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VITAMIN C AND BEYOND

The health benefits of a plant-rich diet are well established. And nutritionally, citrus offers a lot more than just vitamin C. By **Paula Bester**

The Nutrient Rich Foods (NRF) Index is a formal scoring system ranking foods on their nutrient content. This index was previously paired with a food price database and identified citrus fruits and juices as both nutritious and affordable, giving consumers the highest nutrients per unit cost.[2,3] In light of the challenging times we live in and the universal desire to pursue healthier lifestyles and immune boosting diets, this article aims at providing some insight on the potential health benefits related to citrus consumption.

If we imagine a single citrus fruit as a pie chart, its proximate composition in descending order would be water (85-88%), sugars (9-11%), fibre (0.3-1.7%), protein (0.7-1.5%), essential oils (0,5 -5 % of the peel), vitamins, minerals, and non-nutritive phytochemicals in trace amounts.[1,2] There are many intriguing compounds within the phytochemical group, including the flavonoids, and their significance may very well outweigh their concentration.

Flavonoids

The subclasses of flavonoids found in citrus are the flavanones (generally the most abundant in citrus), flavones, flavonols, chalcones, anthocyanins and flavanonols.[3,4] Flavonoids give flowers and fruits their colour and aroma, which attract pollinators, and they protect plants against extreme environmental conditions such as frost and drought.[3] Flavonoids have been the topic of many research studies due to their miscellaneous health promoting effects, including anti-oxidants, and being anti-inflammatory, anti-carcinogenic, anti-microbial and anti-diabetic, amongst many others.[3,5,6,7] These are some bold claims, but here things start to get interesting. Although there is still much to learn in this avenue on how exactly phytochemicals work inside our bodies, there is already a substantial amount of research to showcase this.

If you consider the chemical structure of flavonoids, they all share the same basic skeleton, rich in double carbon-hydrogen bonds and hydroxyl (–OH) groups, enabling them to donate electrons (H·) to highly reactive free radicals.[5] In essence, these phytochemicals protect our cells this way, by neutralising free radicals so that structures within our own cells do not get oxidised, hence the term anti-oxidants. What a noble sacrifice!

Flavanones are introduced in our diet almost exclusively through citrus fruits and juices, besides through some herbs such as mint.[7,8] Taking this into account,

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it's much easier to consume a few citrus fruits than hands full of mint leaves! The most abundant flavanones in citrus fruits are hesperidin, followed by naringin and others.[4] Grapefruits are high in naringin, while oranges, mandarins, lemons and limes are rich in hesperidin, especially in the peels and albedo or white regions.[7] This explains why the consumption of whole citrus fruits are encouraged, implying a greater phytochemical intake.[9] Nonetheless, a glass of grapefruit juice contains approximately 300 mg naringin and orange juice around 150 mg hesperidin.[7]

COVID-19

Hesperidin has recently been in the limelight for its ability to bind to major proteins involved in SARS-CoV-2 infections.[10] Although its inhibitory effect seems to vary between studies, hesperidin has previously shown antimicrobial, -viral and -fungal activities. [11, 12, 13] Dried bitter citrus fruits and citrus peels known as "Chenpi" in Chinese, are used in traditional Chinese medicine as a lung cleansing and detoxifying decoction (LCDD). This decoction is now officially recommended by the National Administration of Traditional Chinese Medicine as a treatment for COVID-19. The main active ingredients in this medicine are the citrus flavones that are abundant in especially citrus peels.[14]

Obesity, cholesterol and bowel health

Flavonoids may help treat obesity due to their ability to modulate mechanisms involved in fat metabolism. Citrus fruit and juices show potential to induce fat breakdown, reduce fat accumulation and regulate enzymes associated with obesity.[15] Lemon phytochemicals may suppress the development of diet-induced obesity, improve insulin resistance and lipid metabolism

