Relationship between composition and bioactivity of persimmon and kiwifruit

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ABSTRACT

Fruits are foods that contain plenty of vitamins, minerals and some bioactive phytochemicals like polyphenols. Thus, fruits may exert different functional properties on human health, some of which are directly related to their antioxidant capacity like cancer or atherosclerosis. Owing to globalization, consumers have a wide repertory of fruits throughout the year. Among them, tropical and subtropical fruits are steadily expanding, as well as the studies about them. In this sense, this timely review focused on the nutritional value and chemical composition of persimmon and kiwifruit, two tropical fruits with a protective role on different chronic diseases. Thus, this review focused mainly on the presence of bioactive compounds such as polyphenols, tannins, carotenoids, vitamin C, etc. and the different functional properties (i.e. antioxidant capacity, antithrombotic activity, decrease of plasmatic lipids, etc.) arising from the presence of such biologically active molecules. Finally, the effects of genotype and ripening stage on antioxidant capacity and the content of bioactive compounds in persimmon and kiwifruit are also discussed.

KEYWORDS: Persimmon, kiwifruit, antioxidant capacity, polyphenols, functional properties.

1. Introduction

Antioxidant capacity of fruits is becoming more and more an object of interest as possible treatment or as a means to prevent many diseases. Oxidation is directly related to the damage caused to biological molecules such as DNA, proteins, lipids, etc., which are all essential parts of cells. Hydroxyl radicals are one of the most common and harmful free radicals, which can be generated as a result of unhealthy habits such as smoking. However, regular respiration also produces them, and they are free to attack and damage cell components (Lee et al., 2004). In this sense, oxidative stress is known to be one of the causes of several chronic diseases such as cancer, liver disease, inflammation, diabetes, Alzheimer´s disease, Parkinson´s disease, atherosclerosis and aging (Moon & Shibamoto, 2009). Therefore, antioxidants consumption is thought to be an important means to fight such diseases and these are present some kind of foods, especially vegetables and fruits (Roginsky & Lissi, 2005). This healthy property depends on food composition and specifically on their content in bioactive compounds such as phenolics, vitamins, carotenoids, etc. (Patil, Jayaprakasha, Murthy, & Vikram, 2009).

Several studies have shown that fruit consumption could have a beneficial effect on health and a protective role on some chronic diseases such as atherosclerosis and cancer (Kim, Lee, Lee, & Lee, 2002). These properties have been attributed to bioactive compounds with antioxidant capacity, which can avoid or make slower the oxidative damage (Shi, Noguchi & Niki,2001). Thus, the nutritional composition and functional properties of fruits depend on several factors: Species and variety, crop conditions, ripening, treatment with phytosanitary products, conditions and storage time, etc. Moreover, ripening can occur either in the tree or after harvesting the fruit, but in both cases it involves complex processes that transforms their components (Abellan, García-Villanova & Ruiz, 2010).

Nowadays, owing to globalization, exotic tropical and subtropical fruits that some years ago were not available outside their climate zones can be found in almost any market around the world. There are many of these kinds of fruits but this review is focused only on kiwifruit (*Actinidia* spp.) and persimmon (*Diospyros kaki*) and their functional properties, especially their antioxidant capacity. Both of them are important in markets all around the world, especially kiwifruit, which in fact has lost some of that exoticism it had when it first arrived at some markets (Illescas, Bacho & Ferrer, 2007). On the contrary, persimmon consumption and cultivation is not so widespread as that of kiwifruit, but is a subtropical fruit with many bioactive compounds. These fruits have been introduced in the last decades in Spain, becoming an important factor for the Spanish economy since they are mostly exported to the European Union. Taking into account the economic value of these fruits and their content on bioactive compounds, this review described the nutritional composition and effect on human health of persimmon and kiwifruit. Special emphasis is placed on persimmon, since it is not as popular as kiwifruit, but scientific reports about its health properties is steadily expanding.

2. Persimmon

2.1 Persimmon production

Worldwide production of persimmon in 2014 was 5190624 tonnes, obtained from a harvested area of 1025989 ha. Persimmon production in the world is 0.75% of total fruit production (Food and Agricultural Organization of the United Nations, 2016). Most persimmon production is located in Asia, with 91% of world production, followed by Europe, with 5%. In the case of countries, the main production comes from China (73% of world production). On the other hand, although the harvesting area in Spain is lower than that of China, Spanish production of persimmon is 4.7% of world production (Food and Agricultural Organization of the United Nations, 2016).

Persimmon production has expanded in the last 15-20 years, being the world production multiplied by 5 in that period of time. On the other hand, focusing on Spain, in the early 1990s, production was basically absent. However, persimmon production in

2015 reached 250k tonnes, which gives an idea of how important this crop has become. For example, during 2015, in Spain alone, 4424 million kilograms were consumed, which meant an expenditure of 5973 million euros (MERCASA, 2016). In the same manner, production value has also grown worldwide and in Spain (Food and Agricultural Organization of the United Nations 2016). Thus, an expansion on production and economical value make this fruit of great interest in the last years, and consequently lot of research has focused on it.

2.2 Composition and nutritional value of persimmon

The composition of persimmon can change depending on the variety. **Table 1** shows the generic composition of persimmon and kiwifruit. Regarding macronutrients, persimmon has a low protein and fat content and around 16% of carbohydrates, mainly sugars. These sugars are mostly fructose, glucose and sucrose, which can be found in higher quantities than in other commonly consumed fruits. Moreover, persimmon has pectin and mucilagues as part of the soluble fiber and a large amount of insoluble fiber (Spanish Ministry of Agriculture, Fisheries, Nutrition and Environment, MAPAMA, 2016). Regarding micronutrients, persimmon is an exceptional source of provitamin A as β-carotene (with 160 μg/100g of fresh weight) and also a good source of vitamin C (16 mg/100g of fresh weight). Persimmon has important amounts of potassium but rather low quantities of other minerals such as magnesium and phosphorus (MAPAMA, 2016). Persimmon has also an important content in tannins which gives them astringency. In this sense, persimmon cultivars can be divided into astringent and non-astringent cultivars. However, astringency decreases in both cultivars during ripening due to their transformation in their insoluble forms (Pei, Zhang, Guo, & Luo, 2013). The differences between such cultivars is dependent on the large amount of tannins still present in the astringent cultivars even in mature state (Yaqub et al., 2016). During ripening there is also an increase in sugars, glucose and fructose due to the activity of the invertase enzyme, which hydrolyzes sucrose (Del Bubba et al., 2009). On the other hand, there is also a decrease of vitamin C content during fruit growing and ripening due to its use in the Kreb´s cycle (Antoniolli, de Camargo, Kluge & Filho, 2002).

