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Review

Potential Nutritional Benefits of Current Citrus Consumption

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Abstract: Citrus contains nutrients and phytochemicals that may be beneficial for health. We collected citrus production and consumption data and estimated the amount of these compounds that are consumed. We then compared the amounts of citrus and citrus-derived compounds used in studies that suggest a health benefit to the amounts typically found in citrus. Data is scarce, but suggests that citrus consumption might improve indices of antioxidant status, and possibly cardiovascular health and insulin sensitivity.

Keywords: citrus; vitamin C; vitamin A; carotenoid; flavonoid; limonoid; health; human

1. Introduction

Citrus is the largest genus in the family Rutaceae and is the most traded horticultural product in the world [1]. Taxonomic identification is difficult because there are many spontaneous and commercial hybrids, but citrus can be generally classified into the following categories: sweet oranges (most are *C. sinensis* but also includes blood and acidless oranges), mandarins (such as Satsuma (*C. unshi*), tangerines (*C. tangerina*, and *reticulata*), and clementines (*C. clementine*)), sour/bitter oranges (such as Seville, *C. aurantium*), lemons (*C. limon*), limes (*C. aurantifolia* and *latifolia*), grapefruit (*C. paradisi*) and pummelos (*C. grandis*), hybrids (e.g., tangelos, tangors, and limequats), and citrons (*C. medica*, which has a rind that is used primarily for confectionary and is only commercially grown in limited areas) [2].

Diets rich in fruits and vegetables have been strongly associated with numerous health benefits and lower risk of disease [3,4]. Citrus fruits contain a variety of vitamins, minerals, fiber, and phytochemicals such as carotenoids, flavonoids, and limonoids, which appear to have biological activities and health benefits. There is considerable evidence that citrus fruit have antioxidant and antimutagenic properties and positive associations with bone, cardiovascular, and immune system health [5].

2. Data Sources

Production and consumption data were used to estimate the amounts of nutrients and non-nutrient components of citrus fruits that are consumed. Data for production and estimated consumption was compiled from databases maintained by the U.S. Department of Agriculture (USDA) and the Food and Agriculture Organization of the United Nations (FAO). U.S. data on the amount of nutrients in citrus consumed/capita/day and the percentage of the total dietary nutrient intake from citrus was taken directly from USDA data [6]. Nutrient and non-nutrient concentrations of citrus fruit were gathered from published literature and from the USDA. Then nutrient concentration ranges reported in 100 g of citrus were compared to the RDA or AI (based upon age and life stage) for that nutrient. We reviewed the literature for health benefits of whole citrus fruits, for those nutrients and phytochemicals that are derived primarily from citrus fruit or that are present in citrus varieties in high concentrations by searching the electronic databases PubMed, Web of Science, and Agricola using keyword and phase searches such as "citrus and health", "citrus and cardiovas*", "carotenoid and citrus", "flavonoid and citrus", *etc.* The amounts of nutrients and phytochemicals typically reported in citrus fruit were compared to the amount of citrus or citrus-derived nutrients used in studies that showed health benefits. Barriers to citrus consumption and trends in the citrus industry were identified through online government databases from the USDA Economic Research Service, National Agriculture Statistical Service, and Economic Statistics and Market Information System, as well as from university extension and citrus supplier websites.

3. 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 [7] (Figure 1). Worldwide, there has been a steady increase of estimated per capita consumption of citrus over the last 30 years (Table 1). 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 [8–10], also have the lowest consumption of citrus. Despite the growth of the citrus industry in China [6,7], 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 [11].

Figure 1. World production of citrus by fruit type in 2010 [7].

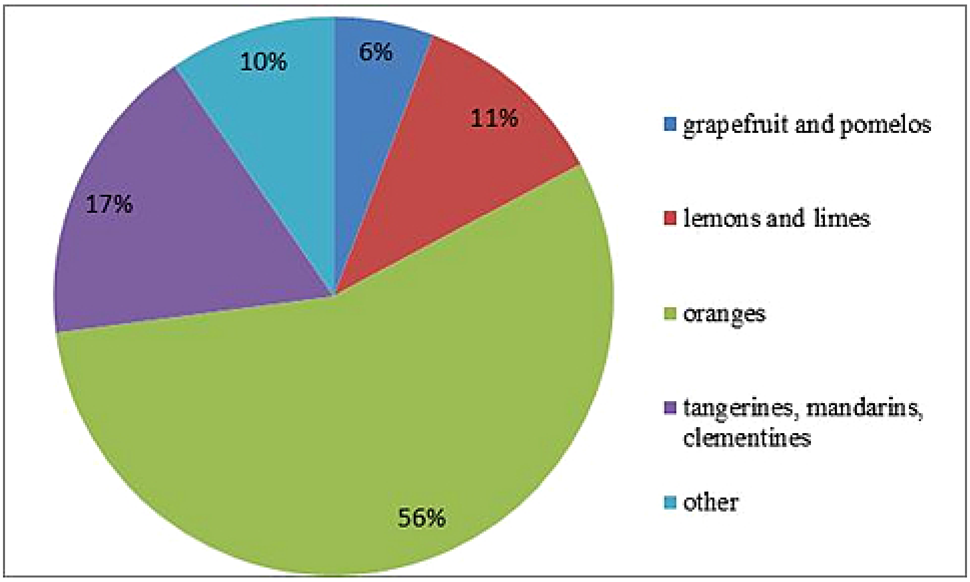

Table 1. Estimated supply and consumption of citrus by region, per person per day, and the percentage of citrus consumed that is oranges and mandarins 1979–2009 [11].

