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Oranges, potatoes and phytonutrients; why are they good for human health

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Abstract

Dietary chemoprevention has emerged as a cost-effective approach to control most prevalent chronic diseases including cancer. Changes in dietary patterns and lifestyle, such as increasing the consumption of fruits and vegetables and more balanced intakes of meat and plant foods, are a practical and effective strategy for reducing the incidence of chronic diseases. Phytonutrients (or phytochemicals) are found in eatable fruits and vegetables that, daily ingested, may exhibit a potential for modulating human metabolism in a manner favourable for the prevention of chronic and degenerative diseases. Carotenoids and flavonoids (anthocyanins, phenolic acids, polyphenols) are examples of phytonutrients. Consumption of total phytochemical intake has been consistently linked to protection from chronic diseases, including cardiovascular disease, cancer and neurodegenerative diseases. To highlight the beneficial health effects of phytonutrients in plants, we choose two interesting plants, the potato and the citrus fruits. They were chosen owing to their phytonutrient content, and low price, which makes them more easily acquired in low incoming populations, and consequently they are highly consumed not only in developing but also in developed countries. Due to its high nutrient and phytochemical content, the potato can lower oxidative stress, a key mechanism for cancer and cardiovascular disease prevention. Its phenolic compounds act as antioxidants and improve heart health. Furthermore, this review emphasizes the bioactive compounds in citrus which can reduce inflammatory mediators and reactive oxygen species generation, thus attenuating the risk of neurodegenerative diseases, cardiovascular disease, diabetes, and cancer. Besides important applications in the functional food sector, phytochemicals are also employed in the production of cosmetic and/or cosmeceutical products.

Keywords

Oranges; potatoes; phytonutrients; chemoprevention; antiinflammatory; anti-oxidative stress

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1. Introduction

Dietary chemoprevention has emerged as a cost-effective approach to control most prevalent chronic diseases including cancer (Bhuvaneswari and Nagini, 2005; Kotecha et al., 2016). Humans depend on plants as primary food sources, not only to gain access to basic carbohydrates and amino acids, but also for a variety of metabolites that we lack the ability to synthesize (Hellmman et al., 2021). Plants make an array of beneficial organic molecules for human physiology, such as numerous antioxidants, which inhibit oxidative processes. In principle, this is mostly related to the presence of reactive oxygen species (ROS) that can quickly undergo redox reactions in the cell, and thereby significantly alter and damage other metabolites, DNA, proteins or fatty acids (Hellmann et al., 2021).

The Academy of Nutrition and Dietetics (formerly the American Dietetics Association) has recognized that a well-planned vegetarian diet is beneficial and nutritionally adequate, and appropriate for human growth and development (Fresan and Sabate, 2019). This suggests that changes in dietary patterns and lifestyle, such as increasing the consumption of fruits and vegetables and more balanced intakes of meat and plant foods, are a practical and effective strategy for reducing the incidence of chronic diseases.

2. Phytonutrients

Phytonutrients commonly called phytochemicals, are biological non-nutrient active chemicals produced by plants that have drawn attention, regarding food, health and cosmetic issues (Pan et al., 2018). They are found in eatable fruits and vegetables that, daily ingested, may exhibit a potential for modulating human metabolism in a manner favourable for the prevention of chronic and degenerative diseases (Tripoli et al., 2007; Gupta and Prakash, 2014; Monjotin et al., 2022; Lu et al., 2013).

More than 5000 individual dietary phytochemicals have been identified in fruits, vegetables, whole grains, legumes, and nuts, but a large percentage of them remain unknown. Many studies, including animal models, population observations and clinical trials, have investigated the protective effects of dietary phytochemical intakes from food. A wide variety of fruits and vegetables provide a range of nutrients and various bioactive compounds including phytochemicals, vitamins (vitamin C, folate, and pro-vitamin A), minerals (potassium, calcium, and magnesium), and fibers. It has been suggested that phytochemicals consumed as a part of their natural food matrix may be more bioactive than a high dose of isolated phytochemicals provided by dietary supplements. This may be attributed to phytochemicals working synergistically with other phytochemicals that are inherently present in the food. Furthermore, their bioactivity may also be attributable to the interactions between the phytochemicals and other nutrients (e.g,, vitamin C) or other constituents or contaminants in the food. (Liu, 2013). Previous studies have shown that phytonutrients are effective in preventing and mitigating a variety of diseases and physiological disorders, thus imposing a tremendous impact on the medical and health care system (Kan and Wu, 2022).

Consumption of total phytochemical intake has been consistently linked to protection from chronic diseases, including cardiovascular disease, cancer and neurodegenerative diseases (Probst, 2017). Phytonutrients are not essential nutrients, however they have important properties such as antioxidant activity, antimicrobial effects, modulation of detoxification enzymes, stimulation of the immune system, decrease of platelet aggregation and modulation of hormone metabolism, and anticancer property (Ditu et al., 2018) (Simran, A., 2020). Phytonutrients are health-promoting compounds that can lower the risk of heart disease, cancer and other diseases; they include carotenoids and flavonoids (anthocyanins, phenolic acids, polyphenols). The antioxidant capacity of fruits is related to their contents of anthocyanins, phenolic compounds, carotenoids, ascorbic acid, and vitamin E. (Gonzalez-Aguilar, 2011; Espín et al., 2007; Zehiroglu, 2019; Cömert, 2020).

