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COMPILATION OF HEALTH BENEFITS AND PHYTOCHEMICALS FROM CITRUS PLANTS

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ABSTRACT
Citrus fruits are the main fruit trees grown throughout the world and are well – appreciated for their refreshing juice and health benefits. Numerous therapeutic properties have been attributed to citrus fruits, like anticancer, antiviral, anti-tumor, anti-inflammatory activities, and effects on capillary fragility as well as an ability to inhabit platelet aggregation. More recently, therapeutic values related to cardiovascular diseases and age related macular degeneration have been reported. These numerous health benefits of citrus fruits are linked to the high amounts of photochemical and bioactive compounds such as flavonoids, carotenoids, vitamins and minerals available in citrus fruits. These phytonutrients may act as antioxidants, stimulate the immune systems; induce protective enzymes in the liver or block the damage of the genetic materials. present work is a study to intorch on the use of citrus fruits and its parts in the field of health and a compilation of chemical constituents from the plant.

KEYWORDS: Citrus fruit, health benefits, phytochemicals, phytoconstituents.

INTRODUCTION
Citrus fruits, which belong to the family of*rutaceae*are one of the main fruit tree crops grown throughout the world. Although sweet orange (Citrus sinensis) is the major fruit in this group accounting for about 70% of citrus output. The group also encompasses small citrus fruits such as tangerine tree (Citrus reticulata), grapefruit tree (Citrus vitis), lime tree (Citrus aurantifulia) and lemon tree (Citrus limonum).[1]

Citrus trees are evergreen trees that produce fruits of different forms and sizes (from round to oblong), which are full of fragrance, flavor and juice. It has a rough, robust and bright color from green to yellow skin or rind known as epicarp or flavedo, which covers the fruits and protects from damages. The glands contain the essential oils that give the fruit its typical citrus fragrance.[1,2]

It consists of a white, thick and spongy mesocarp or albedo which together with the epicarp forms the pericarp or peel of the fruit. The internal part constitutes the pulp which is divided into separate segments or juice sacs (with or without seeds, according to varieties) by a thick radical film or endocarp. This part is rich in soluble sugars, ascorbic acid, pectin, fibers, different organic acids and potassium salt that gives the fruit its characteristic citrine flavor. The exact origin of citrus fruits is not clearly identified, although most researchers place its origin to be South East Asia. Later, the citrus fruits were transported to America by the Spaniards, specifically to Mexico, Florida, Brazil and California, where we currently find the largest orange orchards in the world.[2,3]

Citrus fruits are consumed as fresh or utilized for processed citrus products and Citrus-by-products. Approximately, one third of total citrus production is utilized for processing. This proportion in the case of oranges is more than 40% of globally produced oranges utilized for processing. In addition, orange utilization also applies to their juice used as flavorings in beverages.

The most important processed citrus fruits product is orange juice. Orange juice can be presented in different forms. The major types of orange juice are the freshly squeezed orange juice and frozen concentrated orange juice. The juice is squeezed from fresh fruit and packaged in paper cartons, glass or plastic containers, without being pasteurized. The product is clearly labeled and located in the produce or dairy section of the grocery shop with a shelf life of only a few days.[3,4]

It is also typically processed and prepared at home. Traditionally, an important proportion of orange juice consumers have preferred to freshly squeeze oranges at home. The frozen concentrated orange juice is obtained by removing through evaporation, the water from the orange juice of fresh, ripe oranges that have been graded, sorted, washed and strength ration to normal single-strength orange juice. If it is not concentrated, the juice is processed and pasteurized by flash heating immediately after squeezing the fruits, without removing the water content from the juice.