Region	Item	1979	1989	1999	2009
World	Total citrus supply tonnes	49,114,005	67,645,354	89,146,403	112,910,151
	Total citrus g per capita/day	32	36	42	47
	% of total that is oranges & mandarines	78	81	76	72
Least	Total citrus supply tonnes	718,199	918,998	1,358,035	2,182,861
Developed	Total citrus g per capita/day	6	6	7	8
Countries	% of total that is oranges & mandarines	33	33	43	50
Africa	Total citrus supply tonnes	4,371,141	5,955,141	8,312,179	10,988,040
	Total citrus g per capita/day	26	28	31	32
	% of total that is oranges & mandarines	50	54	52	50
Asia	Total citrus supply tonnes	4,371,250	5,955,256	8,312,304	10,988,172
	Total citrus g per capita/day	12	18	23	31
	% of total that is oranges & mandarines	83	78	78	71
SE Asia	Total citrus supply tonnes	991,627	1,695,364	3,008,770	4,947,774
	Total citrus g per capita/day	7	10	16	24
	% of total that is oranges & mandarines	100	100	81	83
Oceania	Total citrus supply tonnes	515,315	569,112	547,564	548,025
	Total citrus g per capita/day	73	71	60	52
	% of total that is oranges & mandarines	84	86	90	88
Europe	Total citrus supply tonnes	9,631,873	13,039,703	14,584,512	19,532,380
	Total citrus g per capita/day	35	46	55	73
	% of total that is oranges & mandarines	77	80	80	81

Table 1. *Cont.*

Region	Item	1979	1989	1999	2009
North America	Total citrus supply tonnes	13,292,610	14,506,257	14,141,748	13,928,358
	Total citrus g per capita/day	144	143	125	112
	% of total that is oranges & mandarines	81	81	82	79
South America	Total citrus supply tonnes	7,516,799	10,525,514	15,148,330	13,530,945
	Total citrus g per capita/day	87	99	121	96
	% of total that is oranges & mandarines	89	91	83	80

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 [12].

The types of citrus produced and consumed vary throughout the world (Table 1). About 80% of the citrus grown are oranges and tangerines in most of the world, except for Africa (Table 1). 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% [6].

In the U.S., current consumption is estimated at 147 g/person/day, which is very high [13]. The total estimated nutrients contributed by citrus/capita/day in the U.S. in 1970 and 2006 [6] are shown in Table 2. 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 carotenoids (Table 2).

Table 2. Total estimated nutrients contributed by current consumption of citrus and estimated percentage of total dietary nutrients provided by citrus consumption/capita/day in the U.S. in 1970 and 2006 [6].

Nutrient	1970	2006
Vitamin C		
mg	26.4	32.8
% of dietary nutrients from citrus	24.9	27.6
Vitamin A		
μg RAE	3.7	4.3
% of dietary nutrients from citrus	0.3	0.4
Folate (DFE)		
μg	19.2	30.5
% of dietary nutrients from citrus	6.4	3.4
Dietary Fiber		
g	0.6	0.6

Table 2. *Cont.*

Nutrient	1970	2006
% of dietary nutrients from citrus	3.0	2.2
Carotenoids		
µg	7.7	8.2
% of dietary nutrients from citrus	1.5	1.2

4. Nutritional and Phytochemical Contents of Citrus

Citrus contains no fat, sodium or cholesterol. The average energy value of citrus is very low which can be important for consumers concerned about obesity. Citrus contains large amounts of vitamin C and appreciable amounts of carotenoids (some capable of converting to vitamin A), folate, and fiber. The amount of selected nutrients are given in Table 3 along with the percentage of the recommended daily allowance (RDA) or adequate intake (AI) [14] that is met when consuming 100 g of citrus fruit.

Table 3. The amount of nutrients and the percent of the recommended daily allowance or adequate intake met from the consumption of 100 g of selected citrus fruit [15–18].

	Vitamin C	Vitamin A*	Folate	Fiber
Oranges	**53–88 mg**	**17 µg**	**30 µg**	**2.4 g**
Children under 9 y (%) †	213–589	3–6	15–20	10–13
Persons 9+ y	59–195	2–4	8–10	6–11
Pregnant/lactating women	44–110	2–3	5–6	8–9
Grapefruit	**31–61 mg**	**58 µg**	**13 µg**	**1.6 g**
Children under 9 y	125–244	12–15	7–9	6–8
Persons 9+ y	35–135	6–10	3–4	4–8
Pregnant/lactating women	26–76	4–8	2–3	6
Tangerines	**27–72 mg**	**46–144 µg**	**16 µg**	**1.8 g**
Children under 9 y	107–480	9–36	8–11	7–9
Persons 9+ y	30–160	5–24	4–5	5–9
Pregnant/lactating women	21–90	4–19	3–4	6
Lemons/limes	**29–61 mg**	**2–22 µg**	**11–16 µg**	**1.8–2.8 g**
Children under 9 y	116–407	0.4–6	4–7	11–15
Persons 9+ y	32–135	0.2–4	2–4	9–13
Pregnant/lactating women	24–76	0.2–3	1–2	10

* assumes that 12 µg beta-carotene from food forms 1 µg vitamin A, and that 24 µg beta-cryptoxanthin or alpha-carotene from food forms 1 µg vitamin A; † percent of the recommended intake met by consuming 100 g of food and is based upon the U.S. DRIs [14].

Of course, the nutritional and phytochemical contents of citrus vary widely depending upon growing conditions, the variety of fruit, maturity, storage conditions, and on processing [5,19,20].

4.1. Vitamin C

Citrus is an excellent source of vitamin C. Most persons can achieve 100% of the RDA for vitamin C by consuming moderate amounts of citrus fruit (Table 3). Vitamin C (ascorbic acid) is a water-soluble essential nutrient which acts as an antioxidant, is involved in iron metabolism, the biosynthesis of carnitine, neurotransmitters, collagen and in the cross-linking of these fibers in bone, and is a cofactor in various enzymatic and hormonal processes [14,21,22]. Vitamin C is also involved in the immune system by stimulating white blood cell function [23]. Vitamin C can help reduce the risk of pre-eclampsia during pregnancy [24], and in some studies vitamin C has been shown to lessen the severity and duration of cold symptoms (reviewed in [23]). In vitro, ascorbic acid was observed to contribute 40%–54% of the antioxidant potential of oranges, mandarins, and grapefruit [25].