Terpenoids or isoprenoids are one of the largest groups of secondary metabolites of plants. Under this umbrella are included carotenoids, saponins, tocopherols, and isoprenoid derivatives, as well as isoprenoid derivatives (Wildman, 2016; Ditu, 2018; Tholl, 2015). Carotenoids and their derivatives are versatile isoprenoids involved in many varied actions, hence their importance in the agri-food industry, nutrition, health and other fields. All carotenoids are derived from the colorless carotenes phytoene and phytofluene, which are oddities among carotenoids due to their distinct chemical structure. They occur together with lycopene in tomato and other lycopene-containing foods. Furthermore, they are also present in frequently consumed products like oranges and carrots, among others (Melendez, 2015).

Carotenoids are ubiquitously present in nature, and more than 750 structures and geometrical isomers have been identified in plants, algae, fungi, and bacteria (Mercadante, & Egeland, 2004; Zhu et al., 2022). Carotenoids are composed of two main groups: (i) the highly unsaturated hydrocarbons (α, β-, and γ-carotene, lycopene), (ii) xanthophylls (lutein, β-cryptoxanthin, and zeaxanthin) (Holzapfel et al., 2013). Carotenoids can be associated to fatty acids, sugars, proteins, or other compounds that can change their physical and chemical properties and influence their biological roles (Rodriguez-Concepcion et al., 2018).

Flavonoids, especially their glycosides, are the most important polyphenols in our diets with an extensive spectrum of benefits for human health, including antioxidant, anticancer, anti-inflammatory, anti-diabetes, and antiviral activities (Dias et al., 2021; Ullah, 2020; Xiao et al., 2015; Xiao, 2016). However, recent findings have demonstrated that besides having antioxidant properties, polyphenols can affect cellular signalling cascades thus regulate the activity of transcription factors, and consequently alter the expression of genes involved in cellular metabolism and survival (Zhang, 2016). Fruits and vegetables rich in antioxidants are perishable and difficult to preserve as fresh products, which can be resolved by drying.). In general, the freeze-drying is a better drying method to preserve antioxidants and leads to higher extraction efficiency of antioxidants (Kamiloglu et al. 2016).

Rowles and Erdman (2020) and Koklesova et al. (2020a,b) intimated that approximately two of every five people will develop cancer in their lifetime, associated with irreversible impairment of cellular homeostasis and function. Dietary modifications are one of the most promising lifestyle changes that can adjust the risk of developing cancer by nearly 40%. Despite non-modifiable risk factors (such as age or heredity), approximately 85–90% of cancers are driven by environmental factors that are mostly determined by lifestyle (Krinsky and Johnson, 2005). Epidemiological studies have correlated diet with cancer incidence and aggressiveness. Among these studies, several carotenoids have been associated with a protective effect in various types of cancer (Rowles and Erdman, 2020). To substantiate the importance of phytonutrients for human health, here we discuss two important, widely consumed and cheap foods, a tuber, the potato, and a fruit, citrus fruit, predominantly the orange. Accordingly, we may also highlight that millions of people have access to these two foods in developed or developing countries.

3. Potatoes

3.1. Basic information about the potato

Potato (Solanum tuberosum L.) belongs to the Solanaceae family, about 90 genera and 2,800 species. The cultivated potato originated around 8,000 years ago near Lake Titicaca, which sits at 3,800m above sea level in the Andes Mountain range of South America, on the border between Bolivia and Peru (Ekmekcioglu, 2018; Haverkort, 2013). (Verastegui-Matínez, 2023; Sahir et al., 2018).

The extraordinary adaptive range of the potato crop, combined with its relative ease of cultivation and high nutritional value, has led to steady increases in potato consumption in developing countries. In fact, the developing world's potato production exceeded that of the developed world for the first time in 2005 (FAO 2014). The potato is presently the fourth most important staple food crop in the world after maize, wheat, and rice, with a production of 368 million tonnes (Akyol H et al., 2016). Moreover, potato and wheat need less water compared to rice. In addition, the potato has the lowest carbon footprint of the three (Robertson, 2018).

In the last two decades, there has been a dramatic increase in potato production and demand in Asia, Africa, and Latin America. China is now the biggest potato producer, and almost a third of all potatoes are harvested in China and India (Devaux, 2014). Potatoes are important, affordable food in our diet for hundreds of years with known economic and health consequences. As a staple food, the potato plays an important role in global food security, providing a sustainable food supply and lessening poverty and malnutrition in many parts of the world as highlighted in the Food and Agriculture Organization of the United Nations (FAO) review 'International Year of the Potato' (Devaux et al., 2021).