Phytochemicals are an important fraction of persimmon fruit comprising proanthocyanidins, flavonoid oligomers, tannins, phenolic acids and carotenoids. In fact, persimmon has 160-250 mg of polyphenols/100g of fresh weight and 2 mg of carotenoids/100 g of fresh weight (Butt et al., 2015), which is a high amount compared with the protein content (640-1300 mg of proteins/100g of fresh weight).

Carotenoids. Carotenoids are responsible of the colour of the fruit and also responsible for some of their antioxidant capacity. Their content increases as the fruit matures except for lutein and lycopene. Their content is very variable depending on the cultivar, but usually the most abundant carotenoid is β-cryptoxanthin (Yaqub et al., 2016).

Tannins. Tannins are an important fraction of persimmon. These compounds are responsible of astringency. As stated above, persimmon cultivars can be divided into two groups with respect to astringency: astringent and non-astringent cultivars. The first group has a higher content of insoluble tannins than the second. However, during ripening, astringency decreases as soluble forms of tannins are transformed into their insoluble forms. According to some authors (Gu et al., 2008; Matsui, 2015), persimmon tannins are composed of epicatechin gallate, epigallocatechin gallate, epigallocatechin and an unknown monomer. These compounds are commonly called catechins and comprise of a group of bioactive compounds with strong antioxidant capacity involved in many chronic diseases based on oxidative stress. These catechins are higher in astringent persimmons than in non-astringent ones.

Phenolic compounds. According to some authors, total polyphenols are around 1.45 mg/100 g of fresh weight (Butt et al., 2015). However, phenolic content is very variable among cultivars due to the different climate conditions, crop characteristics, harvest time, processing, nutrients available, etc. In persimmon, phenolics can be divided into low and high molecular groups. In the first one, phenolic acids, catechins and hydrolyzed tannins are included. In the high molecular weight group tannins and proanthocyanidins can be found (Yaqub et al., 2016).

Proanthocyanidins. These compounds increase during the early stages of growing, giving the fruit resistance against different types of aggressions. They are composed of condensed flavan-3-ols. However, their content decreased during maturation, which results in a decreased antioxidant capacity (Yaqub et al., 2016).

2.3 Effect of genotype on antioxidant capacity and bioactive compounds of persimmon

The presence of antioxidant compounds such as carotenoids, ascorbic acid, tannins, catechins and other phenolic molecules make persimmon a great source of antioxidants. This means that persimmon consumption could help prevent or reduce diseases related to oxidative stress (Butt et al., 2015). In this sense, **Table 2** shows the data available in bibliography about antioxidant phytochemicals (total polyphenols, total carotenoids, α- and β-carotene, zeaxanthin and β-cryptoxanthin) for a total of 21 genotypes of *Dyospiros kaki* (Pu, Ren, & Zhang, 2013; Veberic, Jurhar, Mikulic-Petkovsek, Stampar, & Schmitzer, 2010).

The total content of polyphenols was analyzed by means of the Folin-Ciocalteu method in different cultivars (Veberic et al., 2010; Pu et al., 2013). Phenolic content is very variable depending on the genotype. Results extracted from bibliography show that the genotype with higher phenolic content is *D. kaki. var. silvestris M*, with 1520 mg GAE/100 g of dry weight (**Table 2**). However, the genotype with the lowest amount of total phenols is *D. kaki cv. Mopan*, with 32 mg GAE/100 g of dry weight. Such huge difference (50 times higher) is just a sample of how phenolic content could vary. Not surprisingly, the wild genotype *D. kaki. var. silvestris M* was also the one with statistically significant higher values of total flavonoids and flavanols compared with commercial varieties (Veberic et al., 2010). In the case of individual polyphenols, different types such as p-coumaric acid, catechin, epicatechin, epigallocatechin, condensed proanthocyanidins, quercetin or kaempferol can be found in persimmon (**Table 3)**. All these compounds could play a protective role against oxidative stress and, in extension, with diseases related to such condition.

Other family of important bioactive compounds in persimmon is carotenoids, which are responsible of their pigmentation. These molecules have shown antioxidant capacity and therefore are able to decrease oxidative stress (Yaqub et al., 2016). Carotenoids are able to protect biological membranes from oxidation and therefore they are potentially able to slow down cellular aging protecting against degenerative deseases (Suzuki, Someya, Hu, & Tanokura, 2005). Total carotenoid content did not vary that much compared to polyphenols (**Table 2**). Results from 11 genotypes showed a range between 490-936 mg/kg of fresh weight. Since the amount of carotenoids is up to 25-times lower than that of polyphenols, it could be hypothesized that the antioxidant properties of persimmon could rely more on the phenolic content. When individual carotenes were measured, β-carotene was the predominant species, with a 4-5 higher content than α-carotene. In this sense, β-carotene content ranged from 259 to 459 mg/kg of fresh weight while α-carotene was in the range of 73-160 mg/Kg of fresh weight.

The content on two other carotenoids, such as zeaxanthin and β-cryptoxanthin, are in the same range (**Table 2**).

Regarding vitamin C, one fruit can fulfill around 46% of vitamin C requirements (Rao & Rao, 2007) since the vitamin C content ranges from 0.25-2.14 mg/ g of fresh weight (**Table 2**). In general, vitamin C levels in non-astringent cultivars are significantly higher (10-times) than those of the astringent cultivars (Giordani, Doumett, Nin, & Del Bubba, 2011). Vitamin C exists in persimmon under two forms: L-ascorbic acid and its oxidized product, L-dehydroascorbic acid. Although both chemical species are important compounds thanks to their antioxidant and anti-radical activities, they do not exert the same activity since L-ascorbic acid is more active than the oxidized form (Gregory, 2007). Around 2/3 of total vitamin C in persimmon is available as L-ascorbic acid (Giordani et al., 2011).