Studies in humans have also provided strong evidence for the antioxidant properties of citrus. Drinking 500 mL/day of orange juice for two weeks (~250 mg ascorbic acid/day) increased plasma vitamin C concentrations by 40%–64% and reduced oxidative markers (8-epi-$PGF_{2\alpha}$) in adults, with a more pronounced effect in smokers [26]. In another study, a 47% reduction in plasma lipid peroxidation in healthy adults was observed from the consumption of 8 ounces (~236 mL) of orange juice (~70 mg vitamin C) every day for two weeks [27]. These data show that rapid improvement of vitamin C and antioxidant status can be achieved by consuming reasonable amounts of citrus. Vitamin C deficiency is not typically considered a problem in the U.S. or Canada [14], since U.S. residents consume about 72–102 mg/day of vitamin C from food, or 101–245 mg/day when supplements are included [28]. However, the prevalence of deficiency in the U.S., measured by serum ascorbic acid and indicated by the NHANES III (1984–1994) and NHANES (2003–2004) data, was ~9%–13% and ~7.1%, respectively [29]. Smokers, those who abuse drugs and alcohol, and those with diets low in fruits and vegetables are at higher risk of having low vitamin C [14]. Also, prevalence of mild vitamin C deficiency worldwide is probably fairly high [9], and data from undernourished women in developing countries indicates breast milk levels to be inadequate (25 μg/L whereas the AI is 50 μg/L) (taken from [30]). Regular consumption of citrus can also improve breast milk concentrations. In a study by Daneel-Otterbech *et al.* [31], three servings or orange juice (~100 mg vitamin C/serving) for six weeks doubled milk vitamin C concentrations (1 serving/week had no significant effect). Furthermore, there is supporting evidence that more than 200 mg/day of vitamin C may be optimal for maximum health benefits [32], and citrus may be the best food source for increasing vitamin C intake.

4.2. Carotenoids and Vitamin A

Citrus contains many carotenoids. Carotenoids are terpenes (tetraterpenoids) and are yellow and orange pigments found ubiquitously in plants; over 600 carotenoids have been identified and about 50 are present in the human diet [33,34]. The most abundant carotenoids in the human diet, lutein, zeaxanthin, lycopene, and the pro-vitamin A carotenoids, α- and β-carotene and β-cryptoxanthin, are found in fruits and vegetables. Many functions and health benefits of carotenoids have been described: they are antioxidants, have positive effects on the immune system [33,35–37], promote bone formation and health [38,39], stimulate gap junction communication between cells [40], promote eye health [41,42], and lower the risk of cancer [43–45]. Much data support beneficial health effects of ingesting carotenoids; however, the only well-established health benefit of carotenoids in humans is the ability of several to form vitamin A [14].

According to NHANES data (2009–2010), most people in the U.S. are not consuming enough vitamin A from food, and only a small proportion of vitamin A is consumed as carotenoids (~20%–35%

of the RDA for vitamin A) [28]. Worldwide, vitamin A deficiency is estimated to affect 209 million women and children and is the leading cause of preventable blindness [8]. On the other hand, high intakes of vitamin A from supplements or liver have been associated with negative health effects including diarrhea, nausea, vomiting, headaches, bone abnormalities and osteoporosis, liver damage, hair loss, and possibly birth defects [46,47]. Consuming even very large amounts of pro-vitamin A carotenoids from food is safe [14].

Carotenoids in fruit are dissolved in the chromoplast as opposed to being bound to proteins in the chloroplasts of dark-leafy green vegetables, and considerable evidence supports fruit carotenoids having higher bioavailability [48,49]. Tangerines in particular can provide a substantial amount of the pro-vitamin A carotenoid, β-cryptoxanthin, a carotenoid that appears to be a highly bioavailable source of vitamin A [50,51]. In a recent study of breastfeeding women with low vitamin A status, the consumption of tangerines (254 g or ~ 5.3 g/day β-cryptoxanthin) for 18 days maintained vitamin A concentrations in breast milk and increased plasma and milk β-cryptoxanthin [52]. These results suggest that the vitamin A contributed by tangerines might be more than twice as much than assumed, such that 100 g of tangerine would meet as much as 72% of the recommended daily intake of vitamin A for children. Furthermore, estimates of production and consumption of tangerines specifically demonstrate the capacity to provide significant amounts of vitamin A to populations experiencing vitamin A deficiency if β-cryptoxanthin-rich varieties are selected for production and consumption [53].

4.3. Folate

As a coenzyme, folate participates in converting deoxyuridylic acid to thymidylic acid, in the production of purines (formation of glycinamide ribonucleotide and 5-amino-4-imidazole carboxamide ribonucleotide), and the interconversion of many amino acids; thus, folate is necessary for DNA production, is involved in homocysteine regulation, and protein production primarily *via* methylation transfer reactions [14]. Because DNA production is high during pregnancy, lack of folate is associated with birth defects such as neural tube defects [54]. Lack of folate is also implicated in higher homocysteine concentrations, which increase the risk of atherosclerosis and heart disease [14]. Citrus can be a complementary source of dietary folate and can provide up to 10% to 20% of the RDA for adults and children less than 9 years of age, respectively, with just 100 g. A study on commercial orange juices in Europe found that the folate was 100% bioavailable and highly stable [55], and, in another study, the consumption of orange juice (750 mL) daily for four weeks increased plasma folate concentrations in adults by 18% [56].

4.4. Fiber

Dietary fiber is the edible carbohydrate and lignin in plants that is not digested and absorbed in the small intestine; fibers can promote laxation, satiety, reduce the uptake and/ or reabsorption of glucose, fat, cholesterol, and bile acids thus reducing cardiovascular disease risk and possibly decreasing food intake and promoting healthy intestinal fermentation [57,58]. The main fiber in citrus is pectin, a soluble fiber, which makes up 65%–70% of the total fiber content [59]. Pectin is more completely fermented in the gut by microflora than foods rich in cellulose like cereals and fermentation produces various substrates including short-chain fatty acids that can be absorbed and provide energy [14,58]. There is conflicting data on whether fiber may interfere with the absorption of other nutrients; however, most studies on pectin/ nutrition interactions did not show a decrease in nutrient bioavailability except when large doses of pectin (12 g and 0.15 g/kg body weight) were concomitantly consumed [60,61]. Thus, it has been concluded that a diet rich in dietary fiber will not cause adverse effects in healthy people [14].

The average U.S. adult consumes only ~57% of the RDA for fiber [28]. Because the RDA for fiber is not being met by many adults and dietary fiber can reduce the risk of chronic diseases, citrus can make a valuable contribution to meeting daily fiber goals. Lowering of cholesterol in particular by citrus, however, may depend upon the amount, degree of esterification, molecular weight, and viscosity of the fiber/pectin consumed [58,62] but may be significant with dietary intake that is achievable (2.2–9 g pectin for 30 days) (in[57]).