Potatoes processing throughout the world is moving from fresh to processed product such as fries, chips, canned and mashed potatoes and ready meals. Apart from being one of the main and most consumed types of food by the world population, the potato waste formed by peel and damaged potatoes with a rich source of valuable compounds is also applied in bio-fuel production or animal feed. In addition, potatoes afford remarkable medicinal value used in any form viz, mashed, raw, boiled and peeled.

The USA is the fifth largest potato producer in the world with more than 422,000 ha harvested in 2017 and a total output of almost 20 million tonnes (FAOSTAT 2024). Although in the USA potato is no longer the traditional staple of the past, it is nevertheless gaining increased appreciation by nutritionists because of its nutrient density, which means that for each calorie of potato eaten there is an ample return of essential nutrients and its contribution to a more balanced diet (Bohl and Johnson 2010). The competitiveness of the potato industry has established Europe as the world's biggest net potato exporter, accounting for more than 60% of all exports of fresh potato and a similar percentage of global exports of French fries (Çalışkan et al., 2023).

Sahair R et al. Submitted to International Journal of Phytomedicine Page 2 of 10 The food system, along with dietary choices, affect the health of individuals and populations as well as the natural environment (Fresan and Sabate, 2019). Potato can be promoted as a healthy and versatile component of a nutritious and balanced diet including other vegetables and whole grain foods. From a human nutrition perspective, potatoes are an essential source of energy (carbohydrates 22% and fats 0.1%), proteins (2%), and micronutrients like iron and zinc. They also provide key nutrients including vitamin C, potassium, and dietary fibre (Robertson, 2018; Devaux, 2021) identified white potatoes (including fried), sweet potatoes, beans, carrots and some dark green vegetables as both affordable and nutrient-dense (Drewnowski, 2013). Apart from starch, crude fiber, vitamins, amino acids, and minerals, the tubers are a source of bioactive compounds incorporating various phenolic compounds which constitute the bulk of natural antioxidants (Devaux, 2021).

Many varieties of potatoes offer nutritional quantities of ascorbic acid (up to 42 mg/100 g), potassium (up to 693.8 mg/100 g), dietary fiber (up to 3.3%), and other healthy bioactive components, with lesser amounts of protein (0.85%–4.2%) (Burlingame et al., 2009). The amino acid profile is superior to cereals and legumes.

3.2. Phytochemicals in potatoes

Potatoes also contain a variety of phytonutrients (see Figure1), most notably carotenoids and phenolic acids (Brown et al. 2005; Lu et al. 2013; McGill 2013) and are the largest contributor of vegetable phenolics to the American diet (Song et al. 2010). A Russet potato, one of the favourite varieties in North America, contains the second highest antioxidants only slightly after broccoli in its hydrophilic antioxidant capacity.

Polyphenols—Polyphenols, abundant micronutrients in our diet, protect cells and body chemicals against damage caused by free radical, and they have more beneficial antioxidants in vitro than tocopherols and ascorbate. Antioxidant properties of polyphenols arise from their high reactivity as hydrogen or electron donors, and from the ability of the polyphenol derived radical to stabilize and delocalise the unpaired electron (chain-breaking function), and their ability to chelate transition metal ions (termination of the Fenton reaction) (Song et al. 2010).

Phenolic compounds—Phenolic compounds are particularly heterogeneous type of secondary plant metabolites which can broadly be categorized in phenolic acids. The major phenolic acids in potato are cinnamic acid and its derivatives, although benzoic acids such as gallic and protocatechuic acid are also present. The phenolic acid profile in potato is reported to contain chlorogenic acid (50.3%) caffeic acid (41.7%), gallic acid (7.8%), and protocatechuic acid (0.21%) (Visvanathan 2016).

Most of the phenolic acids in potato are present between the cortex and the peel of the potato tuber, and their content reduces towards the center of the tuber. These phenolics and amino acids present with antioxidant protection towards tissue damage, reactive oxygen species and diseases like atherosclerosis, diabetes mellitus, renal failure, and cancer. (Akyol, 2016; Hellmann et al., 2021).

Chlorogenic acid represents up to 80% of total polyphenols (Perla et al., 2012) Chlorogenic acid is reported to play an important role against the development of diabetes and hypertension and has also been reported to exhibit several desirable anticarcinogenic properties. Chlorogenic acid has strong antioxidant activity and potatoes are an excellent source of this. This partially explains the protective role of potatoes against the development of many chronic diseases. (Hellmann H 2021; Joly et al 2020).

Quercetin—Quercetin is a flavonoid found in highest amounts in red and russet potatoes (Brown 2005) and has demonstrated antioxidant and anti-inflammatory properties in vitro and in vivo (Kawabata et al. 2015).

Catechins—Catechins are potent antioxidants which had been associated with several potential health benefits, although is only a minor constituent in potato (10–13mg/100 g FW), as used to be observed in some cultivars. The group of catechins belong to the group of flavonoids. Catechins exhibit the strong property of neutralizing reactive oxygen and nitrogen species (Musial et al., 2020).