Information about the relationship between cultivar and antioxidant capacity is available for three antioxidant methods: ABTS, FRAP and DPPH. Regarding the ABTS method, *D. kaki cv. Jiro, Zenjimaru, Xingyangshuishi, Zhouqumomoshi, Xiuningbianshi* and the wild genotype *D. kaki var. silvestris M* were compared (Pu et al., 2013). For this method, the results ranged from 0.5 to 37 μmol Trolox/g of fresh weight for *Jiro* and wild genotype, respectively. In the case of the FRAP method, the most antioxidant genotype with significant difference was again the wild one whereas the lowest reducing capacity was obtained by *Zenjimaru* cultivar (9.6 and 0.9 μmol Trolox/g of fresh weight, respectively). Finally, regarding DPPH method, the results showed the same relation. Thus, the antioxidant capacity of such cultivars decreased in the following order: *silvestris* >> *Zhouqumomoshi* > *Xiuningbianshi* > *Xingyangshuishi* > *Zenjimaru* > *Jiro*. Another study reported that irrespective of the antioxidant method used, the antioxidant capacity of persimmon genotypes decreases in the following order:

Seochonjosaeng >> *Bongok* > *Dogeunjosaeng* > *Cheongdobansi* (Jang, Oh, Ahn, Lee, & Lee, 2011). Finally, (Park et al., 2015) reported that the antioxidant capacity of persimmon is usually higher in astringent varieties than in non-astringent ones (Yaqub et al., 2016). In addition, whatever the variety assessed, the antioxidant capacity of persimmon is higher than that found in banana, durian, grape, grapefruit and lemon, but lower than strawberry, apple pulp, kiwifruit and mangosteen.

2.4. Functional properties of persimmon

Persimmon functional properties are related to its content in bioactive compounds, which exerts a protective role on hypercholesterolemia, diabetes, cancer, hypertension and some dermic disorders (Park et al., 2015). Such bioactivity is related to their chemical composition on specific nutrients, described in **Table 4**. In a wide sense, the functional properties of persimmon have been related with its antioxidant capacity. For example, a randomized controlled trial studied the plasmatic antioxidant capacity and urinary excretion of 8-isoprostane in individuals with a high intake of persimmon vinegar (Mure, Takeshita, Morioka & Arita, 2007). A significant increase in plasma antioxidant activity and reduced excretion of 8-isoprostane (a urinary biomarker of oxidative stress) were found.

Diabetes mellitus. Due to the large amount of antioxidants found in persimmon, it is able to prevent at some extent diabetes or decrease the oxidative damage caused by the free radicals released due to this condition (Yaqub et al., 2016). Additionally, pancreatic β-cells are more sensible to oxidative stress due to a lower concentration of antioxidants compared to other tissues (Prasath, Sundaram, & Subramanian, 2013). Moreover, its fiber content could help reduce appetite and blood sugar by trapping glucose in the intestine. A study to elucidate the role of proanthocyanidins found in persimmon peel on diabetes was performed in streptozotocin-induced diabetic rats (Lee, Kim, Cho, & Yokozawa, 2007). A protective modulation of hyperglycemia was obtained thanks to the modulation of glucose and protein glycation. In addition, lipid peroxidation in kidney and serum was decreased in comparison with the control group. Furthermore, reactive oxygen species blockage was higher in the proanthocyanidins group as well as the ratio reduced-gluthatione/oxidized-gluthatione. Finally, proanthocyanidins had a protective role in inflammation due to their activity regulating the expression of some proinflammatory factors such as iNOS, COX-2, NF-κB p65, and IκB (Lee et al., 2007). According to some authors, persimmon peel could reduce blood sugar, cholesterol and triglycerides in diabetics, following a supplemented diet (Gorinstein et al., 2001).

On the other hand, polyphenols extracted from persimmon fruit were tested on rats and humans in order to observe their effect on postpandrial glucose levels (Kometani & Takemori, 2016). The extract rich in persimmon polyphenols gave rise to significantly lower blood sugar levels in 10 subjects, compared to placebo group. It has been suggested that inhibition of alpha amylase as well as reduction of absorption are behind this fact (Kometani & Takemori, 2016). Accordingly, it could be suggested that persimmon could help control postpandrial blood sugar levels, being part of the primary prevention in diabetes (Kometani & Takemori, 2016).

Prasath, Sundaram, & Subramanian (2013) carried out an experiment in male albino Wistar rats in order to study the effect of Fisetin, a flavonoid present in persimmon, over diabetes. In this sense, rats were streptozotocin-diabetic induced and were administered with 10 mg of Fisetin/kg of body weight for 30 days. Rats treated with Fisetin showed a significant reduction in blood sugar levels, as well as in glycosylated hemoglobin. NF-κB p65 unit in pancreas and IL-8β in plasma as well as nitric oxide (NO) also showed significantly reduced levels, whereas circulating insulin levels increased. The observed reduced levels of NF-kB p65 unit along with IL-8b and NO show a potentially anti-inflammatory action reducing pancreatic damage (Prasath, Sundaram, & Subramanian, 2013). On the other hand, the antioxidant status also improved in pancreas and plasma of diabetic rats: Antioxidant enzymes activity (SOD, CAT, GPx, and GST) increased, while the levels of lipid peroxides and hydroperoxydes dropped. Fisetin showed radical scavenging capacity, which could be of help in radical mediated pathological processes. Thus, improved insulin levels could be related with pancreatic protection owing to Fisetin antioxidant capacity, resulting in protection against oxidative stress derived from hyperglycemia.