4.5. Flavonoids and Limonoids

Flavonoids are polyphenolic compounds widely distributed in plants and are pigments responsible for fruit and flower coloration [63] and involved in defense against UV radiation or aggression from pathogens [64]. Flavonoids are divided into multiple classes of compounds such as flavones, flavanones, isoflavones, flavonols, flavanols, flavan-3-ols (tannins, catechins), anthocyanidins, aurones, chalcones, and coumarins [65–67]. Citrus is the major source of flavanones from food [65]; the most predominant and widely studied flavanones in citrus are hesperetin (aka hesperidin) (predominant in oranges) and naringenin (predominant in grapefruit) [63,67,68]. Of the edible parts, the membranous segments of citrus fruit have the highest content of many bioactive compounds making high-pulp juices more recommended for consumption [5]. Although the peels and seeds are often discarded, they generally have different flavonoid composition than the edible fruit [63] making citrus byproducts a good source of flavonoid extracts. Furthermore, the peels and seeds can contain the highest amounts of flavonoids; for example the albedo (pith) of an orange can have up to five times higher flavanone content than orange juice [64].

The health benefits of citrus flavonoids have been generally studied using individual extracted compounds instead of whole foods, but these studies have had promising results. Flavonoids extracted from citrus have been shown to act as antioxidants and anti-inflammatory agents, to reduce cholesterol and triglycerides [69,70], and improve bone health [70,71] in experimental animals.

Their effects in humans are more controversial, because there is large intra- and inter-variability in absorption, metabolism, and reported effects of flavonoids. Furthermore, the solubility of flavonoids is often low and effected by microbiota in the gut [67,72,73]. Thus, the amount of flavanones from whole citrus fruits may be very different than those that have beneficial effects in studies of animal models using extracts. Nevertheless, in a study in adults with metabolic syndrome, the consumption of 500 mg hesperitin/day as a supplement for three weeks resulted in improved brachial artery flow-mediated dilation and reduced markers of inflammation (C-reactive protein, serum amyloid A protein, soluble E-selectin) [74]; for comparison 236 mL (~ 8 oz) of orange juice contains ~39–62 mg of hesperitin [66]. Observational data indicate that dietary intake of flavanones (primarily hesperitin) is estimated at 15.4 to 69.54 mg/day in people from European countries (EPIC study) [75] and 17 to 24 mg flavonoids/day in people from Finland [76], the UK [77], and the U.S. [78]. Higher intakes of flavonoids found in citrus were associated with lower cardiovascular disease risk, asthma [76], and higher bone mineral density [77]. Although observational evidence may be correlating health benefits to increased fruit and vegetable intake rather than specifically to flavonoid intake, the data from cell culture, animal studies, and limited human studies that associate citrus flavanones to positive health outcomes is encouraging.

The bitter taste in citrus can be attributed to limonoids. Limonoids are terpenes and occur only in plants of the Rutaceae (citrus) and *Meliaceae* (neem, mahogany) families [79]. The most abundant limonoids in citrus are glycosides of limonin and nomilin [79,80]. Citrus can contain 150–300 mg of limonoids in 100 g of fruit whereas the peels and flesh solids can contain 500 mg per 100 g fruit. In animal and human cell lines, limonoids have been shown to help reduce or inhibit proliferation of cancer of the pancreas, stomach, colon, and breast; in animal studies, limonoids also reduced skin tumors [81–83]. There is evidence of antiviral and antibacterial, properties of limonoids [84–86]. Most studies on limonoids have used extracted compounds rather than citrus as a whole food making translation of the dose used in cell culture and animal studies to intake in humans difficult; however, with high concentrations of limonoids in citrus, it may be highly participatory in providing the health benefits described.

5. 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 [87,88]. 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. 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 [89]. In humans, the antioxidant effects of orange juice have been observed with as little as 8 ounces (236 mL) consumed for two weeks [27]. 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 [90,91].

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 [92]. 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 [56]. 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) [93]. 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 [94].

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 [95,96]. Evidence of an anitobesity effect of citrus in humans, however, is lacking.

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 beneficial, 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 [33,97,98]. 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 [15]. On the other hand, many compounds such as folate may have limited bioavailability from food [14] or, as in flavonoids, are not present in concentrations in food as high as those used in studies suggesting a health benefit (see section 4.5). Thus, depending on the compound, juices, extracts, or supplements may be a more abundant or bioavailable source of the phytonutrient than whole foods [88]. 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 [99]. Overall, the compounds in citrus, whether obtained from whole foods, extracts, or supplements, appear to have positive health benefits.

6. 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) [100,101] and its consumption in top markets (U.S., European Union) has declined [102]. 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 [1,103]. 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" [1]. 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 [18].

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.

References and Notes

1. Fresh Citrus Report. Available online: http://www.pir.sa.gov.au/horticulture/citrus/fresh_citrus_report (accessed on 14 October 2012).
2. Ortiz, J.M. Botany. In *Citrus: The Genus Citrus*; Dugo, G., Di Giacomo, A., Eds.; Taylor and Francis: New York, NY, USA, 2002; pp. 16–35.
3. Radhika, G.; Sudha, V.; Sathya, R.M.; Ganesan, A.; Mohan, V. Association of fruit and vegetable intake with cardiovascular risk factors in urban South Indians. *Brit. J. Nutr.* **2008**, *99*, 398–405.
4. Boeing, H.; Bechthold, A.; Bub, A.; Ellinger, S.; Haller, D.; Kroke, A.; Leschik-Bonnet, E.; Mueller, M.J.; Oberritter, H.; Schulze, M.; Stehle, P.; Watzl, B. Critical review: Vegetables and fruit in the prevention of chronic diseases. *Eur. J. Nutr.* **2012**, *51*, 637–663.
5. Codoñer-Franch, P.; Valls-Bellés, V. Citrus as Functional foods. *Curr. T. Nutraceut. Res.* **2010**, *8*, 173–183.
6. Food Availability (Per Capita) Data System, Nutrient Availability. US Deparment of Agriculture, Economic Research Service. Available online: http://www.ers.usda.gov/data-products/food-availability-%28per-capita%29-data-system.aspx#26705 (accessed on 17 October 2012).
7. FAOSTAT, Production Crops. Food and Agriculture Organization of the United Nations. Available online: http://faostat3.fao.org/home/index.html#VISUALIZE (accessed on 5 October 2012).
8. Global prevalence of vitamin A deficiency in populations at risk 1995–2005: WHO global database on vitamin A deficiency. World Health Organization: Geneva, Switerzland, 2009. Available online: http://whqlibdoc.who.int/publications/2009/9789241598019_eng.pdf (accessed on 18 October 2012).
9. *Guidelines on Food Fortification with Micronutrients*; World Health Organization: Geneva, Switerzland, 2006.