Another is the refrigerated orange juice that has been processed to obtain the frozen concentrate and then reconstituted by adding back the water that had been originally removed. Reconstituted single strength juice is normally reconditioned by the packager or the beverages industry and sold as a ready-to-serve product. In addition, citrus fruits can be processed to obtain other food products such as dehydrated citrus products or marmalades and jams. Citrus essential oils are another by-product of citrus fruits. Essential oils arevolatile oils obtained from the citrus fruits peel's sacks. [1,5]

Citrus fruit peels and leaves have always been odis the imperative attention of different researchers in pharma and cosmeceutical field. The literature on citrus plants has been reported several times by different researchers for different pharmacological activities (Sharma et al., 2015). Moreover, the aroma of essential oil has gained good reputation in aromatherapy. Aromatherapy the alternative medicinal system describes the healing effect by essential oils from plant origin. The volatile oil from citrus fruit has already been reported by several researchers by hydrodistillation (Vashist and Sharma, 2013; Vashist et al., 2014; Costa et al., 2013; Hamdan et al., 2013) and using supercritical carbon dioxide (Atti-Santos et al., 2005). The volatile oil fraction in citrus peels present in the oil duct, oil gland or oil cells beneath the layer of epithelial cells. The oil cells when get ruptured the oil starts to ooze out of the cell through the duct, which get formed during rupturing of surrounding cell layers. It has been reported that populations in several countries opt to the preparations obtained from Citrus species to treat problems related to the nervous system, especially symptoms of anxiety or insomnia (Costa et al., 2013). This may be because of the less side effects from such preparations, which again underlines the importance of citrus extracts in alternative medicinal system. The extraction of volatile oil from leaves and peels of citrus plants has been reported by cold expression method and steam distillation several times but the water distillation has been selected by very less time. So, the present study represents an approach for the extraction of the volatile oil of citrus peel and leaf essential oil by hydrodistillation method.[34]

Like citric acid, calcium citrate has a sour taste. Like other salts, however, it also has a salty taste. This should not be confused with the product commonly found in grocery stores labeled as "sour salt", which is simply powdered citric acid (which only resembles salt superficially. In many individuals, bioavailability of calcium citrate is found to be equal to that of the cheaper calcium carbonate. However, alterations to the digestive tract may change how calcium is digested and absorbed. According to recent research into calcium absorption after gastric bypass surgery, calcium citrate may have improved bioavailability over calcium carbonate in Rouxen-Y gastric bypass patients who are taking calcium citrate as a dietary supplement after surgery. This is mainly due to the changes related to where calcium absorption occurs in the digestive tract of these individuals.[3]

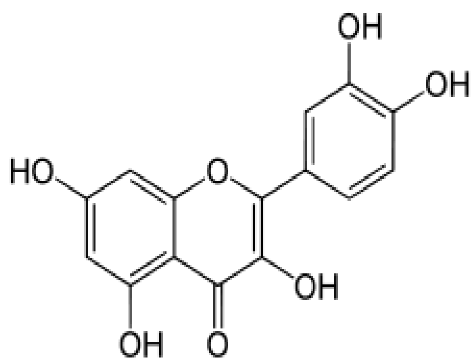
Phyto-Chemicals in Citrus

Phytochemicals constitute one of the most numerous and widely distributed groups of chemical substances in the plant kingdom. Plants produce chemicals known as secondary metabolites that are not directly involved in the process of growth but acts as deterrents to insects and microbial attack. Alkaloids, cyanogenic glycosides, flavonoids, terpenoids and phenolic compounds all fit in this category.[6,7]

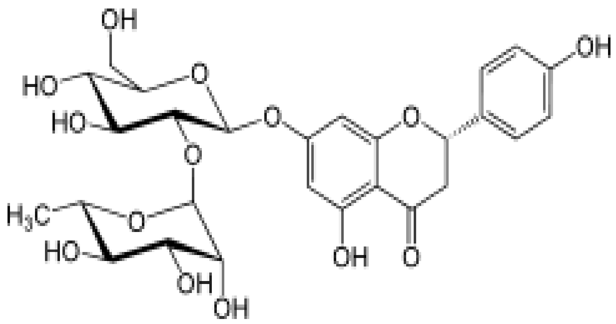
Phytochemicals that possess many ecological and physiological roles are widely distributed as plant constituents. Citrus plants synthesize and accumulate in their cells a great variety of phytochemicals including low molecular phenolic (hydroxy benzoic and hydroxycinnamic acids, acetophenones,terpenoids, flavonoids, stilbenes and condensed tannins. There are about 40 limonoids in citrus with limonin and nomilin being the principal ones. These compounds, which occur in high concentration in grapefruit (C. vitis) and orange juice (C. sinensis) partly provide the bitter taste in citrus.[7,8]