Atherosclerosis and lipid metabolism is another condition closely related to oxidative stress. The oxidation of LDL initiates the atheromatous plaque, being the oxidative species in the vessels the main cause of this problem. Due to its high content in antioxidants, persimmon could be of help reducing or preventing LDL oxidation and thus the developing of atherosclerosis (Yaqub et al., 2016). In addition, tannins have shown ability to trap bile acids (Gato, Kadowaki, Hashimoto, Yokoyama, & Matsumoto, 2013) which could lead to lower cholesterol levels in plasma, resulting in reduced cardiovascular disease risk. According to some authors, Wistar rats fed with anhypercholesterolemic diet enriched in persimmon (7%) had lower values of plasmatic lipids (cholesterol, triglycerides, LDL) after a 4-weeks period compared to control rats (Dembitsky et al., 2011).

Persimmon is known to have a high amount of tannins, especially astringent cultivars. As previously stated, tannins behave as fiber and trap bile acids, which would be convenient in hypercholesterolemia treatment (Gato et al., 2013). These authors performed a randomized control trial double-blinded (40 subjects) to shed some light into the hypocholesterolemic effect of persimmon tannins. The study lasted 12 weeks and it was comprised of a placebo group, low-dose group (3 g, three times per day) and high-dose group (5 g, three times per day). These authors found that in both low- and high-dose groups, total plasmatic cholesterol was significantly lower than in the placebo groups while low density lipoproteins levels were only lower in the high-dosed group. Accordingly, persimmon could be of used in hypercholesterolemic patients.

Antiatherogenic and antioxidant capacity has also been assessed in persimmon wine. The process of vinification is known to improve polyphenol preservation and make them more bioavailable (Suh et al., 2011). Accordingly, Suh et al. (2011) compared persimmon wine against grape wine (Merlot) in order to expose their effects on hypercholesterolemic hamsters. In this sense, they observed that both wines improved total cholesterol, low density lipoprotein, triglycerides and glucose levels, but no significant differences among both types of wines were obtained. They also proved to protect endothelial function from damage related to such dyslipidemic status (Suh et al., 2011).

In addition, a reduced oxidative stress (lower oxidized LDL and lipid peroxides) was observed. These properties were attributed to the persimmon content insoluble fiber and polyphenols. In another study, rats fed with a hypercholesterolemic diet were separated into two groups: One supplemented with whole dry persimmon and the other with polyphenol free dry persimmon (Gorinstein et al., 2011). Both groups showed reduced levels of plasmatic lipids but only the whole persimmon group showed an improvement in the antioxidant status, proving that antioxidant properties are mostly due to the polyphenol content. In a different study, rats were fed with either a standard cholesterol-rich diet or the same diet supplemented with two persimmon cultivars for 47 days (Gorinstein et al., 2011). The results showed that that diet supplemented with persimmon (whatever the cultivar used) gave lower lesions in aorta compared to the control group.

Obesity is a pathology characterized not only with fat accumulation (adipocyte hypertrophy) but also related with adipocyte hyperplasia, which in turn reveals preadipocytes differentiation. In this sense, it was stated that persimmon tannins have the potential to be an antiadipogenic bioactive compounds (Zou, Ge, Zhu, Xu, & Li, 2015). Persimmon tannins can inhibit *in vitro* 3T3-L1 preadipocyte differentiation and reduce the expression of adipogenic transcription factors such as PPAR-γ and C/EBP-α in the early stages of adipogenesis.

Inflammatory bowel disease. Direito et al. (2017) tested the anti-inflammatory effects of persimmon phenolic extracts over colitis by using mice with TNBS-induced colitis. The experiment lasted for 4 days. Persimmon administration achieved several improvements in TNBS-induced colitis mice; visible injuries spread less and visible (ulcers), less severe diarrhea, reduced mortality rate and mucosal hemorrhage and improvement of colonic general inflammation. Two possible mechanisms behind this finding were proposed: Cyclooxygenase 2 (COX-2) and nitric oxide synthetase (iNO) expression reduction. COX-2 overexpression is related with inflammatory bowel disease and colorectal cancer progression. Accordingly, colitis-induced mice showed increased levels of COX-2, whereas the administration of the persimmon phenolics led to a significant decrease. On the other hand, NO is known to play a role in inflammation. Accordingly, its production was found to be higher in colitis-induced mice (Direito et al., 2017).

Cancer. Persimmon has been found to have protective effect against some types of cancer such as prostate, breast, oral carcinoma or lymphoid leukemia due to its high carotenoids content, which are known to regulate cell growth and differentiation (Yaqub et al., 2016). Direito et al. (2017) also carried out an *in vitro* experiment in HT-29 colon carcinoma cells to observe the possible antiproliferative effect of persimmon phenolics. These polyphenols impaired cell proliferation and invasion, suggesting a promising therapy. Moreover, 28-oxoallobetulin, a compound isolated from persimmon calyx has proven to have cytotoxic effects on HT-29 colon cancer cells (Lee, Koo, & Park, 2014).

Moreover, aside from the scavenging activity mentioned above, Fisetin has anti-cancer activity both *in vitro* and *in vivo* through interfering in signaling pathways related to cell survival, growth and proliferation (Syed, Adhami, Khan, & Mukhtar, 2016). Fisetin has shown to decrease growth and proliferation of prostate cancer cells. It also showed capacity to inhibit PI3K/Akt and mTOR pathways in non-small cells lung cancer, which is quite important since both of them are key signaling pathways implicated in cancer (Syed, Adhami, Khan, & Mukhtar, 2016). Fisetin was also negatively correlated with melanoma cells growth, not only *in vitro* but also *in vivo* (Pal et al., 2015). Fewer lung metastases were observed in athymic mice treated with fisetin along with sorafenib, compared to mice treated only with sorafenib, showing therefore its anti-invasive effects.

The effects of persimmon have also been studied over human lymphoid leukemia Molt 4B cells. In this sense, a persimmon extract and some of its individual polyphenols (catechin, epicatechin, epigallocatechin and epicatechin gallate) were investigated (Achiwa, Hibasami, Katsuzaki, Imai, & komiya, 1997). These authors found that persimmon extract, as well as epigallocatechin and epicatechin gallate, inhibited the growth of these cells in a dose dependant manner. After 3 days of treatment they observe severe damage on cells, such as DNA fragmentation. These findings could indicate a possible use for therapeutic purposes. Additionally, as part of a case-control study about thyroid cancer in Korean women, it was found out that an inverse correlation exist between persimmon consumption and malignant as well as benign thyroid cancer risk (Jung, Kim, Tae, Kong, & Kim, 2013). This study included 111 cases of malignant cancer and 115 of benign cases.