10. *Vitamin and Mineral Requirements in Human Nutrition*; World Health Organization: Geneva, Switerzland, 2004.
11. FAO Food Supply Crops Primary Equivalent. Food and Agriculture Organization. Available online: http://faostat.fao.org/site/609/default.aspx#ancor (accessed on 18 October 2012).
12. Plattner, K.; Perez, A. Fruit and Tree Nuts Outlook: Total Citrus Production Slightly Down in 2011/12. US Deparment of Agriculture, Economic Resource Service. Available online: http://www.ers.usda.gov/media/468106/fts351.pdf (accessed on 10 October 2012).
13. Loss-Adjusted Food Availability, Fruit. US Department of Agriculture, Economic Research Service. Available online: http://www.ers.usda.gov/data-products/food-availability-%28per-capita%29-data-system.aspx#26705 (accessed on 17 October 2012).
14. *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*; The National Academies Press: Washington, DC, USA, 2006.
15. National Nutrient Database for Standard Reference Release 24. US Department of Agriculture, Agriculture Research Service. Available online: http://www.ars.usda.gov/nutrientdata (accessed on 14 October 2012).
16. USDA-NCC Carotenoid Database for US Foods—1998. US Department of Agriculture, ARS Nutrient Data Laboratory. Available online: http://www.nal.usda.gov/fnic/foodcomp/Data/car98/car98.html (accessed on 19 October 2012).
17. Yano, M.; Kato, M.; Ikoma, Y.; Kawasaki, A.; Fukazawa, Y.; Sugiura, M.; Matsumoto, H.; Oohara, Y.; Nagao, A.; Ogawa, K. Quantitation of carotenoids in raw and processed fruits in Japan. *Food Sci. Technol. Res.* **2005**, *11*, 13–18.
18. Nagy, S. Vitamin C contents of citrus fruit and their products: a review. *J. Agr. Food Chem.* **1980**, *28*, 8–18.
19. *Carotenoids and Food Preparation: The Retention of Provitamin A Carotenoids in Prepared, Processed and Stored Foods*; OMNI Project: Campinas, Brazil, 1997.
20. Fraser, P.D.; Bramley, P.M. The biosynthesis and nutritional uses of carotenoids. *Prog. Lipid Res.* **2004**, *43*, 228–265.
21. Meister, A. Glutathione ascorbic acid antioxidant system in animals. *J. Biol. Chem.* **1994**, *269*, 9397–9400.
22. Palacios, C. The role of nutrients in bone health, from A to Z. *Crit. Rev. Food Sci.* **2006**, *46*, 621–628.
23. Wintergerst, E.S.; Maggini, S.; Hornig, D.H. Immune-enhancing role of vitamin C and zinc and effect on clinical conditions. *Ann. Nutr. Meta.* **2006**, *50*, 85–94.
24. Chappell, L.C.; Seed, P.T.; Briley, A.L.; Kelly, F.J.; Lee, R.; Hunt, B.J.; Parmar, K.; Bewley, S.J.; Shennan, A.H.; Steer, P.J.; Poston, L. Effect of antioxidants on the occurrence of pre-eclampsia in women at increased risk: A randomised trial. *Lancet* **1999**, *354*, 810–816.
25. Szeto, Y.T.; Tomlinson, B.; Benzie, I.F.F. Total antioxidant and ascorbic acid content of fresh fruits and vegetables: implications for dietary planning and food preservation. *Brit. J. Nutr.* **2002**, *87*, 55–59.
26. Sánchez-Moreno, C.; Cano, M.P.; de Ancos, B.; Plaza, L.; Olmedilla, B.; Granado, F.; Martín, A. Effect of orange juice intake on vitamin C concentrations and biomarkers of antioxidant status in humans. *Am. J. Clin. Nutr.* **2003**, *78*, 454–460.