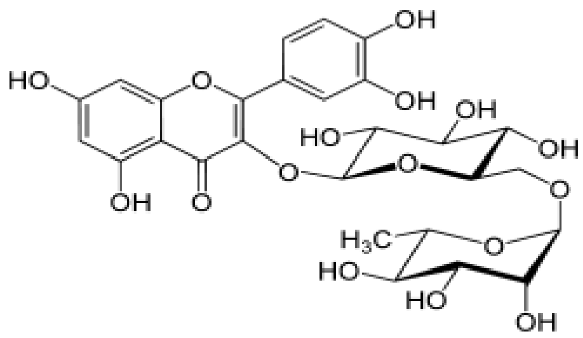
Limonoids possess the ability to inhibit tumor formation by stimulating the enzyme glutathione S-transferase (GST). GST is a detoxifying enzyme that catalyzes the reaction of glutathione with dangerous electrophiles to form less toxic and more importantly watersoluble compounds that can be easily excreted from the body. Orange and lemon oil contain substantial amounts of GST that also possesses anti-cancer activity. [8,9]

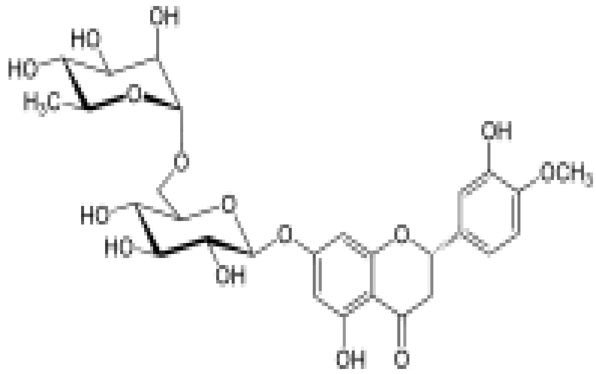
Citrus pulp and the albedo (the white of the orange) are rich in glucarates. These substances are being studied extensively for their potentials in preventing breast cancer and to lower the risk and symptoms of premenstrual syndrome.



(QUERCETIN)







(HESPERIDIN)

Citrus sinensis **Citrus limonum**

Chemical structures of citrus flavonoids

Flavonoids are another phytochemicals found in citrus fruits. The flavonoids have strong inherent ability to modify the body's reaction to allergens, viruses and carcinogens. They show anti-allergic, anti-inflammatory, anti-microbial and anti-cancer activity. Quercetin, rutin, tangeritin, naringin and hesperidin are found amongst the common flavonoids in citrus fruits.

These flavonoids are responsible for the bitter taste of some grape fruits, lemons and oranges. Quercetin is a flavonoid and more specifically a flavonol that constitutes the aglycone of the glycoside rutin. Quercetin is found to be the most active due of the flavonoids and many medicinal plants owe much of their activity due to their high quercetin content.[10]

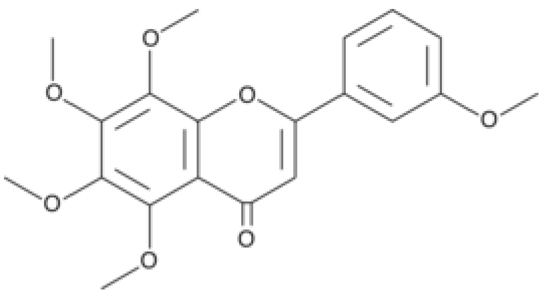
Quercetin has demonstrated significant anti-inflammatory activity because of direct inhibition of several initial processes of inflammation. For example, it inhibits both; the production of histamine and other allergic/inflammatory mediators.[9,12]

In addition, it also exerts potent antioxidant activity and ascorbic acid sparing action. Quercetin also shows remarkable anti-tumor properties. Quercetin may have positive effects in combating or helping to prevent cancer, prostatitis, heart diseases, cataracts, allergies/inflammations and respiratory diseases such as bronchitis and asthma. Hesperidin is a flavonoid glycoside found abundantly in citrus fruits. It'saglycone form is called hesperetin.