3. Kiwifruit

3.1 Kiwifruit production

World production of kiwifruit is around 3447604 tons, which is supposed to be around 0.5% of the total fruit production. Asia is the main producer followed by Europe, Oceania, America and finally Africa with an almost inexistent production (Food and Agricultural Organization of the United Nations, 2017). The main producer of kiwifruit is China, with 1840000 tons and a 53.4% of worldwide kiwifruit production. New Zealand is another important producer with 410746 tons and 12% of kiwifruit production. In this country kiwifruit is a really important crop since it constitutes about 29% of total fruit production in the country and therefore is an important factor for their economy. For other countries, kiwifruit is not one of the main crops, with percentages below one. For example, the Spanish production in 2015 was only 21000 tons, a 0.61% of world production (well below persimmon production) being almost 2000 tons exported to the European Union (MAPAMA, 2017).

In the last three decades kiwifruit production has grown greatly, around 3.5 times. This tendency shows that kiwifruit is becoming more popular, probably being introduced as an exotic fruit but also due to their health benefits. Accordingly, kiwifruit value has doubled since 1990. The same tendency occurred in Spain, moving the value from less than 50 to around 2500 million dollars in the last three decades (MAPAMA, 2017). Thus, taking into account kiwifruit value and that the main part of the Spanish production is sold in the EU, kiwifruit is important for the Spanish economy.

3.2 Composition and nutritional value of kiwifruit

Kiwifruit (*Actinidia* sp.) is an important source of vitamin C, also with high levels of fiber, potassium, vitamin E and folic acid **(Table 1)**. However, the nutritional composition of kiwifruit, especially regarding vitamin C, can vary depending on the cultivar. Usually, "SunGold" and "Sweet Green" cultivars have the highest contents in vitamin C (Sivakumaran, Huffman, Sivakumaran, & Drummond, 2018). Thus, one kiwifruit can fulfill 85% or vitamin C requirements. As kiwifruit ripens, the acid content decreases and aromatic compounds appear (Perera, 1998). Moreover, sugars such as glucose, fructose and sucrose increase, improving the taste of the fruit (Park et al., 2006). Glucose and fructose are the main sugars in kiwifruit, but some cultivars like "hardy kiwifruit" are richer in sucrose (Latocha, Łata, & Stasiak, 2015). Among the organic acids, citric and quinic acids are the most abundant (Latocha et al., 2015).

There are several species of kiwifruit, the most popular ones being *A. deliciosa* (Hayward), *A. chinensis* and *A. eriantha* (*Bidan*). However, there are also other species that are grown in colder climates such as *A. arguta* (Hardy kiwifruit), *A. kolomikta* and *A. purpurea.* (Leontowicz et al., 2016). *A. arguta* includes several different cultivars such as *Bingo* (hybrid between *A. arguta* and *A. purpurea)*, *M1* (select arguta), *Anna*, *Weiki*, *Jumbo* and *Geneva* (Leontowicz et al., 2016).

Kiwifruit is considered an important source of antioxidants species (**Table 4**) (Wojdyło, Nowicka, Oszmiański, & Golis, 2017) due to its content in bioactive compounds like polyphenols (**Table 3**) and vitamin C (**Table 2**), a positive correlation exist among both chemical species (Leontowicz et al., 2016). Vitamin C is an important compound in kiwifruit since its contribution to antioxidant capacity is equal to that of polyphenols (Park et al., 2011). In addition, chlorophyls are also important antioxidant compounds, which play a role on the characteristic green color of kiwifruit. Chlorophyls are also important as regulators of inflammatory processes, microbial infections, ageing and atherosclerosis (Leontowicz et al., 2016). Moreover, other pigments like lutein, zeaxantine and β-carotene are present in kiwifruit. These compounds contribute also to their functional properties, especially to those related with antioxidant capacity such as neutralization of free radicals, reduction of muscular degeneration, cancer risk or cellular aging (Abuajah, Ogbonna, & Osuji, 2015).

Another important contribution of kiwifruit to diet is related to its fiber content (**Table 5**) (Wojdyło et al., 2017). Total dietary fiber ranges from 9 to 27% of dry weight, being the highest fraction insoluble fiber (65-90% to total fiber). Insoluble fiber can trap glucose, cholesterol, bile acids and dietetic carcinogens, reducing their absorption and improving conditions such as diabetes, dyslipidemia or hypercholesterolemia (Abellan et al., 2010). On the other hand, soluble fiber increases satiety, slow down gastric emptying and stimulates intestinal motility, being used as treatment for constipation. In addition, soluble fiber can be fermented by the gut microbiota, producing butyric acid that lowers colorectal cancer (Wojdyło et al., 2017).

The amount of all these bioactive compounds is very variable among species and cultivars. Not only do they vary among species but also, according to several authors, these quantities can depend on fertilization conditions, weather, etc. (Park et al., 2013; Park et al., 2014). For example, a comparison among organic and conventionally grown cultivars showed that kiwifruit grown under organic conditions had a higher antioxidant capacity, although such was not statistically significant in all the cultivars (Park et al., 2013).