27. Johnston, C.S.; Dancho, C.L.; Strong, G.M. Orange juice ingestion and supplemental vitamin C are equally effective at reducing plasma lipid peroxidation in healthy adult women. *J. Am. Coll. Nutr.* **2003**, *22*, 519–523.
28. What We Eat in America. US Department of Agriculture, ARS. Available online: http://www.ars.usda.gov/Services/docs.htm?docid=18349 (accessed on 7 October 2012).
29. Schleicher, R.L.; Carroll, M.D.; Ford, E.S.; Lacher, D.A. Serum vitamin C and the prevalence of vitamin C deficiency in the United States: 2003–2004 National Health and Nutrition Examination Survey (NHANES). *Am. J. Clin. Nutr.* **2009**, *90*, 1252–1263.
30. Allen, L.H. Multiple micronutrients in pregnancy and lactation: an overview. *Am. J. Clin. Nutr.* **2005**, *81*, 1206S–1212S.
31. Daneel-Otterbech, S.; Davidsson, L.; Hurrell, R. Ascorbic acid supplementation and regular consumption of fresh orange juice increase the ascorbic acid content of human milk: Studies in European and African lactating women. *Am. J. Clin. Nutr.* **2005**, *81*, 1088–1093.
32. Frei, B.; Birlouez-Aragon, I.; Lykkesfeldt, J. Authors' perspective: What is the optimum intake of vitamin C in humans? *Crit. Rev. Food Sci.* **2012**, *52*, 815–829.
33. Britton, G. Structure and properties of carotenoids in relation to function. *FASEB J.* **1995**, *9*, 1551–1558.
34. Khachik, F.; Spangler, C.J.; Smith, J.C.; Canfield, L.M.; Steck, A.; Pfander, H. Identification, quantification, and relative concentrations of carotenoids and their metabolites in human milk and serum. *Anal. Chem.* **1997**, *69*, 1873–1881.
35. Frankel, E.N. Lipid oxidation. *Prog. Lipid Res.* **1980**, *19*, 1–22.
36. Katsuura, S.; Imamura, T.; Bando, N.; Yamanishi, R. Beta-carotene and beta-cryptoxanthin but not lutein evoke redox and immune changes in RAW264 murine macrophages. *Mol Nutr Food Res.* **2009**, *53*, 1396–1405.
37. Matsumoto, A.; Mizukami, H.; Mizuno, S.; Umegaki, K.; Nishikawa, J.I.; Shudo, K.; Kagechika, H.; Inoue, M. beta-Cryptoxanthin, a novel natural RAR ligand, induces ATP-binding cassette transporters in macrophages. *Biochem. Pharmacol.* **2007**, *74*, 256–264.
38. Uchiyama, S.; Yamaguchi, M. Inhibitory effect of [beta]-cryptoxanthin on osteoclast-like cell formation in mouse marrow cultures. *Biochem. Pharmacol.* **2004**, *67*, 1297–1305.
39. Sahni, S.; Hannan, M.T.; Blumberg, J.; Cupples, L.A.; Kiel, D.P.; Tucker, K.L. Protective Effect of total carotenoid and lycopene Intake on the risk of hip fracture: A 17-year follow-up from the Framingham Osteoporosis Study. *J. Bone Miner. Res.* **2009**, *24*, 1086–1094.
40. Stahl, W.; Nicolai, S.; Briviba, K.; Hanusch, M.; Broszeit, G.; Peters, M.; Martin, H.D.; Sies, H. Biological activities of natural and synthetic carotenoids: induction of gap junctional communication and singlet oxygen quenching. *Carcinogenesis* **1997**, *18*, 89–92.
41. Snodderly, D. Evidence for protection against age-related macular degeneration by carotenoids and antioxidant vitamins. *Am. J. Clin. Nutr.* **1995**, *62*, 1448–1461.
42. Seddon, J.M.; Ajani, U.A.; Sperduto, R.D.; Hiller, R.; Blair, N.; Burton, T.C.; Farber, M.D.; Gragoudas, E.S.; Haller, J.; Miller, D.T.; *et al*. Dietary carotenoids, vitamins A, C, and E, and advanced age-related macular degeneration. *J. Am. Med. Assoc.* **1994**, *272*, 1413–1420.
43. Petro, R.; Doll, R.; Buckley, J.D.; Sporn, M.B. Can dietary beta-carotene materially reduce human cancer rates? *Nature* **1981**, *290*, 201–208.

44. Gallicchio, L.; Boyd, K.; Matanoski, G.; Tao, X.; Chen, L.; Lam, T.K.; Shiels, M.; Hammond, E.; Robinson, K.A.; Caulfield, L.E.; Herman, J.G.; Guallar, E.; Alberg, A.J. Carotenoids and the risk of developing lung cancer: A systematic review. *Am. J. Clin. Nutr.* **2008**, *88*, 372–383.
45. Nishino, H.; Murakoshi, M.; Tokuda, H.; Satomi, Y. Cancer prevention by carotenoids. *Arch. Biochem. Biophys.* **2009**, *483*, 165–168.
46. Russell, R.M. The vitamin A spectrum: from deficiency to toxicity. *Am. J. Clin. Nutr.* **2000**, *71*, 878–884.
47. Penniston, K.L.; Tanumihardjo, S.A. The acute and chronic toxic effects of vitamin A. *Am. J. Clin. Nutr.* **2006**, *83*, 191–201.
48. Castenmiller, J.J.M.; West, C.E. Bioavailability and bioconversion of carotenoids. *Ann. Rev. Nutr.* **1998**, *18*, 19–38.
49. De Pee, S.; West, C.E.; Permaesih, D.; Martuti, S.; Muhilal; Hautvast, J.G. Orange fruit is more effective than are dark-green, leafy vegetables in increasing serum concentrations of retinol and beta-carotene in schoolchildren in Indonesia. *Am. J. Clin. Nutr.* **1998**, *68*, 1058–1067.
50. Arscott, S.A.; Howe, J.A.; Davis, C.R.; Tanumihardjo, S.A. Carotenoid profiles in provitamin A-containing fruits and vegetables affect the bioefficacy in Mongolian gerbils. *Exp. Biol. Med.* **2010**, *235*, 839–848.
51. Burri, B.; Chang, J.; Neidlinger, T. Beta-cryptoxanthin- and alpha-carotene-rich foods have greater apparent bioavailability than beta-carotene-rich foods in Western diets. *Brit. J. Nutr.* **2011**, *105*, 212–219.
52. Turner, T. Pro-vitamin A Carotenoids: Aspects of the Biology, Chemical Analysis, and Utilization of Foods for Improving Public Health. Ph.D. Thesis, University of California, Davis, CA, USA, 2012.
53. Burri, B.J.; Chang, J.S.; Turner, T. Citrus can help prevent vitamin A deficiency in developing countries. *Calif. Agr.* **2011**, *65*, 130–135.
54. Green, N.S. Folic acid supplementation and prevention of birth defects. *J. Nutr.* **2002**, *132*, 2356S–2360S.
55. Öhrvik, V.; Witthöft, C. Orange juice is a good folate source in respect to folate content and stability during storage and simulated digestion. *Eur. J. Nutr.* **2008**, *47*, 92–98.
56. Kurowska, E.M.; Spence, J.D.; Jordan, J.; Wetmore, S.; Freeman, D.J.; Piché, L.A.; Serratore, P. HDL-cholesterol-raising effect of orange juice in subjects with hypercholesterolemia. *Am. J. Clin. Nutr.* **2000**, *72*, 1095–1100.
57. Brown, L.; Rosner, B.; Willett, W.W.; Sacks, F.M. Cholesterol-lowering effects of dietary fiber: A meta-analysis. *Am. J. Clin. Nutr.* **1999**, *69*, 30–42.
58. Dikeman, C.L.; Fahey, G.C. Viscosity as related to dietary fiber: A review. *Crit. Rev. Food Sci.* **2006**, *46*, 649–663.
59. Economos, C.; Clay, W. Nutritional and health benefits of citrus fruits. Food and Agriculture Organization. Available online: ftp://ftp.fao.org/docrep/fao/X2650T/X2650t03.pdf (accessed on 1 October 2012).
60. Rock, C.L.; Swendseid, M.E. Plasma beta-carotene response in humans after meals supplemented with dietary pectin. *Am. J. Clin. Nutr.* **1992**, *55*, 96–99.