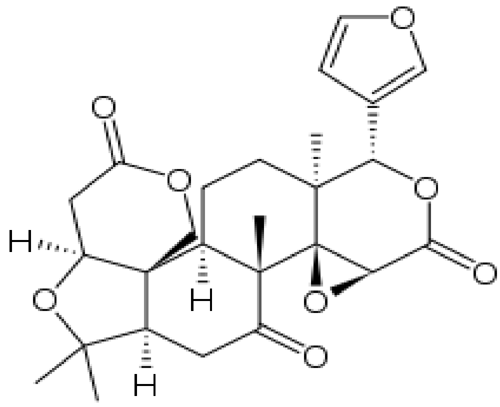
Hesperidin is believed to play a role in plant defence. It acts as antioxidant according to in vitro studies. Hesperidin reduces cholesteroll while hesperidin has anti-inflammatory effects. Hesperitin also showed an ability to penetrate the blood brain barrier in an in vitro model.[13,14]

Another useful citrus flavonoid glycoside is rutin and it is also known as rutoside or quercetin-3-rutinoside, In humans, rutin attaches to the Fe2+ ion and it is, preventing it from binding to hydrogen peroxide and creating a highly reactive free radical that may damage cells.

It is also an antioxidant and therefore, it plays an important role in inhibiting some cancers. Furthermore, rutin strengthens the capillaries and therefore, it can reduce the symptoms of hemophilia. It also helps to prevent edema of the legs.[5] Rutin, as ferulicacid can reduce the cytotoxicity of oxidized low density lipoprotein (LDL) cholesterol and lower the risk of heart diseases. Tangeritin is a polymethoxyleted flavone that is found in tangerine and other citrus pells. Tangeritin shows potential as an anti-cancer agent. It strengthens the cell wall and protects it from invasion.[15,16]



Tangeritin



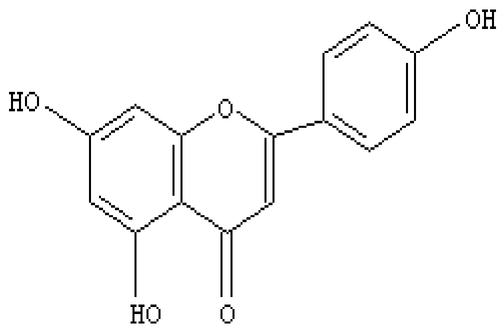
Limoniod

Citrus flavonoids
Flavonoids are known for their ability to enhance the effects of ascorbic acid. Flavonoids protect the vascular system by strengthening, maintaining and repairing Capillaries. Plant flavonoids comprise anthocyanins, proanthocyanins, flavones, flavonols, flavonones, biflavinonoids, flavin-3-4-diol, isoflavones and catechins.[10,11]

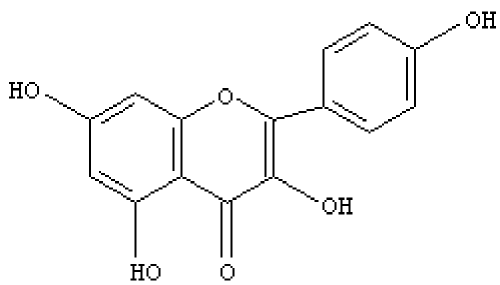
Flavonoids found in citrus species include quercetin, naringin, tangeritin. hesperidin and rutin. The biological function of flavonoids includes action against allergies, inflammation, microbes, ulcers, hepatotoxin, viruses and tumors. Flavonoids are plant water-soluble super antioxidants, which prevent oxidative cell damage and have strong anti-cancer activity and inhibit all stages carcinogensis.

