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Citrus Fruits: An Overview of their Beneficial and Pharmacological Properties

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Abstract: ***This paper reviews citrus fruits' beneficial and pharmacological importance on human health. Citrus fruits are consumed in abundance worldwide due to their attractive aromas and taste. They have been identified as one of the highest-consumption fruits in terms of energy, health supplements, and nutrients. Citrus fruits are a treasured resource of phytochemicals such as vitamin C, Vitamin B, potassium, phosphorous, and many other functional bioactive phytochemicals such as flavonoids, terpenoids, amino acids, polysaccharides, etc. Extracted bioactive compounds from citrus fruits have anticancer, anti-diabetic, antifungal, antibacterial, and neuroprotective activity. Citrus juice contains enzymes for obesity control and a range of proteins that burn human fats.They are used in various industrial food procedures and for the production of cakes, pies, juices, etc.***

Keywords: Citrus fruits, human health, phytochemicals, bioactive compounds, industrial food procedures.

1. Introduction

Citrus fruits belong to the family Rutacea, subfamily Aurantioideae, and subtribe Citrinae. These include oranges, limes, grapefruits, lemons, mandarins, and citrons. Citrus fruits are consumed in abundance worldwide due to their attractive aromas and taste and are identified as one of the highest-consumption fruits in terms of energy, health supplements, and nutrients. The size of citrus fruits ranges from round to oblong. The characteristics of citrus fruits constitute powerful organoleptic and commercial properties.

Table 1.1: Common names of citrus fruits and their respective scientific names

Common Name	Scientific Name
Sweet orange	*C. sinensis*
Tangerine	*C. reticulata*
Lime	*C. aurantifolia*
Grapefruit	*C. paradisi*

Table 1.2: Minor types of citrus and their respective scientific name

Types of Citrus	Scientific Name
Sour orange	*C. quarantium*
Shaddock	*C. grandis*
Citron	*C. medica*

Citrus fruits are a good source of vitamin C. The fruits are abundant in macronutrients such as potassium, niacin, vitamin B6, phosphorus, thiamin, magnesium, calcium, copper, and riboflavin. The composition and content of bioactive and nutrients vary immensely among citrus growth stages, varieties, and fruit parts including fruit peel, flesh, juice, and seed. They contain carbohydrates such as glucose, fructose, and sucrose.Citrus peels and peel powder consist of bioactive compounds that have reduced overall cholesterol, glucose levels, LDL, and triglycerides.Also, thesefruits contain enzymes for obesity control and have low fat and protein content.

Secondary metabolites are small molecules with pharmacological activity, including flavonoids, alkaloids, coumarins, limonoids, carotenoids, phenol acids, and essential oils that protect from various illnesses, including cancer, inflammatory, digestive, and cardiovascular diseases. In addition, these active secondary metabolites also show crucial significance to human health, including anti-oxidative, and neuroprotective effects, and are also used as medicinal herbs in countries like China, Japan, and Korea. Citrus whole fruits are well known to treat indigestion, cough, skin inflammation, muscle pain, ringworm infections,and lower blood pressure. It alsocontains enzymes for obesity control and a range of proteins that burn human fats.

Citrus fruit is used in the production of juice, jam, candies, jelly, marmalades, pies, cakes, etc. Citrus fruit peel consists of pectin extracted and used in various industrial food procedures as a gelling agent, texturizer as a stabilizer in dairy products, thickener, emulsifier, and used in dental, cosmetic, and pharmaceutical industries.

2. Characteristics of Citrus Fruits

2.1 Lemon

Lemon (*Citruslimon L.*) is ranked third among Citrus species. Lemon fruit generally consists of pulp, skin, and seeds. These fruits mature throughout the year, have a sour taste, and are a great source of vitamin C. It has natural and bioactive compounds such as flavonoids, minerals, citric acid, ascorbic acid, essential oils, vitamins, and dietary fiber. Lemon fruits consist of carotenoids that can function against photo-oxi damage, flavonoids have a significant role in preventing diseases such as diabetes, cardiovascular disease, obesity, lowering blood lipids, and some forms of cancer.

2.2 Orange

Orange (*Citrus sinensis*) is one of the most common citrus fruits consumed. Brazil is the leading cultivator of oranges. It can be consumed whole or in the form of juice. A medium-sized orange consists of approximately 60 to 80 kcal of energy, 70 mg of vitamin C, 235 mg of potassium, and 3.0 g of dietary fiber. Additionally, it contains carbohydrates, fat, protein, ash, and natural oils. Orange

peels are effective against various infections, flu, and cold as they are rich in vitamin A and vitamin C. It also reduces the risks of diabetes, asthma, osteoarthritis, and heart disease and prevents high blood pressure.