Anthocyanins—Anthocyanins pigments, also belonging to the widely distributed flavonoid group, are bioactive plant polyphenols with known salutary effects. Cultivated varieties of potato incorporate various amounts of anthocyanins and carotenoids within the tuber skin and flesh. Anthocyanin pigment is responsible for the purple and red colours of potato varieties. Potato anthocyanins have been recognized for their contributions to health, as they have been shown to have strong antioxidative activity, anti-influenza virus activity and anti-stomach cancer activity (Mori et al.,2010). Some studies have found that potato anthocyanins can inhibit the growth of the cell line of human erythrocyte leukaemia and their potential anti-cancer role in stomach, pancreatic and breast cancers. (Zhao et al 2009). Anthocyanins are involved in response to various environmental stressors such as excessive light, UV-B radiation, drought, and pathogen attack (Li et al., 2023).

The carotenoid present in four white and yellow-fleshed potato cultivars (S. tuberosum) was identified by antheraxanthin, violaxanthin, zeaxanthin and lutein, which are present at different proportions, whereas β-cryptoxanthin, β-carotene and neoxanthin, are minor constituents (Breithaupt, 2002; Brown et al. 2005).

Glycoalkaloids—Glycoalkaloids (Steroidal alkaloids) are produced in potatoes during germination and serve to protect the tuber from pathogens, insects, parasites and predators (Woolfe 1987; Friedman 2006). The primary glycoalkaloids in domestic potatoes are α-chaconine and α-solanine and are found in the highest levels in the outer layers of the potato skins (i.e., the periderm, cortex, and outer phloem) (Friedman, 2006).

Like other plant phytonutrients, glycoalkaloids not only have toxic effects but also beneficial effects including cholesterol lowering, antiallergic and antipyretic effects (Friedman 2006). Additionally, recent studies have demonstrated that these compounds also possess useful properties such as anticancer and anti-inflammatory effects depending on dose and conditions of use particularly (Mohammad, 2016). α-Chaconine has demonstrated identical anticancer activity to that of the commercial anticancer drugs such as tamoxifen (Sahair et al., 2018).

Because of the antioxidative nature of potato phytochemicals, consumption of good quality potato can make contributions to the prevention of LDL oxidation, therefore lower the risk of cardiovascular and heart diseases (Hellmann, 2021).

3.3. Other beneficial nutritional components in potatoes

Potatoes provide one of the most concentrated sources of **potassium** significantly more than those foods commonly associated with being high in potassium, such as bananas, oranges, and broccoli (DGA 2015) (Drewnowski 2013). Potatoes concerning high potassium content are associated with beneficial effects on the reduction of blood pressure (Binia, 2015) and a decreased risk of chronic disease (So, 2020) (Goyer, 2011).

Potatoes are a natural source for both iron and folic acid, which are essential for formation of red blood cells finding their application in aiding treatment of different forms of anaemia. With their high mineral and organic salt content potatoes are recommended as one of the best anti-inflammatory foods for arthritis (Sahair R 2018). At the domestic circuits raw potatoes with their antiirritating, soothing and de-congesting properties are best applied for healing wounds caused by burns or rashes.

4. ORANGES

Citrus fruits are one of the most prominent categories of fruit and vegetables, both because of their production volume and trade. In the last thirty years citrus production worldwide has continued to steadily increase and is now reaching more than 130 million tonnes, representing a growth of around 125% (World Citrus Organization, 2024). Citrus is an important horticultural crop with global, economic and nutritional value. Carotenoids represent the main pigments in citrus fruits and contribute to the esthetic and nutritional value (Zhu et al., 2022).

Carotenoids in oranges

Carotenoids in oranges, as one of the most widespread fruit crops, citrus has the largest number of carotenoid species. More than 115 carotenoid compounds have been discovered in citrus, including β-carotene, lycopene, β-cryptoxanthin, zeaxanthin and neoxanthin (Xu et al., 2006; Zacarías-García J., 2022).

The peel and pulp of citrus fruits are among the richest source of carotenoids, with hundreds of micrograms per gram of tissue and more than 100 different carotenoids identified (Bramley et al., 1993; Rodrigo et al., 2003; Stewart and Wheaton, 1973). Carotenoid content and composition can vary greatly among citrus species, depending on the growing

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conditions and determines the distinctive pigmentation of citrus fruits (Gross, 1987). In coloured citrus fruits, such as oranges and mandarins, epoxy and hydroxylated carotenoids are the major components and account for up to 80% of total carotenoids. (Xu et al., 2006; Lu et al., 2016; Lu et al., 2021; Rodrigo et al., 2003; Lado et al., 2016; Saini et al., 2022).

Carotenoids are indispensable for both plant survival and human health. Carotenoids participate in many essential processes in plants, such as photosynthesis, quenching reactive oxygen species, hormone biosynthesis, and pollination (Cazzonelli and Pogson, 2010; Zhu et al., 2022). In addition, carotenoids can ameliorate various chronic diseases in humans by serving as precursors for vitamin A and antioxidants (Fiedor and Burda, 2014; Harjes et al., 2008; Wurtzel et al., 2012). Vitamin A is essential for multiple functions in mammals; without vitamin A, mammals cannot grow, reproduce, or fight off disease (Olson, 1989). Mammals possess at least two different kind of oxygenase enzymes able to cleave carotenoids to give retinoids, apocarotenoids and other oxidized derivatives (Lietz et al., 2012; Sui et al., 2013; Olson, 1989). However, humans are unable to de novo synthesize carotenoids and must necessarily uptake them through the diet (Meléndez-Martínez et al., 2015).