3.3 Effect of genotype on antioxidant capacity and bioactive compounds of kiwifruit

The antioxidant capacity and bioactive compounds content of several cultivars of kiwifruit have been described elsewere: *Bidan*, *M1*, *Bingo*, *Geneva*, *Anna*, *Jumbo*, *Weiki*, *SKK12*, *Hwamei*, *Hort16A*, *Hayward*, *Haenam* and *Daheung* (Park et al., 2011; Drzewiecki et al., 2016; Leontowicz et al., 2016). These papers studied the antioxidant capacity of kiwifruit with several antioxidant methods such as FRAP, ABTS, DPPH and CUPRAC. In the FRAP method, *Bidan* cultivar gave the highest antioxidant value, which was almost three times more antioxidant than the second (*Haenam*). In general, the reducing capacity measured by the FRAP method ranged from 7 to 63 μmol Trolox/g of fresh weight; the lowest activity corresponded to *Hort16A* and *Hayward* cultivars. The ABTS method showed that the *M1* cultivar was the most antioxidant cultivar, with 112 μmol Trolox/g of fresh weight. On the other hand, the lowest value corresponded to the *Hayward* cultivar, with 17 μmol Trolox/g of fresh weight. In the case of DPPH method, *Bidan* again was the most antioxidant cultivar with 84 μmol Trolox/g of fresh weight, being the lowest value of that of the *Hayward* cultivar, with 7 μmol Trolox/g of fresh weight. Finally, the CUPRAC assay showed that the *M1* and *Bidan* cultivars were the most antioxidant, with 105 μmol Trolox/g of fresh weight. Again, the *Hayward* cultivar showed the lowest value with 15 μmol Trolox/g of fresh weight. In conclusion, the antioxidant capacity of kiwifruit decreases in the following order: *Bidan* >> *Bingo* > *Anna* > *Geneva* > *Jumbo* > *Weiki* > *Haenam* > *SKK12* > *Hwamei* > *Daheung* > *Hort16A* > *Hayward*.

As stated above, ascorbic acid and polyphenols are the most important chemical species contributing to the antioxidant capacity of kiwifruit (Park et al., 2011). Thus, the knowledge about the content of such bioactive compounds is essential in order to give clear dietetic recommendations. According to the scientific literature (**Table 2**), the concentration of vitamin C in kiwifruit ranges from 0.07 to 0.97 mg/ g of fresh weight.

The highest amounts of vitamin C are present in the *Bidan* cultivar, followed by the *Bingo*, *M1*, *Geneva* and *Hayward* genotypes. However, *Anna*, *Weiki*, *Jumbo*, *Daheung* and *Haenam* varieties had the lowest values.

According to the findings about antioxidant capacity and vitamin C, the kiwifruit cultivar with the highest content of total phenolics is the *Bidan* genotype with 27 mg gallic acid/g of dry weight. On the contrary, the *Daheung* cultivar showed the lowest content, with 4 mg gallic acid/g of dry weight. In general, polyphenols content decreases in kiwifruit cultivars in the following order: *Bidan* > *M1* > *Bingo* > *Geneva* > *Anna* > *Jumbo* > *Weiki* > *SKK12* > *Hwamei* > *Hort16A* > *Hayward* > *Haenam* > *Daheung*. Finally, statistically significant correlations were found among the four antioxidant methods and total phenolics, reinforcing the idea that these chemical species are probably the most important compounds for the antioxidant capacity of any kiwifruit cultivar (Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016).

Flavonoids, flavanols and tannins have been also reported (**Table 3**), since they are an important fraction of total polyphenols. In the case of flavonoids, the highest content was reported for the *Daheung* cultivar, with 5 mg catechin equivalents/g of dry weight. On the contrary, the lowest value was found in the *Bidan* genotype, with 0.3 mg catechin equivalents/g of dry weight. In the case of flavanols, the content ranged from 17 to 0.6 mg catechin equivalents/g of dry weight for the *Hort16A* and *Bingo* cultivars. The values of tannins were distributed again between *Bingo* and *Hort16A* cultivars, with values ranging from 9 to 1 mg catechin equivalents/g of dry weight, respectively. From these data it could be deduced that flavonoids, flavanols and tannins are not the main contributors to antioxidant capacity in some kiwifruit cultivars such as *Bidan* or *M1*. These genotypes showed a high antioxidant capacity but the amount of different polyphenols classes were quite low. Thus, in such cultivars the antioxidant capacity could be related more specifically with other chemical species such as vitamin C, carotenoids, chlorophyll, xanthophylls, anthocyanins, etc, (Rao & Rao, 2007).

3.4 Functional properties of kiwifruit

Due to the large amount of bioactive compounds found in kiwifruit, some functional properties derived from its intake could be expected. Among them, the effects over platelet aggregation, plasma antioxidant capacity, plasmatic lipids, hypertension, inflammation or insulin resistance have been demonstrated among others.

Platelet aggregation. A randomized cross-over study with healthy volunteers was carried out in order to unravel whether kiwifruit consumption could have any effect on platelet aggregation (Duttaroy & Jørgensen, 2004). Kiwifruit was able to inhibit ADP-induced aggregation in a dose dependent manner and reduced collagen-induced aggregation. In addition, kiwifruit also inhibited arachidonic-induced aggregation. Such platelet inhibition could be ascribed to a decrease in TXB2 synthesis (Dizdarevic et al., 2014). In this sense, a margarine supplemented with kiwifruit extracts resulted in decreased platelet aggregation just two hours after consumption (Dizdarevic et al., 2014).

Plasma antioxidant capacity/ROS protection. Kiwifruit consumption also resulted in an increased antioxidant capacity of plasma, measured with the FRAP method of volunteers consuming 2-3 kiwifruits per day (Duttaroy & Jørgensen, 2004). Moreover, plasmatic levels of vitamin C and E also increased significantly after 4 and 8 weeks of kiwifruit consumption while decreasing LDL oxidation (Chang & Liu, 2009). Kiwifruit has also proven its ability to reduce DNA damage due to oxidation. In this sense, kiwifruit juice administrated to individuals proved to reduce significantly DNA damage in lymphocytes (Collins, Horská, Hotten, Riddoch, & Collins, 2001). Since kiwifruit juice was more active than vitamin C supplementation, it was suggested that part of the induced antioxidant protection of kiwifruit should come not only from ascorbic acid but also from other compounds such as polyphenols.

Apart from vitamin C and polyphenols, the antioxidant capacity of kiwifruit is also related with the presence of an antioxidant peptide called kissper, a 39 residue peptide with pore-forming ability (Ciardiello et al., 2008). The antioxidant potential of kissper peptide on intestinal mucosa inflammation was studied by using Caco-2 cells and colonic mucosa from healthy and Chron´s disease individuals (Ciacci et al., 2014). Kissper peptide was able to reduce or modulate the damage induced by ROS derived from LPS challenge in Caco-2 cells as well as in CD mucosa. Moreover, kissper was also able to increase cell viability. In addition, the kissper peptide has showed ability to reduce TG2 levels in Caco-2 cells and colonic mucosa. This is an important result since TG2 is a protein closely involved in mitochondrial functionality, and its expression is considered a link between oxidative stress and inflammation (Ciacci et al., 2014). Finally, some authors found statistical association between the antioxidant capacity of kiwifruit and its ability to reduce proliferation in two cell lines of human carcinoma (lung and stomach) (Park et al., 2012).