2.3 Grape fruit

Grapefruit (*C. paradisi)*, commonly known as Toronjais a blend *of citrus x paradise* and *citrus maxima.* It is rich in flavonoids (hesperidin,narigenin, hesperedin, naringin, and rutin) and ascorbic acid. It nourishes, uplifts, and energizes the skin. It is used asan additive as it enhances the flavor of food. It is used in the treatment of the common cold and fever. It is effective in weight loss, prevents arthritis, and cancer, and lowers cholesterol levels.

2.4 Pomelo

Pomelo is the most extensive citrus fruit-a promising source of proteins, vitamins, fiber, carbohydrates, and minerals. It is consumed whole or made into juice. It consists of various bioactive compounds including vitamin C, fiber, lycopene, polyphenols, carotenoids, flavonoids, and limonoids. These bioactive compounds contribute to the defense mechanism against hyperglycemia, high blood pressure, and oxidative stress. Pomelo peels have essential components such as phytochemicals, pectin, and polysaccharides.

3. Value-Added Components of Citrus Fruits

3.1 Vitamin C (ascorbic acid)

Citrus fruits are a rich and valuable source of the essential water-soluble vitamin - Vitamin C (ascorbic acid). As it is an antioxidant it boosts immunity and white blood cells, reduces the risk of cardiovascular diseases, lowers the risk of pre-eclampsia during pregnancy, etc. It also helps in the formation of connective tissue, collagen, and also the absorption of iron.37mg of ascorbic acid is provided per 100g of lemon fruit, while 100 g of pomelo flesh consists of 37.5mg of ascorbic acid. It has been reported that an individual can achieve 100 per cent Vitamin C level by consumption of a moderate number of citrus fruits each day.

3.2 Folate (folic acid)

Folic acid is a water-soluble vitamin present in citrus fruit of which reduced 5-methyl tetrahydrofolate and polyglutamate compounds are the most significant ones. Citrus is a source of dietary folate. Folate plays a crucial role in protein production. It has been reported that daily consumption of citrus fruits can help increase folate levels, decrease blood homocysteine, reduce neural tube defects, and lower the risk of atherosclerosis and cardiovascular diseases. Lemon (100gm) consists of 11-16mg of Folate.

3.3 Essential Oil

Essential oils are a natural mixture of aromatic oils obtained from the plant. Fruit peel of citrus fruit has about 400 compounds of volatile and nonvolatile compounds Hence citrus species are a rich source of aromatic compounds. Essential oils in citrus fruits are commonly known to produce a good fragrance and have been approved as healthy for consumption. Lemon essential oil is used in the cosmetic industry due to its antifungal and antimicrobial properties and also in the food industry because of its natural preservative and flavouring properties. It has also been reported that lemon essential oil when employed as preservation for edible coating delayed the aging in tofu and fresh strawberries.

3.4 Dietary Fiber

The primary dietary fibre present in citrus fruits is pectin.They are stabilizing, gelling, emulsifying, and texturizing agents. It is present in citrus peels and is considered to have positive effects on metabolic and digestive processes. Dietary intake of pectin has been reported to reduce the risk of colon cancer as pectin is involved in bile absorption and bile excretion from the colon. Consumption of citrus fruit is associated with reducing cholesterol levels. Previous studies have also reported that a fibre-rich diet lowers the risk of chronic diseases such as cancer, diabetes, and cardiovascular diseases, and lowers blood sugar levels. Epidemiological studies have reported that citrus peel is effective in reducing total liver lipids, plasma liver cholesterol, serum triglyceride levels, and total serum cholesterol. Pomelo is considered a rich natural source of pectin. In the food industry, pectin from lemon peel is used in the production of carrot and pumpkin jams.

3.5 Antioxidants

Antioxidants prevent damage caused by free radicals in the body, hence they are considered to reduce the risks of cancer and cardiovascular diseases. Lemon peel and flesh are considered to have the highest antioxidant capacity. Pomelo peel contains a rich source of natural antioxidants.

3.6 Mucilage and Tannins

Mucilage is a fibre-like substance that forms a gel when mixed with water. It is present in citrus fruits seed, peel, and pulp.Citrus fruits such as grapefruit, lemon, and lime are rich sources of tannin compounds. These compounds play a very crucial role in treating diarrhoea, controlling extreme secretions of the body, and decreasing bleeding.

3.7 Enzymes

Citrus fruit peels are used in the production of pectinolytic enzymes. Lemon peels, being a good source of naringin, can be used for the production of naringinase. Naringinase is used as an aroma enhancer in winemaking, rhamnose manufacturing, production of sweetener precursors, etc. The p-45 enzyme in grapefruit juice is considered a natural tool for obesity control and burns human fats.