Several health benefits have been attributed to carotenoids or to foods rich in these pigments, via multiple mechanisms-of-action carotenoids also have been implicated in cancer therapy secondary to inhibition of pathways involved in cell growth. Other pathways commonly modified by carotenoid consumption are related to their antioxidant activities (Rodriguez-Concepcion et al., 2018). They also include anti-inflammatory effects and enhance the immune system function. As antioxidants, carotenoids in both plants and animals mitigate oxidative stress by interacting with singlet oxygen and reducing the range of free radicals protecting cell membranes from oxidative damage. (Bohn, 2019). It has been suggested that carotenoids can protect lungs from early carcinogenic events through their antioxidant activity (Shree et al., 2017). Moreover, carotenoids can be cleaved to produce compounds that modulate growth, such as abscisic acid (ABA) and strigolactones, as well as other bioactive molecules (Holzapfel et al., 2013). The most studied carotenoids in this regard are β-carotene, lycopene, and zeaxanthin (see Figure 2). β-carotene and lycopene are hydrocarbons and belong to a class of carotenoids called carotenes that are very fat-soluble. Lutein and zeaxanthin belong to a class of carotenoids called xanthophylls, which are well known due to their characteristic colors in a range of yellow to red spectrum (Koklesova, 2020a,b; Krinsky and Johnson, 2005). Because xanthophylls contain at least one hydroxyl group, they are more polar than carotenes. Thus, β-carotene and lycopene tend to be localized predominately in the low-density lipoproteins (LDL) in the circulation, whereas lutein and zeaxanthin are more evenly distributed among both LDL and high-density lipoprotein (HDL) (Clevidence and Bieri, 1993). In part, the protection by carotenoids is thought to be through their antioxidant activity, but other mechanisms of protection may exist.

Cancer incidence and mortality are rapidly growing worldwide, especially due to heterogeneous character of the disease (Koklesova et al, 2020a,b). Abundant data on carotenoids efficacy in attenuating carcinogenesis is available (Rowles and Erdman, 2020). At the cellular level, carotenoids exert anti-cancer effects by modulating several signalling pathways that influence cell proliferation, apoptosis, cell cycle progression, angiogenesis, and metastasis, thereby impacting the mechanisms of cancer cell spread (Tanaka, 2012; Rowles and Erdman 2020; Niranjana, 2015).A large number of studies have demonstrated that purified carotenoids (β,β-carotene, β,α-carotene, lutein, zeaxanthin, lycopene, fucoxanthin, astaxanthin, neoxanthin) exert a direct antiproliferative activity on cancer cells grown *in vitro* and induce their apoptosis (Pasquet and Morisset, 2011).

Apocarotenoids, derived carotenoid compounds, have a broad spectrum of anti-cancer effects involving pro-apoptotic signaling through extrinsic and intrinsic pathways. As demonstrated in preclinical oncology research, the apoptotic modulation is mediated at post-genomic levels. Further, carotenoids have additive/synergistic action in combination with conventional oncostatic (Koklesova et al., 2020). Recent studies revealed a significant role of carotenoids in the treatment of neurodegenerative diseases. *In vitro* and *in vivo* studies supported the beneficiary role of carotenoids (namely lycopene, β-carotene, crocin, crocetin, lutein, fucoxanthin and astaxanthin) in alleviating neurodegenerative disease progression. These carotenoids provide neuroprotection by inhibition of neuroinflammation, microglial activation, excitotoxic pathway, modulation of autophagy, attenuation of oxidative damage and activation of defensive antioxidant enzymes. Additionally, studies conducted on humans demonstrated that dietary intake of carotenoids lowers the risk of neurodegenerative diseases (Manochkumar et al., 2021).

Phytoene and phytofluene can be considered as rarities within the “Carotenoid Kingdom” as they are colorless. However, they are key carotenoids because they are precursors of all the others. They are known to occur in widely consumed foods like tomatoes, some citrus, carrots, being also bioavailable. Likewise, they are among the predominant carotenoids in human plasma and tissues (Mapelli-Brahm et al., 2017; Meléndez-Martínez et al., 2015).

Meléndez-Martínez et al. (2018) studied an ordinary orange variety Navel (concerning Pinalate mutant) as well as two color mutants. One of them was Pinalate, (with yellowish pulp) which accumulates approximately 6-fold more total carotenoids than Navel when ripe and contains phytoene and phytofluene, in this order, as major carotenoids. The other variety was Cara Cara, (with reddish pulp) which accumulates approximately 6-fold more total carotenoids than Navel when ripe and contains phytoene, phytofluene and lycopene, in this order, as major carotenoids (Meléndez-Martínez et al., 2018). Several isomers of this carotene have also been detected in both the peel and juice vesicles of diverse citrus fruits (Xu et al., 2006).