Flavonoids in the intestinal tract are known to lower the risk of heart disease Most citrus species accumulate large quantities of flavonoids during the development of their different organs . All the flavonoids obtained in citrus sp. can be classified as flavonones, flvones and flavonols. Among these groups, flavones and flavonols are found in low concentrations in citrus tissues. These flavonoids (flavones and flavonols) have been shown to have powerful antioxidant and free radical scavenging properties.

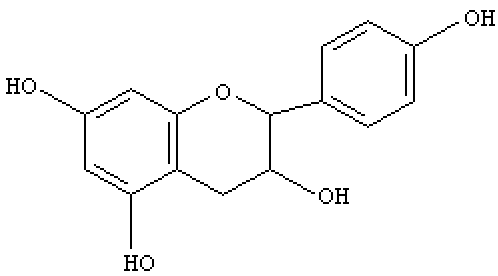
Flavonoids have been reported to act as quenchers of singlet oxygen .Flavonoids are excellent hydroxyl scavengers and according to the studies, these flavonoids possess a degree of effectiveness which depends on their structure. Methoxylated flavonoids are much more active than hydroxylated compounds. Oxidative damage has been suggested to be contributory factor in development and complication of thrombosis. Recently, the beneficial effects of antioxidants from citrus fruits against thrombosis have gained interest.



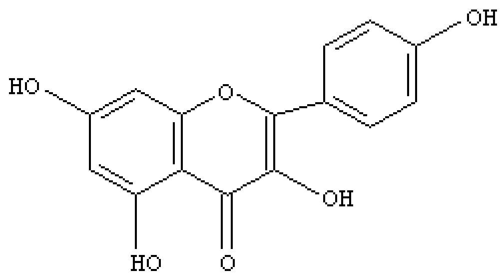
Flavone



Flavonone



Anthocyanin



Flavonol

Antioxidant activity of Citrus flavonoids

Antioxidants are secondary metabolites found naturally in plants such as citrus fruits. An antioxidant can be defined as anything that inhibits or prevents oxidation of a substrate. Aerobic cells undergo metabolism producing free radicals. The oxygen consumption inherent in cell growth leads to the generation of a series of free radicals causing oxidative stress.[10,11] The interaction of these species with molecules of a lipid nature produces new radicals: hydroperoxides and different peroxides. This group of radicals comprising hydroxyl, superoxide and lipids peroxides may interact with biological systems in a clearly cytotoxic manner These species interact with such life essential molecules as nucleic acids and proteins, producing oxidative reactions involving alterations and protein exchange. Citrus phenolic compounds particularly flavonoids have been reported to posses an important antioxidant activity toward radicals. The citrus flavonoids have the ability to capture electrons, block and /or scavenge the radicals. The citrus flavonoids form a tautomeric dislocation, which prevents the propagating chain reactions of these oxygen free radicals. The different radicals responsible for the cell oxidation process are the following: Singlet oxygen; superoxide anion, hydroxyl radical (OH) and peroxyl radical R-O-O.

The hydroxyl radical is the most cytotoxic of all these radicals. Also, polyunsaturated fatty acids present in cell membranes are easily oxidized by both; enzymatic and oxidative preoxidation through free radical chain reaction. Initiation of lipid per oxidation can be induced by free radicals (superoxide, hydroxyl and singlet oxygen) produced in biological systems.[11]

These electrically inert species have the ability to interact and alter genetic constitution. They exhibit catatonic, mutagenic and carcinogenic actions. It has been reported that lipid peroxidation can be inhibited by flavonoids acting as strong radical scavengers and singlet oxygen quenchers. It has also been proposed that citrus flavonoids react with peroxyl radicals; thus, bringing about the termination of the radicals reaction [18, 19]

Nutritional profile of citrus fruits Citrus fibers when taken swells with water; this however increases in volume many times. Consequently this gives consistency to the feces and facilitates its transit through the colon until it is expelled through the rectum, when the diet contains little fiber; the faces are hard, dry and concentrated.