61. Riedl, J.; Linseisen, J.; Hoffmann, J.; Wolfram, G. Some dietary fibers reduce the absorption of carotenoids in women. *J. Nutr.* **1999**, *129*, 2170–2176.
62. Brouns, F.; Theuwissen, E.; Adam, A.; Bell, M.; Berger, A.; Mensink, R.P. Cholesterol-lowering properties of different pectin types in mildly hyper-cholesterolemic men and women. *Eur J Clin Nutr* **2012**, *66*, 591–599.
63. Tripoli, E.; Guardia, M.L.; Giammanco, S.; Majo, D.D.; Giammanco, M. Citrus flavonoids: Molecular structure, biological activity and nutritional properties: A review. *Food Chem.* **2007**, *104*, 466–479.
64. Manach, C.; Scalbert, A.; Morand, C.; Rémésy, C.; Jiménez, L. Polyphenols: Food sources and bioavailability. *Am. J. Clin. Nutr.* **2004**, *79*, 727–747.
65. Peterson, J.; Dwyer, J. Flavonoids: Dietary occurrence and biochemical activity. *Nutr. Res.* **1998**, *18*, 1995–2018.
66. Bhagwat, S.; Haytowitz, D.B.; Holden, J.M. USDA Database for the Flavanoid Content of Selected Foods Release 3. US Deparment of Agriculture, ARS. Available online: http://www.nal.usda.gov/fnic/foodcomp/Data/Flav/flav.pdf (accessed on 5 October 2012).
67. Manach, C.; Williamson, G.; Morand, C.; Scalbert, A.; Rémésy, C. Bioavailability and bioefficacy of polyphenols in humans. I. Review of 97 bioavailability studies. *Am. J. Clin. Nutr.* **2005**, *81*, 230S–242S.
68. Ameer, B.; Weintraub, R.A.; Johnson, J.V.; Yost, R.A.; Rouseff, R.L. Flavanone absorption after naringin, hesperidin, and citrus administration[ast]. *Clin. Pharmacol. Ther.* **1996**, *60*, 34–40.
69. Jeon, S.-M.; Kim, H.K.; Kim, H.-J.; Do, G.-M.; Jeong, T.-S.; Park, Y.B.; Choi, M.-S. Hypocholesterolemic and antioxidative effects of naringenin and its two metabolites in high-cholesterol fed rats. *Transl. Res.* **2007**, *149*, 15–21.
70. Habauzit, V.; Sacco, S.M.; Gil-Izquierdo, A.; Trzeciakiewicz, A.; Morand, C.; Barron, D.; Pinaud, S.; Offord, E.; Horcajada, M.-N. Differential effects of two citrus flavanones on bone quality in senescent male rats in relation to their bioavailability and metabolism. *Bone* **2011**, *49*, 1108–1116.
71. Horcajada, M.N.; Habauzit, V.; Trzeciakiewicz, A.; Morand, C.; Gil-Izquierdo, A.; Mardon, J.; Lebecque, P.; Davicco, M.J.; Chee, W.S.S.; Coxam, V.; *et al*. Hesperidin inhibits ovariectomized-induced osteopenia and shows differential effects on bone mass and strength in young and adult intact rats. *J. Appl. Physiol.* **2008**, *104*, 648–654.
72. Selma, M.V.; Espín, J.C.; Tomás-Barberán, F.A. Interaction between phenolics and gut microbiota: role in human health. *J. Agr. Food Chem.* **2009**, *57*, 6485–6501.
73. Vallejo, F.; Larrosa, M.; Escudero, E.; Zafrilla, M.P.; Cerdá, B.A.; Boza, J.; García-Conesa, M.T.; Espín, J.C.; Tomás-Barberán, F.A. Concentration and solubility of flavanones in orange beverages affect their bioavailability in humans. *J. Agr. Food Chem.* **2010**, *58*, 6516–6524.
74. Rizza, S.; Muniyappa, R.; Iantorno, M.; Kim, J.-A.; Chen, H.; Pullikotil, P.; Senese, N.; Tesauro, M.; Lauro, D.; Cardillo, C.; Quon, M.J. Citrus polyphenol hesperidin stimulates production of nitric oxide in endothelial cells while improving endothelial function and reducing inflammatory markers in patients with metabolic syndrome. *J. Clin. Endocr. Metab.* **2011**, *96*, E782–E792.