Plasmatic lipids. Kiwifruit also play a role in the levels of plasmatic lipids. A human intervention during 28 days (daily intake of 2 kiwifruits) showed no effect on cholesterol concentration (LDL, HDL or total cholesterol) but a decrease in plasmatic triglycerides (Duttaroy & Jørgensen, 2004). When the study was repeated with hyperlipidemic volunteers, there was no difference in total cholesterol, triglycerides, or LDL cholesterol (Chang & Liu, 2009). However, HDL-cholesterol increased in a significant manner as well as the ratio HDL-C/LDL-C and HDL-C/TC. A different cross-sectional study called EVIDENT investigated in healthy individuals whether consuming one or more kiwifruit units per week had any effect on plasmatic lipids, fibrinogen and insulin sensitivity (Recio-Rodriguez et al., 2015). Individuals who consumed at least one kiwifruit per week had significantly higher values of HDL-c and lower triglycerides, fibrinogen values insulin resistance was found. No differences were detected in total cholesterol and LDL-c. According to these findings, kiwifruit might have a beneficial impact in inflammatory processes, atherogeneis and thrombogenesis, exerting also hypolipidemic activity and therefore being beneficial in diabetes development. Interestingly, these findings were only found for kiwifruit and not for other fruits according to the EVIDENT study (Recio-Rodriguez et al., 2015).

Antihypertensive activity. According to some authors, kiwifruit extracts showed inhibitory activity of human and rabbit serum angiotensin-converting enzyme (ACE) in a dose-dependent manner, whereas orange extracts did not showed any activity (Dizdarevic et al., 2014).

Inflammation. The kissper peptide was also able to control the release and expression of proinflammatory cytokines TNF-α, ICAM-1 and COX-2 in a mixed *in vivo*-*in vitro* study (Ciacci et al., 2014).

Insulin resistance. Many metabolic effects of insulin are mediated by signaling pathways involved in the phosphorylation of insulin receptor substrate proteins, and the activation of PI3K, Akt and protein kinase B. The activated Akt can enter the cytoplasm leading to phosphorylation and inactivation of glycogen synthase kinase-3 (GSK-3). Glycogen synthase (GS) is the substrate of GSK-3 which catalyzes glycogen synthesis. Phosphorylation of GS by GSK-3 inhibits glycogen synthesis; therefore the inactivation of GSK-3 by Akt promotes glucose storage as glycogen. Defects at any one of these factors may contribute to insulin resistance (Kim, Kim, Kim, & Lee, 2013). In this sense, kiwifruit extracts were able to increase the phosphorylation of GSK-3/Atk, which in turn reduced the phosphorylation of GS. Moreover, transportation of GS to the membrane was also increased. All together indicates that kiwifruit improves insulin resistance through this pathway.

Large intestine health. Kiwifruit has an important content of fiber, which is helpful to maintain large intestine health as stated above (Wojdyło et al., 2017). A study to unravel the effect of kiwifruit in large intestine health and functionality was carried out in Sprague-Dawley rats with a diet enriched in kiwifruit (10%) (Paturi, Butts, Bentley-Hewitt, & Ansell, 2014). After a 6-weeks treatment, the production of short chain fatty acids increased, colonic barrier function improved and the microbial populations of *Lachnospiraceae* increased. All this suggests that kiwifruit could be beneficial for gut microbiota and in extension for large intestine health (Paturi et al., 2014). Kiwifruit pectin (MonoK) was also tested in order to unravel their potential healthy properties for the gut (Parkar et al., 2010). This pectin was compared with citrus pectin, inulin and guar gum. Kiwifruit pectin was the most efficient fiber in increasing the adhesion of *Lactobacillus rhamnosus* and decreasing the adhesion of *Salmonella typhimorium* to colonic cells (Parkar et al., 2010).

Effects on bone health. Kiwifruit effects on bone resorption were tested in ovariectomized mice (Katsumata et al., 2015). Kiwifruit could have a protective effect against bone resorption through reducing the expression of the receptor activator of NF-kβ ligand (RANKL) mRNA in ovariectomized mice. A different study was conducted in order to study the effect of combining daidzein and kiwifruit on bone density and equol production in ovariectomized rats (Tousen et al., 2014). According to this study, kiwifruit could had a small effect in reducing bone loss due to oestrogen deficiency, although equol production was not affected.

Insomnia. Kiwifruit was tested in a randomized control trial focused on whether this fruit has any effect in reducing insomnia (Nødtvedt, Hansen, Bjorvatn, & Pallesen, 2017). A slight association between kiwifruit consumption before going to sleep (1 h before) and a relative improvement in two out of 12 variables studied was found.

4. Conclusion

This review includes the composition and nutritional value of persimmon and kiwifruit in general, although it describes deeply, the presence of bioactive compounds such as polyphenols, tannins, carotenoids, vitamin C, etc. In addition, the functional properties of these fruits (i.e. inhibition of platelet aggregation, ROS protection, decrease of plasmatic lipids and cholesterol, antihypertensive activity, increase on insulin sensitivity, etc.) and effects on different pathologies is described. Among such health benefits, both persimmon and kiwifruit possess high antioxidant potential due to the high amounts of bioactive compounds. In this sense, the effect of genotype and ripening stage play an important role in antioxidant capacity and the content of bioactive compounds. Taking into account such nutritional profile and large content of bioactive compounds, it can be concluded that the supplementation of diets with the reviewed fruits positively affects human health.

Acknowledgements

This work was supported by project AGL2014-53895-R from the Spanish Ministry of Economy and Competitiveness and by the European Regional Development Fund (FEDER). This paper will form part of Sergio Pérez-Burillo's doctoral thesis, which is being developed within the context of the "Nutrition and Food Sciences Programme" at the University of Granada.