Interestingly, there is evidence from *in vitro*, animal models and human studies indicating that the carotenoids phytoene and phytofluene provide, on their own or in conjunction with other food constituents health benefits. A study of these colorless carotenes in the context of food science, nutrition and health should be further encouraged (Meléndez-Martínez et al., 2015). They have been shown to reduce the risk of developing certain cancers, such as skin, prostate, leukemia, breast and endometrial cancer, and atherosclerosis (reviewed in Meléndez-Martínez et al., 2015). Mathews-Roth (1982) described that the administration of phytoene for 32 weeks delayed the appearance of UV-B light-induced skin tumours and reduced their multiplicity in mice.

Concerning protection against eye disease, the antioxidant role of these two carotenoids, lutein and zeaxanthin and their metabolites is crucial as they are the only carotenoids found in the retina (Snodderly, 1995, Bernstein et al., 2001) and lens (Yeum et al., 1995).

Lycopene is a fat-soluble red-colored non-pro-vitamin A carotenoid with many pharmacological properties. It is synthesized and found in red and yellow fruits or plants (Mirahmadi et al., 2020; Khan, 2021). Lycopene is a carotenoid present in human blood, in adipose tissue, in adrenals and testes (Wilhelm Stahl, 1996. It is a potent antioxidant and has beneficial effects in the prevention and treatment of a wide variety of diseases (Imran, 2020). Lycopene is the most potent antioxidant and is considered the most influential singlet-oxygen quencher among the 600 naturally found carotenoids; every single lycopene molecule can quench about 1000 molecules of O2. The physical quenching rate of lycopene was two and ten times higher than those of β-carotene and α-tocopherol, respectively (Di Mascio, 1989). Due to its substantial antioxidant potential, lycopene has gained significant attention (Ozkan, 2023).

The antioxidant effect of lycopene likely occurs through three pathways: adduct formation, electron transfer to the radical, and allylic hydrogen abstraction. These three possible reactions between lycopene and free radicals can take place simultaneously and depend on different factors such as the types of free radicals, the structure of lycopene, and where lycopene was located in the membrane, especially for biological systems (Ozkan, 2023). The relationship between lycopene intake and reduced incidence of a variety of cancers has been a subject of intense interest (Ozkan, 2023). The data obtained from different epidemiological and clinical studies have displayed that there was an inverse correlation between the amount of serum lycopene, its dietary intake and the incidence of different types of cancers (Giovannucci, E., 1999), including prostate (Stahl, 1996), lung (Jiang, 2019) and breast (Czarnik-Kwasniak, 2020).

Recent findings indicate that lycopene could exert cardiovascular protection by lowering HDL-associated inflammation, as well as by modulating HDL functionality towards an antiatherogenic phenotype. Furthermore, in vitro studies indicated that lycopene could modulate T lymphocyte activity, which would also inhibit atherogenic processes and confer cardiovascular protection. These findings also suggest that HDL functionality deserves further consideration as a potential early marker for CVD risk, modifiable by dietary factors such as lycopene (Thies, 2017; Khan, 2021). Lycopene has also been shown to have a synergistic effect with drugs used in cancer treatment (Chan, 2022; El-Masry, 2024). It is expected that the growing demand for natural carotenoids will boost carotenoid biotechnology as a fundamental player to meet the requirements of consumers and industry for this family of healthy pigments in the next few years (Rodriguez-Concepcion et al., 2018).

Flavonoids in oranges

Flavonoids in oranges; The major flavonoids in oranges and orange juices are hesperetin, naringin and naringenin Liu, 2013). Naringenin is predominantly present in citrus fruits, including grapes, oranges, blood oranges, lemons, and grapefruit, with some studies indicating its high concentration in grapefruit pee (Cai, 2023). Naringin is the inactive form that is converted into naringenin by intestinal bacteria. Naringenin is also the glycoside portion of the monomer naringin (Joshi, 2018). Naringenin (a commonly consumed flavonoid) found in many plants, and since it was discovered to have nutritional benefits, it has been utilized to treat inflammation and infections caused by bacteria or viruses (Ji Cai, 2023). Naringenin has anti-inflammatory effects in a variety of inflammatory disorders. It has already been proposed that anti-inflammatory effects may reduce inflammation in general by modifying proinflammatory mediators released by diverse inflammatory cells, specifically in immune-mediated inflammatory diseases such as rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), inflammatory bowel disease (IBD), and autoimmune neurological diseases such as multiple sclerosis (MS) and immune-induced diabetes mellitus (DM), but the molecular mechanism of its anti-inflammatory effect has not been fully determined. (Joshi, 2018; Stabrauskiene, 2022).

Naringenin

Naringenin controls body lipids by exerting hypo exerting hypolipidemic effects, as well as anti-estrogenic activities. Generally, flavonoids have been investigated and found to be a major regulator of tumor cell growth, EC migration, and angiogenesis. Additionally, naringenin regulates blood pressure and has antagonistic activities against inflammation (Yang, 2022).