75. Zamora-Ros, R.; Knaze, V.; Luján-Barroso, L.; Slimani, N.; Romieu, I.; Fedirko, V.; Santucci de Magistris, M.; Ericson, U.; Amiano, P.; Trichopoulou, A.; *et al*. Estimated dietary intakes of flavonols, flavanones and flavones in the European Prospective Investigation into Cancer and Nutrition (EPIC) 24 hour dietary recall cohort. *Brit. J. Nutr.* **2011**, *106*, 1915–1925.
76. Knekt, P.; Kumpulainen, J.; Järvinen, R.; Rissanen, H.; Heliövaara, M.; Reunanen, A.; Hakulinen, T.; Aromaa, A. Flavonoid intake and risk of chronic diseases. *Am. J. Clin. Nutr.* **2002**, *76*, 560–568.
77. Welch, A.; MacGregor, A.; Jennings, A.; Fairweather-Tait, S.; Spector, T.; Cassidy, A. Habitual flavonoid intakes are positively associated with bone mineral density in women. *J. Bone Miner. Res.* **2012**, *27*, 1872–1878.
78. Maras, J.E.; Talegawkar, S.A.; Qiao, N.; Lyle, B.; Ferrucci, L.; Tucker, K.L. Flavonoid intakes in the Baltimore Longitudinal Study of Aging. *J. Food Compos. Anal.* **2011**, *24*, 1103–1109.
79. Manners, G.D. Citrus limonoids: Analysis, bioactivity, and biomedical prospects. *J. Agr. Food Chem.* **2007**, *55*, 8285–8294.
80. Silalahi, J. Anticancer and health protective properties of citrus fruit components. *Asia Pac. J. Clin. Nutr.* **2002**, *11*, 79–84.
81. Chidambara Murthy, K.N.; Jayaprakasha, G.K.; Patil, B.S. Apoptosis mediated cytotoxicity of citrus obacunone in human pancreatic cancer cells. *Toxicol. In Vitro* **2011**, *25*, 859–867.
82. Chidambara Murthy, K.N.; Jayaprakasha, G.K.; Kumar, V.; Rathore, K.S.; Patil, B.S. Citrus Limonin and its glucoside inhibit colon adenocarcinoma cell proliferation through apoptosis. *J. Agr. Food Chem.* **2011**, *59*, 2314–2323.
83. Lam, L.K.T.; Zhang, J.; Hasegawa, S. Citrus limonoid reduction of chemically-induced tumorigensis. *Food Technol.* **1994**, *48*, 104–108.
84. Battinelli, L.; Mengoni, F.; Lichtner, M.; Mazzanti, G.; Saija, A.; Mastroianni, C.M.; Vullo, V. Effect of limonin and nomilin on HIV-1 replication on infected human mononuclear cells. *Planta Med.* **2003**, *69*, 910–913.
85. Astani, A.; Reichling, J.; Schnitzler, P. Antiviral activity of monoterpene components of essential oils against Herpes Simplex virus. *Antivir. Res.* **2009**, *82*, A46.
86. Vikram, A.; Jesudhasan, P.R.; Jayaprakasha, G.K.; Pillai, S.D.; Patil, B.S. Citrus limonoids interfere with Vibrio harveyi cell-cell signalling and biofilm formation by modulating the response regulator LuxO. *Microbiology SGM* **2011**, *157*, 99–110.
87. Ramful, D.; Tarnus, E.; Aruama, O.I.; Bourdon, E.; Bahorun, T. Polyphenolic composition, vitamin C content, and antioxidant capacity of Mauritian citrus fruit pulps. *Food Res. Int.* **2011**, *44*, 2088–2099.
88. Aruoma, O.I.; Landes, B.; Ramful-Baboolall, D.; Bourdon, E.; Neergheen-Bhujun, V.; Wagner, K.H.; Bahorun, T. Functional benefits of citrus fruits in the management of diabetes. *Prevent. Med.* **2012**, *54*, S12–S16.
89. Sun, J.; Chu, Y.-F.; Wu, X.; Liu, R.H. Antioxidant and antiproliferative activities of common fruits. *J. Agr. Food Chem.* **2002**, *50*, 7449–7454.

90. Harats, D.; Chevion, S.; Nahir, M.; Norman, Y.; Sagee, O.; Berry, E.M. Citrus fruit supplementation reduces lipoprotein oxidation in young men ingesting a diet high in saturated fat: Presumptive evidence for an interaction between vitamins C and E *in vivo*. *Am. J. Clin. Nutr.* **1998**, *67*, 240–245.
91. Ghanim, H.; Sia, C.L.; Upadhyay, M.; Korzeniewski, K.; Viswanathan, P.; Abuaysheh, S.; Mohanty, P.; Dandona, P. Orange juice neutralizes the proinflammatory effect of a high-fat, high-carbohydrate meal and prevents endotoxin increase and Toll-like receptor expression. *Am. J. Clin. Nutr.* **2010**, *91*, 940–949.
92. Codoñer-Franch, P.; López-Jaén, A.B.; De La Mano-Hernández, A.; Sentandreu, E.; Simó-Jordá, R.; Valls-Bellés, V. Oxidative markers in children with severe obesity following low-calorie diets supplemented with mandarin juice. *Acta Pædiatr.* **2010**, *99*, 1841–1846.
93. Devaraj, S.; Jialal, I.; Vega-Lopez, S. Plant sterol-fortified orange juice effectively lowers cholesterol levels in mildly hypercholesterolemic healthy individuals. *Arterioscler. Thromb. Vasc. Biol.* **2004**, *24*, E25–E28.
94. Franke, A.A.; Cooney, R.V.; Henning, S.M.; Custer, L.J. Bioavailability and antioxidant effects of orange juice components in humans. *J. Agr. Food Chem.* **2005**, *53*, 5170–5178.
95. Titta, L.; Trinei, M.; Stendardo, M.; Berniakovich, I.; Petroni, K.; Tonelli, C.; Riso, P.; Porrini, M.; Minucci, S.; Pelicci, P.G.; Rapisarda, P.; Recupero, G.R.; Giorgio, M. Blood orange juice inhibits fat accumulation in mice. *Int. J. Obes.* **2010**, *34*, 578–588.
96. Salamone, F.; Volti, G.L.; Titta, L.; Puzzo, L.; Barbagallo, I.; La Delia, F.; Zelber-Sagi, S.; Malaguarnera, M.; Pelicci, P.G.; Giorgio, M.; Galvano, F. Moro orange juice prevents fatty liver in mice. *World J. Gastroenterol.* **2012**, *18*, 3862–3868.
97. González-Molina, E.; Domínguez-Perles, R.; Moreno, D.A.; García-Viguera, C. Natural bioactive compounds of Citrus limon for food and health. *J. Pharm. Biomed. Anal.* **2010**, *51*, 327–345.
98. Seyoum, E.; Selhub, J. Properties of food folates determined by stability and susceptibility to intestinal pteroylpolyglutamate hydrolase action. *J. Nutr.* **1998**, *128*, 1956–1960.
99. *Dietary Guidelines for Americans*, 7th ed.; U.S. Government Printing Office: Washington, DC, USA, 2010.
100. Citrus Fruits 1999 Summary. US Deparment of Agriculture, National Agriculture Statistics Service. Available online: http://usda01.library.cornell.edu/usda/nass/CitrFrui//1990s/1999/CitrFrui-09-23-1999.pdf (accessed on 5 October 2012).
101. Citrus Fruits 2012 Summary. US Department of Agriculture, National Agriculture Statistics Service. Available online: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1031 (accessed on 5 October 2012).
102. Citrus: World Markets and Trade. US Department of Agriculture, Foreign Agriculture Service. Available online: http://usda01.library.cornell.edu/usda/current/citruswm/citruswm-07-26-2012.pdf (accessed on 7 October 2012).

103. Spreen, T.H. Projections of World Production and Consumption of Citrus to 2010. In *Proceedings of the China/FAO Citrus Symposium*, Beijing, China, 14–17 May 2001.