4. Phytochemicals of Citrus Fruits

4.1 Citrus Flavonoids

Citrus fruits (pulp, peel) are a rich source of flavonoids including diosmin, quercetin, naringenin, rutin, hesperidin, nobiletin, tangeretin, and maringin. Citrus consists of a class of flavonoids including flavonols, flavans, anthocyanins, etc. These flavonoids are effective in controlling antiviral, antioxidant, and anti-microbial activity. Due to these activities, flavonoids effectively reduce cholesterol and triglyceride levels. Flavonone concentration in the citrus fruit peel and seed varies. It was reported that the fruit peel of certain citrus fruits consists of a lower concentration of flavanone as compared to its concentration in the seed. It has also been found that the bitterness of citrus fruits is due to the presence of glycosylated flavanones.

4.2 Citrus Carotenoids

Citrus fruits that are rich sources of carotenoids include grapefruits, sweet oranges, and mandarin are a rich source of carotenoids. They consist of several carotenoids such as auroxanthin, cryptoxanthin, lutein, lycopene, and zeaxanthin. It has been reported that the carotene content of pink grapefruit is higher than other citrus fruits. Carotenoids have significant antioxidant activity. Scientific data mentions that carotenoids promote eye health,and bone formation, and reduce the risk of muscular degeneration, cardiovascular diseases, cancer, etc.

4.3 Citrus Limonoids

Citrus fruits are rich sources of limonoids of which over 30 limonoids have been identified. These fruits consist of two types of limonoids i.e. aglycones and their corresponding glucosides. Limonin and nomilin are the most recognized limonoids in citrus fruits. Grapefruit and orange juice have a high concentration of limonoids. Limonoids are reported to slow down the development of cancers of the stomach, colon, pancreas, and breasts.

5. Health Benefits of Citrus Fruits

5.1 Anti-Carcinogenic & Anti-Tumor Properties

Citrus flavonoids possess anticarcinogenic and anti-tumour activities. *Citrus* fruits are high in Secondary metabolites present in citrus fruits such as flavonoids, carotenoids, and limonoids, which are associated with reducing the risk of cancer, including gastric cancer, breast cancer, hepatocarcinogenesis, lung tumorigenesis, hematopoietic malignancies, and colonic tumorigenesis. It has been reported that Tangerine flavedo extract exhibited potential anti-tumour effects

5.2 Cardiovascular Properties

Citrus fruits are a rich source of flavonoids. Flavonoids are reported to possess antiadhesive and anti-aggregation action against red blood cell clumping. Consumption of flavonoid-rich food reported reduced cardiovascular mortality and morbidity, impacting vascular function. Lime peel ethanolic extract was discovered to be a potential cardio-protector in chemotherapy.

5.3 Antimicrobial Properties

Flavonoids possess antifungal and antiviral activity. It has been reported that d-limonene is used in traditional medicine to treat heartburn, gastroesophageal reflux disease, and gallstone. Reports have revealed that researchers opted for D-limonene as a less toxic substitute for the chemical (xylene) when clearing dehydrated specimens. Previous research indicates that essential oil in Citrus aurantifolia leaf exhibit evident activity against Gram-negative and Gram-positive bacteria and these activities were relatively comparable to standard antibiotics screened under similar conditions.

5.4 Effect of Citrus Fruits on Hyperglycemia And Diabetes

Citrus fruits, being a rich source of flavonoids, have a crucial role in preventing the progression of hyperglycemia. This is mainly achieved by the binding of flavonoids to starch thus decreasing hepatic gluconeogenesis and increasing glycogen concentration as well as hepatic glycolysis. Citrus flavonoids are reported to have a significant hypoglycemic potential inhibiting amylase-catalyzed starch digestion. Previous studies report dietary hesperidin (citrus flavonoid) to lower hepatic gluconeogenesis hence exhibiting antidiabetic activity.

5.5 Citrus Effect on Hypolipidemia

Numerous clinical studies reported that citrus juice is effective in controlling high cholesterol and lipid problems, as they are rich in soluble and insoluble fibre. It was reported that flavonoids such as tangeretin and nobiletin may lower blood cholesterol and triacylglycerol concentrations whereas other flavonoids such as hesperidin and naringin may have no or very weak lipid-lowering effect.

5.6 Neuroprotective Effects

Studies revealed that an aqueous extract of bitter orange (*C. aurantium L.*) and flavonoids present in it such as naringin, hesperidin, neohesperidin, and nobiletin possessed an antidepressant effect and a neuroprotective effect on corticosterone-induced neurotoxicity in PC12 cells.

6. Conclusion

Citrus fruits are a potent source of vitamin C, essential oils, antioxidants, dietary fibre, limonoids, carotenoids, flavonoids, etc. Literature review studies reveal that citrus fruits possess antimicrobial, cardiovascular, neuroprotective, anti-carcinogenic, anti-tumour, and anti-diabetic properties. These fruits also have positive effects on hyperglycemia and hypolipidemia. Citrus fruits have a wide application in the cosmetic industry, food industry, and pharmaceuticals. Further investigations and experimentation can be performed to use citrus fruits more effectively.

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