Hesperidin

Hesperidin and its derivatives are characteristic compounds of citrus fruits such as orange, grapefruit, tangerine, lime and lemon. Their content in citrus fruits depends on fruit variety, part of the fruit itself, climate and degree of maturation (Pyrzynska, 2022). Hesperidin belongs to flavanone compounds, one of the flavonoids subclasses. It has been recently extensively evaluated for its health-promoting and pharmacological effects and is used in a treatment of type 2 diabetes, cancer and cardiovascular diseases, neurological and psychiatric disorders, as well as a radioprotector. Administrations of hesperidin can also benefit a variety of cutaneous function in both normal and diseases skin.

Moreover, Milenkovic et al. (2011) reported a human nutrigenomics study by examining the effects of orange juice and hesperidin, on the expression of genes in leukocytes in healthy volunteers after consumption of orange juice, hesperidin, or placebo for 4 wk. It was observed that the intake of orange juice and hesperidin modulated changes in expression of genes involved in lipid transport, adhesion, chemotaxis, and cell infiltration suggesting lower recruitment and infiltration of circulating cells to vascular wall and intima, lower lipid accumulation, and formation of the atherosclerotic plaque. It was also mentioned that dietary supplements containing hesperidin can significantly improve cerebral blood flow, cognition, and memory performance (Ali, 2020).

5. Conclusions

A phytonutrient-based approach appears to provide an innovative way to address natural health and could be a useful additional therapeutic option for physicians (Monjotin et al., 2022). To highlight the beneficial health effects of phytonutrients in plants, we chose two interesting plants, the potato and the citrus fruits. These two foods were chosen owing to their phytonutrient content, and low price, which makes them more easily acquired in low incoming populations, and consequently they are highly consumed not only in developing but also in developed countries. As discussed throughout this review, they play an important role in promoting the health of a large segment of population mainly in developing countries where the ability to choose foods is more limited. to its high nutrient and phytochemical content, the potato can lower oxidative stress, a key mechanism for cancer and cardiovascular disease prevention. Its phenolic compounds act as antioxidants and improve heart health. (Ezekiel et al., 2013). Pigmented Potatoes can be used for developing functional food/nutraceuticals. (Ezekiel et al., 2013).

Furthermore, this review emphasizes the bioactiv compounds in citrus which can reduce inflammatory mediators and reactive oxygen species generation, thus attenuating the risk of neurodegenerative diseases, cardiovascular disease, diabetes, and cancer. As noted by Saini et al. (2022) other issues concerning citrus fruits should be explored like the study of the synergetic effects between citrus bioactives and clinically used drugs as well as citrus fruit wastes that can potentially serve as a low-cost and eco-friendly source of bioactives (Andrade, 2022). Research in potato chemistry has established the fact that there is a lot more in potatoes than starch. Processing the potatoes rich in phytochemicals can play an important role in promoting the health of a large segment of population in the countries where potatoes form a substantial part of daily diet (Ezekiel et al., 2013). Due Citrus species are regarded as being among the most economically important biological resources since they contain a diverse range of phytonutrients and phytochemicals with promising therapeutic properties. (Addi and Mohamed, 2022; Lu et al, 2015; Monjotin et al., 2022).

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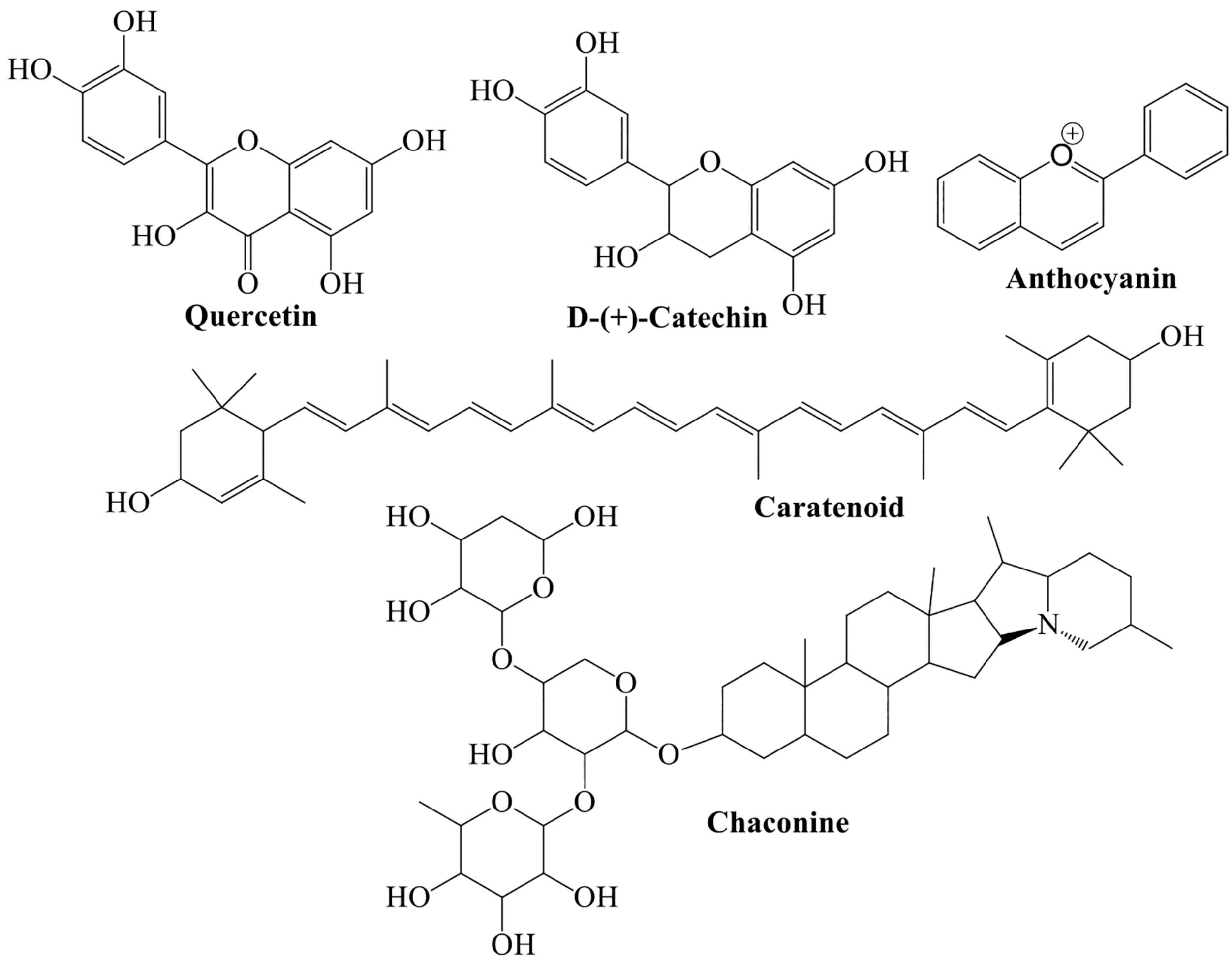

