granola bars, or adding oats to smoothies, baked goods, or savory dishes for an added nutritional boost.

✓ Wheat bran

Wheat bran is a functional food that offers several health benefits. It is the outer layer of the wheat kernel and is packed with nutrients and fiber. Here are some ways in which wheat bran can be considered a functional food:

1. Fiber content: Wheat bran is exceptionally high in dietary fiber, including **both insoluble and soluble fiber**. Insoluble fiber adds bulk to the **stool, promoting regular bowel movements and preventing constipation. Soluble fiber, on the other hand, can help regulate blood sugar levels, lower cholesterol levels, and support digestive health.**

2. Digestive health: The high fiber content in wheat bran promotes a healthy digestive system. It can help alleviate constipation **by increasing stool bulk and improving bowel movements**. Additionally, the insoluble fiber in wheat bran acts as a **prebiotic, providing nourishment for beneficial gut bacteria and supporting a balanced gut microbiome**.

3. Weight management: Including wheat bran in your diet can aid in **weight management**. The fiber in wheat bran adds **volume to meals, promoting a feeling of fullness and reducing overeating**. It also slows down the digestion and absorption of carbohydrates, helping to regulate **blood sugar levels and prevent blood sugar spikes that can contribute to weight gain**.

4. Cholesterol management: The soluble fiber in **wheat bran, specifically beta-glucan, has been shown to help lower cholesterol levels**. It binds to cholesterol in the **digestive tract, preventing its absorption and promoting its excretion from the body**. Regular consumption of wheat bran can contribute to improved cholesterol profiles and **reduced risk of cardiovascular diseases.**

✓ Rice bran

Rice bran is another example of a functional food that offers several health benefits. It is the outer layer of the rice grain and contains various nutrients and bioactive compounds. Here are some ways in which rice bran can be considered a functional food:

1. Nutrient-rich: Rice bran is a **good source of essential nutrients**, including **vitamins (such as vitamin E, B vitamins, and beta-carotene)** and **minerals (such as magnesium, potassium, and zinc)**. These nutrients play important roles in supporting overall **health, immune function, and energy metabolism.**

2. Antioxidant properties: Rice bran contains **antioxidants, such as tocopherols, tocotrienols, and gamma-oryzanol**. These antioxidants help protect cells from oxidative damage caused by **free radicals, which can contribute to chronic diseases and aging.** The antioxidant properties of rice bran may have potential benefits for **cardiovascular health and reducing the risk of certain diseases.**

3. Fiber content: Rice bran is a good source of dietary fiber, both **soluble and insoluble.** The fiber in rice bran supports digestive health by promoting regular **bowel movements, preventing constipation, and supporting a healthy gut microbiome.** It can also aid in weight management by providing a feeling of fullness and promoting satiety.

4. Cholesterol management: Certain components in rice bran, such as **gamma-oryzanol, have been shown to help lower cholesterol levels.** Gamma-oryzanol inhibits the absorption of cholesterol in the intestines and may contribute to reducing LDL cholesterol levels. Including rice bran in your diet can be beneficial for maintaining healthy cholesterol profiles and **supporting cardiovascular health.**

5. Blood sugar control: Rice bran, particularly brown rice bran, has a lower glycemic index compared to polished rice. This means that it has a **slower and steadier impact on blood sugar levels.** Including rice bran in meals can help **regulate blood sugar levels**, which is especially important for individuals with diabetes or those looking to manage their **blood sugar.**

6. Skin health: Rice bran oil, which is derived from rice bran, is often used in **cosmetic products due to its moisturizing and antioxidant properties.** It can help nourish and hydrate the **skin, improve its texture, and protect against oxidative damage.**

✓ Seafood

Seafood is indeed considered a functional food due to its many health benefits and nutritional value. Seafood, including fish and shellfish, offers several functional components that promote optimal health. Here are some reasons why seafood is considered a functional food:

1. Omega-3 fatty acids: Seafood, especially fatty **fish like salmon, mackerel, sardines, and trout, is an excellent source of omega-3 fatty acids.** These essential **fatty acids, including eicosatetraenoic acid (EPA) and docosahexaenoic acid (DHA),** have been associated with numerous health benefits. They support heart health by reducing the **risk of cardiovascular diseases, improving blood lipid profiles, and lowering blood pressure. Omega-3 fatty acids also have anti-inflammatory properties, supporting overall joint and brain health.**

2. Protein and amino acids: Seafood is a rich source of **high-quality protein, providing essential amino acids necessary for various bodily functions.** Protein is crucial for **muscle growth, tissue repair, and the production of enzymes and hormones.** Including seafood in your diet helps ensure an adequate intake of quality protein.