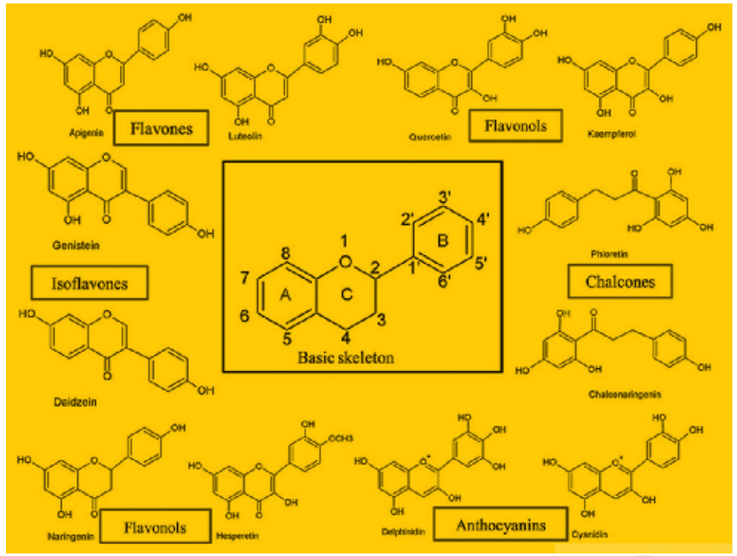

Figure 1. Basic skeleton of the flavonoid structure with the subclasses generally present in citrus fruits and juices. Panche, A.N., Diwan, A. D. & Chandra, S.R. (2016).[6]

and orange juice demonstrated potential as a weight management agent through interestingly regulating gene expression. [16,17]

Dietary fibre can either be water soluble, or insoluble. The latter is fermented by our gut bacteria and is connected with carbohydrate and lipid breakdown, while the former reduces fecal transit time, keeping us regular. Pectin is the primary fibre in citrus and is linked to numerous bowel health benefits.[25] Pectin intake has shown to reduce low density lipoproteins, known as the "bad" cholesterol type, which clogs artery walls over time and increases the risk of heart diseases and strokes.[18, 26] Pectin helps maintain the thick mucus layer which forms part of our gut barrier and is known to bind and remove heavy metals from our digestive tract. It has also been linked to combatting bowel cancer, inhibiting the aggregation of Alzheimer's disease, and mysteriously relieving allergies by promoting growth of certain beneficial gut bacteria.[26] The satiety effect of fibre from a diet high in whole citrus fruits can assist with better portion control and weight management.

Anti-cancer

Although not entirely understood, the proposed anti-cancer mechanisms of phytochemicals include a protective effect against free radicals, the effects on cell differentiation, catalytically effect on enzymes involved in detoxing carcinogens, blocking nitrosamines (known carcinogens) and inhibiting cell proliferation.[18, 19] Numerous studies have focussed on the anti-cancer properties of citrus fruit juices and their extracts, with varying success rates[19], most likely through a synergistic effect of many of these phytochemical compounds in whole citrus fruits.

Benefits we just can't deny

Humans cannot produce vitamin C or ascorbic acid, and the deficiency thereof leads to scurvy, making it an essential vitamin. It is debatable whether vitamin C actually reduces the incidence, duration or severity of the common cold.[20] However, we do know that as an anti-oxidant it helps combat damage caused by free radicals, as is the case with flavonoids. Furthermore, there is a connection between vitamin C intake and a favourable effect on blood pressure and heart and blood vessel membrane function, supporting the hypothesis that vitamin C contributes to preventing or treating heart diseases.[21] Vitamin C intake is needed for collagen formation, which is one of the main connective tissues in our bodies, forming a grand ~30-40% of our body's protein content.[24] Collagen forms part of our skin, tendons and ligaments, blood vessels and bones. The weakening of these tissues, like poor wound healing, is often connected to a vitamin C deficiency.[18,24] Furthermore, vitamin C plays a pivotal role in the absorption of non-haem iron from plant sources. Regularly consuming citrus fruits, especially if you follow a meat-free diet, may prevent the onset of an iron deficiency and anaemia.[18] Citrus juices and pulps are considered rich in vitamin C and they typically provide 100% or more of the dietary reference Intake.[15, 22]

Moderate inclusion of 100% citrus juices as part of a balanced lifestyle is encouraged to meet several key nutrient dietary recommendations.[15] For a sustained flavonoid effect, regular consumption of citrus fruits and related products are required, because of the short half-life of these active ingredients. Indeed, 24 hours after the ingestion of orange juice, the urinary elimination of phytochemicals was nearly complete and the metabolites were no longer present in plasma.[10] The total phenolic composition and subsequent total anti-oxidant effect differ significantly among citrus cultivars and is dependent on the climate, environmental conditions and fruit maturity.[4] It's thus best to incorporate a variety of citrus fruits in the diet.

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