This eventually causes the intestine to make effort to eliminate them. This causes or worsens several problems such as intestinal diverticulum, hemorrhoids and even cancer of the colon. Even though citrus fiber does not provide energy, nor it passes to the blood directly; it is an indispensable component of a healthy and balanced diet.

This is because it is devoid of intestinal constipation. Fiber has a physiological effect on the gastrointestinal function of promoting the reduction of tracolonic pressure, which is beneficial in diverticular disease such as cancer of the colon and hemorrhoids.

Citrus fiber also has a biochemical effect on the absorption and reabsorption of cholesterol and bile acids, respectively. Citrus fiber aids the excretion of bile acids and prevents the reabsorption of bile acids and consequently, the absorption of dietary fat cholesterol pool and prevents the formation of plaque, whose components are cholesterol, some fats and protein.

Citrus fruits have high calorific values. This may be done to the carbohydrate contents which supplies the energies in calories. The carbohydrate content, also acts as mild natural laxative for human being. They also add to the bulk of the diet.

The carbohydrate content of citrus fruits comprises mainly of dietary fiber, sucrose, glucose and fructose. With the exception of dietary fiber, all other carbohydrates (glucose, fructose and sucrose) are water soluble and sweet-tasting sugars.[20]

Production and Consumption

In 2010, the production of citrus fruit worldwide was estimated as 122.5 million tonnes with ~8.7 million hectares harvested; oranges were 50%–62% of the total area harvested and total production. Worldwide, there has been a steady increase of estimated per capita consumption of citrus over the last. However, least developed countries located in areas of Sub-Saharan Africa and Southeast Asia, which generally have the highest proportion of persons with malnutrition and micronutrient deficiencies, also have the lowest consumption of citrus.[21,22]

Despite the growth of the citrus industry in China, people in lower income countries of Africa and Asia consume approximately one-fourth as much citrus as developed countries. In fact, populations in least developed countries consume only 8 g /person/day, six times less than the world average. On the other hand, with the high production of citrus in the U.S., Mexico, Brazil, and Spain it is not surprising that North Americans have the highest estimated consumption /capita /day in the world followed by South Americans and Europeans.

Estimated supply and consumption of citrus by region, per person per day, and the percentage of citrus consumed that is oranges and mandarins 1979-2009.

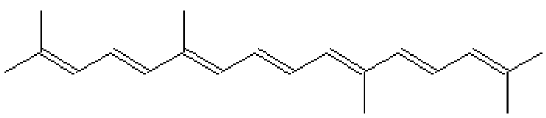
USA production (2011–2012) was 10.6 million tonnes, with 65% from Florida and 32% from California. However, citrus production in the USA has been declining, apparently because of adverse climate events such as hurricanes, freezes, and drought.

The types of citrus produced and consumed vary throughout the world. About 80% of the citrus grown are oranges and tangerines in most of the world, except for Africa. The main citrus crop produced in the USA is oranges, while Japanese consumers prefer tangerines. Most citrus are produced in temperate climates, where they grow well. Harvest losses are moderate, at about 50%.

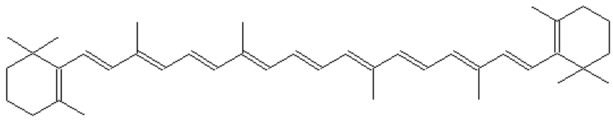
In the U.S., current consumption is estimated at 147 g/person/day, which is very high. The total estimated nutrients contributed by citrus/capita/day in the U.S. in 1970 and 2006. In 2006, citrus contributed more of the dietary intake of all listed nutrients except fiber, which was unchanged from 1970.

Importantly, citrus provides about 25%–28% of vitamin C /capita /day. However, citrus actually contributes a lower proportion of dietary carotenoids and folate in 2006 than in 1970. U.S. residents are now consuming more of these nutrients from other sources (e.g., fortified foods or other fruits and vegetables).