3. Minerals: Seafood is a natural source of important minerals such as **iodine, selenium, zinc, and iron**. These minerals play essential roles in various bodily processes, including **thyroid function, immune system support, antioxidant activity, and oxygen transport in the blood.**

4. Vitamins: Seafood is a good source of vitamins, particularly fat-soluble vitamins such as **vitamin D and vitamin A.** Vitamin D is necessary for **bone health, immune function, and calcium absorption,** while vitamin A is important for **vision, immune function, and skin health**. Some seafood, like **shellfish, also provides B vitamins, including vitamin B12, which is crucial for nerve function and red blood cell production.**

5. Antioxidants: Seafood contains various antioxidants, including selenium and astaxanthin. These compounds help **protect cells from oxidative stress, which can contribute to chronic diseases and aging**. Astaxanthin, in particular, has been shown to have potent antioxidant and anti-inflammatory properties.

✓ Coffee

Coffee is often considered a functional food due to its potential health benefits and the presence of bioactive compounds. Here are some reasons why coffee can be viewed as a functional food:

1. Antioxidant properties: Coffee is a rich source of antioxidants, such as chlorogenic acid and
caffeine. These compounds help neutralize harmful free radicals in the body, reducing oxidative stress and potentially lowering the risk of chronic diseases like cardiovascular diseases, certain cancers, and neurodegenerative disorders.

2. Mental alertness and cognitive function: Coffee contains caffeine, a stimulant that can enhance alertness, concentration, and mental

performance. Moderate consumption of coffee has been associated with improved cognitive function, including enhanced memory, attention, and reaction time. However, individual responses to caffeine can vary, and excessive consumption may lead to negative effects like jitteriness or insomnia.

3. Physical performance and exercise: The caffeine in coffee has been shown to have ergogenic effects, meaning it can enhance physical performance. It can **increase endurance, improve muscle contraction, and decrease the perception of effort during exercise**. Drinking coffee before a workout or athletic activity may provide a performance boost for some individuals.

4. Metabolic effects: Coffee consumption has been associated with potential metabolic benefits. Some studies suggest that coffee may **increase metabolic rate, enhance fat oxidation, and improve insulin sensitivity**. These effects may contribute to weight management and reduce the **risk of type 2 diabetes.**

5. Liver health: Research indicates that moderate coffee consumption may be associated with a lower risk of liver diseases, including **liver cancer, cirrhosis, and non-alcoholic fatty liver disease**. Coffee has been shown to have protective effects on liver enzymes and reduce inflammation in the liver. **It's important to note that individual responses to coffee can vary, and some people may be more sensitive to its effects, especially when it comes to caffeine. Excessive consumption or certain preparations with high amounts of added sugars and unhealthy fats can have negative effects on health. Additionally, some individuals may experience gastrointestinal issues or sleep disturbances from coffee consumption.**

✓ Tea

Tea is widely recognized as a functional food due to its many health-promoting properties and the presence of bioactive compounds. Here are some reasons why tea can be considered a functional food:

1. Antioxidant content: Tea, especially green tea and certain herbal teas, is rich in antioxidants known as **polyphenols**. These compounds, **including catechins and flavonoids,** have potent antioxidant properties and help **protect cells from oxidative damage caused by free radicals.** Antioxidants in tea have been associated with a **lower risk of chronic diseases, such as cardiovascular diseases, certain cancers, and neurodegenerative disorders.**

2. Heart health: Regular tea consumption has been linked to cardiovascular benefits. The polyphenols in tea have been shown to help **reduce blood pressure, improve blood lipid profiles by lowering LDL cholesterol levels and increasing HDL cholesterol levels**, and enhance the health of blood vessels. These effects may contribute to a **lower risk of heart disease and stroke.**

3. Mental alertness and cognitive function: Tea contains caffeine, albeit in lower amounts compared to coffee. The caffeine in tea can provide a gentle **energy boost and enhance mental alertness without the jittery effects associated with higher caffeine doses.** Additionally, tea contains the **amino acid L-theanine, which has a calming effect and may promote relaxation and focus. The combination of caffeine and L-theanine in tea can contribute to improved cognitive function and attention.**

4. Weight management: Certain compounds in tea, particularly green tea, have been suggested to support weight management. Green tea extract has been shown to **increase metabolism and fat oxidation, potentially aiding in weight loss.** Additionally, the moderate caffeine content in tea can help **increase energy expenditure and suppress appetite, contributing to overall weight management.**

5. Digestive health: Some herbal teas, such as peppermint or ginger tea, have been traditionally used to support digestive health. **Peppermint tea may help alleviate symptoms of indigestion, such as bloating and discomfort, while ginger tea has been associated with reducing nausea and aiding digestion.**

6. Hydration: Tea is a hydrating beverage and can contribute to meeting daily fluid needs. It is a refreshing and calorie-free option for staying hydrated, especially when consumed without added sugars or excessive milk.

It's important to note that individual responses to tea can vary, and the specific benefits may depend on the type of tea and brewing methods. Additionally, some herbal teas may interact with certain medications or have specific considerations for certain individuals, such as pregnant women or those with specific health conditions. Consulting with a healthcare professional or registered dietitian can provide personalized advice on incorporating tea into a healthy lifestyle.