Figure 1.

Major phytochemicals isolated from potatoes

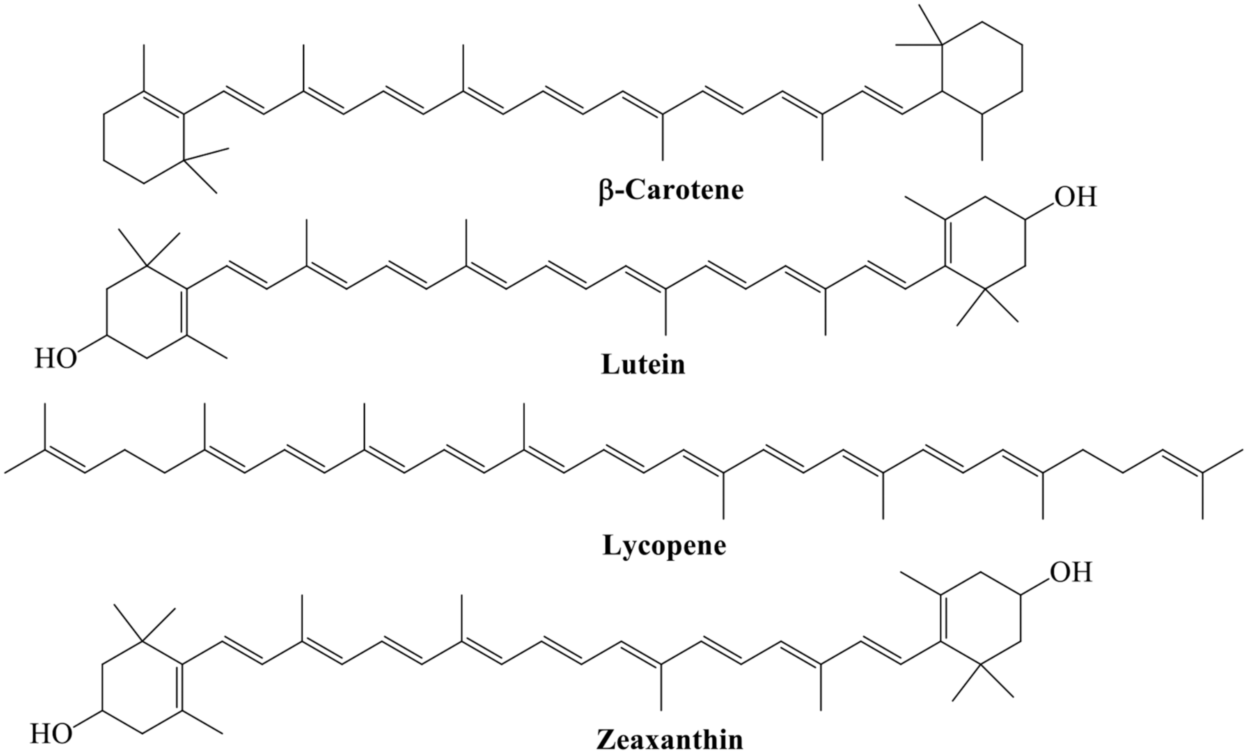

Figure 2.
Major Carotenoids isolated from oranges