Currently, citrus contributes lesser but non-neglible amounts of vitamin A (mostly derived from beta-cryptoxanthin), folate, fiber and carotene.[23,24,25]



(Central part of carotenoid)



(Beta carotenoid)

Evidence of Health Benefits of Whole Citrus Fruits

The data on individual compounds contained in citrus shows that these can be related to antioxidant activity and health outcomes such as diabetes. However, much of the data can be difficult to place in context of whole foods. Although many of the nutrients and phytochemicals found in citrus may exert positive health outcomes, the combination of these compounds in a whole fruit may have synergistic or antagonistic effects. Evidence is building that citrus fruits as whole foods, not just extracted individual compounds, may provide a plethora of health benefits.[23,24]

In an *in vitro* comparison study of common fruit, lemons exerted very high antioxidant and antiproliferative activities; lemons and grapefruit also decreased proliferation of human liver cancer cells in a dose-dependent manner. In humans, the antioxidant effects of orange juice have been observed with as little as 8 ounces (236 mL) consumed for two weeks. Even in the presence of a high-fat diet or high-fat/ carbohydrate meal, orange juice (containing either 500 mg of vitamin C or 300 kcal (probably ~630 mL) reduced the acute effects of oxidative and inflammatory stress.

Evidence for improved cardiovascular health biomarkers and insulin sensitivity have also been observed in some but not all studies consuming citrus. In obese children, consumption of mandarin juice (500 mL /day for 1 month) reduced biomarkers of oxidative stress, increased antioxidants (vitamin E, C, and glutathione), reduced blood pressure, and lowered insulin or improved insulin resistance homoeostasis.

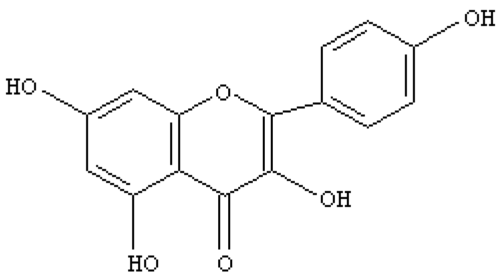
In hypercholesterolemic adults, 750 mL, but not 250 or 500 mL, of orange juice daily for four weeks increased HDL and decreased LDL/HDL ratios as well as increased plasma folate and vitamin C concentrations. However, mildly hypercholesterolemic adults consuming a moderate volume of orange juice (480 mL/day for 10 weeks), did not have an improvement in plasma lipid profiles unless the orange juice was fortified with plant sterols (2 g/day). Also in a small study of healthy adults where 236 mL of orange juice was incorporated into habitual diets three times a day for three weeks, cholesterol concentrations were unaffected.

Fat and weight gain was inhibited by feeding mice blood orange juice (ad libitum in place of water) for three months with a high-fat diet, and enhanced insulin sensitivity, decreased serum triglycerides, total cholesterol, alanine aminotransferase, and reduced liver steatogenisis were observed .Evidence of an anitobesity effect of citrus in humans, however, is lacking.[25,26]

Thus, the evidence for health benefits of whole citrus fruits is sparse, but promising. In summary, the amount of citrus needed to provide health benefits is quite variable but appears to be within reasonably consumable amounts. One to three glasses of orange juice a day appears to provide improvement in antioxidant, cardiovascular, and insulin sensitivity biomarkers as well as increase vitamin C concentrations in plasma and breast milk.

Two large tangerines a day may provide a substantial amount of carotenoids and improve vitamin A concentrations. Contributions to folate, fiber, and phytochemicals in the diet from citrus could also be benefcial, but the amount needed to obtain the health benefits observed in studies is uncertain.

Extracted compounds from citrus from peels and seeds that are generally discarded, such as pectin, flavonoids, and limonoids, may also be beneficial to health, but the amounts needed to have an effect are also uncertain. Many nutrients and phytochemicals are degraded when exposed to light, oxygen, and during extracting procedures.



Flavonone

Thus, whole citrus consumption may provide increased nutritional benefits compared to supplements and sometimes even juices. For example, oranges often contain higher amounts of carotenoids and fiber than orange juice. On the other hand, many compounds such as folate may have limited bioavailability from food or, as in flavonoids, are not present in concentrations in food as high as those used in studies suggesting a health benefit.

Thus, depending on the compound, juices, extracts, or supplements may be a more abundant or bioavailable source of the phytonutrient than whole foods. However, while specific nutritional inadequacies may require the consumption of supplements in certain groups, it is generally recommended that most nutrients be obtained primarily from whole foods rather than from supplements.

Overall, the compounds in citrus, whether obtained from whole foods, extracts, or supplements, appear to havepositive health benefits.[27,28,29]

Barriers of Increasing Citrus Intake and Recommendations

In some areas, such as the U.S., production and consumption of citrus fruit (per capita/day) has declined. In addition, the production of processed citrus in the U.S. (7.3–7.7 million tonnes in 2012 and 10.5–12.7 million tonnes in 1999) and its consumption in top markets (U.S., European Union) has declined.[30,31]

Lower production can be attributed to citrus diseases and fewer new plantings due to low prices in the past, and lower consumption because of greater competition from other fruits now available due to improved logistics in transportation and in packaging.

Although consumption data should be interpreted with caution because it is restricted to the availability of data and is a reflection of availability of food for consumption rather than actual intake, as with most commodities, price and accessibility heavily influence citrus consumption.

The price of citrus at the consumer level is multifaceted and influenced heavily on complex trade matrices, thus there have been calls for reforms in the citrus industry for promotion of long-term relationships along the supply lines to consumers allowing the “share of risk of price and yield variability and costs of marketing promotion, and on-going R&D”.

Increasing domestic production, improving current yields, and investing in transportation, storage, and production infrastructure, especially in developing countries, may improve accessibility, which can influence price. Agriculturalists, governments, and industry can provide assistance in increasing production and trade and provide information to improve citrus varieties.

For example, some nutrients and phytochemicals can be increased by not only selecting for nutrient-rich varieties of citrus, but also by manipulating external conditions and harvesting times.

Vitamin C can be increased by increasing potassium and maintaining adequate zinc, magnesium, and copper in the soil, and can be negatively affected by elevated nitrogen from fertilizer; growth and storage in cooler temperatures, and growth in direct sunlight can also increase and retain vitamin C in citrus as well as the type of rootstock the citrus is grafted on.

Another barrier is a dearth of knowledge about the nutrient content, bioavailability, and potential health benefits of citrus varieties grown in tropical areas. Currently most research and development has been done using common citrus fruits grown in temperate climates, such as oranges, lemons, and mandarins.

Encouraging research on lesser known citrus varieties, and developing citrus varieties capable of expanding into new environs might increase consumption in low income countries that currently lack sufficient domestic citrus production and extend the potential health benefits of citrus to these populations. Finally, promoting the nutritional and health benefits of citrus may correspondingly encourage consumption.[32,33]

CONCLUSION

It is significant to note that soft drinks that are so called lemonade or that they are made of lime not only lack medicinal properties but are also noxious for health due to their contents of carbonic gas, artificial coloring and aromatizes and sugar or other flavors.

The herbal vitamins are dietary supplements and may be used safely as preventive health measure for nutritional values. Herbal vitamins are manufactured from parts of specific plants such as seeds, roots, stems, barks, leaves, berries or capsules or pills.

The best way to take advantage of the many medicinal virtues of lemon, lime, grapes and other citrus juice is to consume them just after they have been squeezed from the fruits.

It was concluded that the peels of C. aurantium, C. maxima and C. pseudolemon provided maximum percentage of essential oil which could be a rich source of essential oil. Whereas, percentage C. medica, C. sinensis, C. aurantium may be an intermediate source. But C. maxima and C. reticulate leaves are poor source.[34]

All sour citrus fruits were reported to provide more amount of calcium citrate than sweet varieties. Calcium citrate is a better intervention to all other available salts as calcium salt supplement, antioxidant and antacid. Present report on the percentage yield of calcium citrate may help to select high yielding source of the salt. The hydrodistillation of orange peel was performed which further lay a new method and less time consuming and less tedious method for the extraction of volatile oil from citrus fruits peel.[35]

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