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Table 1.

Generic composition of persimmon and kiwifruit (Barea-Álvarez et al., 2016; MAPAMA, 2016; United States Department of Agriculture, Agricultural Research Service, Food Composition Database, 2017).

	Kiwifruit		**Persimmon**	
	100 g of edible portion	**By unit (100g)**	**100 g of edible portion**	**By unit (100g)**
Energy (Kcal)	59.00	49.00	71.50	114.40
Proteins (g)	1.06	0.87	0.64	1.02
Total fats (g)	0.39	0.32	0.25	0.39
Carbohydrates (g)	13.20	10.95	17.30	27.67
Fiber (g)	1.65	1.35	2.60	4.16
Water content (g)	84.17	70.34	80.86	129.38
Calcium (mg)	21.00	17.75	8.00	12.80
Iron (mg)	0.31	0.24	0.20	0.31
Magnesium (mg)	13.50	11.45	9.25	14.80
Zinc (mg)	0.09	0.08	0.11	0.17
Sodium (mg)	3.50	2.70	2.50	4.00
Potassium (mg)	302.50	252.00	175.50	280.80
Phosphorus (mg)	30.00	25.05	19.50	31.20
Selenium (µg)	0.60	0.50	0.60	0.96
Thiamine (mg)	0.01	0.01	0.03	0.04
Riboflavin (mg)	0.05	0.05	0.03	0.05
Niacin equivalents (mg)	0.42	0.34	0.20	0.32
Vitamin B_6 (mg)	0.11	0.10	0.10	0.16
Vitamin B_{12} (µg)	0.04	0.03	0.00	0.00
Vitamin C (mg)	110.15	90.70	11.75	18.80
Vitamin A: Retinol Eq. (µg)	2.00	1.80	119.50	191.20
Vitamin D (µg)	0.00	0.00	0.00	0.00
Folate (mg)	31.00	25.00	7.50	12.00

Table 2.

Bioactive compounds found in persimmon and kiwifruit.

Astringent (A)/Not astringent (NA)	Persimmon Genotypes/Kiwifruit Cultivar	Total polyphenols mg GAE g^{-1} DW[a]	Total chlorophylls mg g^{-1} DW	Anthocyanins mg CGE kg^{-1} DW	Vitamin C mg g^{-1} FW[b]	Zeaxanthin mg Kg^{-1}FW	β-Cryptoxanthin mg Kg^{-1} FW	α-Carotene mg Kg^{-1} FW	β-Carotene mg Kg^{-1} FW	Total carotenoids mg Kg^{-1} FW	Ref.
	Persimmon										
NA	*D. kaki* cv. Amankaki	1.40	NF	NF	NF	52	287	73	391	921	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011;Pu et al., 2013)
NA	*D. kaki* cv. Cal Fuyu	2.00	NF	NF	2.13	35	47	76	303	490	(Chen et al., 2007; Veberic et al., 2007; Giordani et al. 2011; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki* cv. Fuji	3.00	NF	NF	0.45	35	80	78	314	507	(Chen et al., 2007; Veberic et al., 2007; Giordani et al. 2011; Jang et al., 2011; Pu et al., 2013)
NA	*D. kaki* cv. Hana Fuyu	1.90	NF	NF	2.14	87	257	83	403	727	(Chen et al., 2007; Veberic et al., 2007; Giordani et al. 2011; Jang et al., 2011; Pu et al., 2013)
NA	*D. kaki* cv. O'Gosho	1.75	NF	NF	0.25	82	148	83	459	763	(Chen et al., 2007; Veberic et al., 2007; Giordani et al. 2011; Jang et al., 2011; Pu et al., 2013)

NA	*D. kaki* cv. Tenjin O'Gosho	2.25	NF	NF	NF	58	154	160	360	758	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
NA	*D. kaki* cv. Thiene	2.15	NF	NF	NF	98	206	92	384	795	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
NA	*D. kaki* cv. Tipo	1.60	NF	NF	104	53	210	86	468	936	(Chen et al., 2007; Veberic et al., 2007; Giordani et al. 2011; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki* cv. Tone Wase	1.55	NF	NF	NF	37	236	80	305	814	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
NA	*D. kaki*. cv. Zenjimaru	3.48	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki*. cv. Xingyangshuishi	5.38	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki*. cv. Zhouqumomoshi	9.05	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki*. cv. Xiuningbianshi	10.55	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
Wild	*D. kaki. var. silvestris* M	15.20	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007;

											Jang et al., 2011; Pu et al., 2013)
A	*D. kaki* cv. Triumph	1.45	NF	NF	NF	53	262	113	448	920	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki cv.* Bongok	8.39	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki cv.* Cheongdobansi	7.75	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki cv.* Dogeunjosaeng	7.36	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
NA	*D. kaki* cv. Seochonjosaeng	4.23	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
A	*D. kaki* cv. Mopan	0.32	NF	NF	NF	NF	NF	NF	NF	NF	(Chen et al., 2007; Veberic et al., 2007; Jang et al., 2011; Pu et al., 2013)
NA	*D. kaki*. cv. Jiro	1.68	NF	NF	2.12	49	178	121	259	576	(Chen et al., 2007; Veberic et al., 2007; Giordani et al. 2011; Jang et al., 2011; Pu et al., 2013)
	Kiwifruit										
	Bingo	15.0	121	60.1	0.15	0.26	NF	NF	0.96	5.21	(Park et al., 2011; Park et al., 2013; Leontowicz et al.,

										2016)
M1	19.3	117.8	NF	0.19	0.21	NF	NF	0.59	6.23	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Anna	14.2	142	22	0.11	0.24	NF	NF	1.1	8.35	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Weiki	10.2	202.4	7.2	0.07	0.57	NF	NF	2.47	14.65	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Jumbo	11.1	190.5	70.2	0.08	1.03	NF	NF	1.51	11.11	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Geneva	14.3	139	20.1	0.15	0.58	NF	NF	1.18	10.06	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Hayward	6.0	84.5	NF	0.18	NF	NF	NF	NF	6.73	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Bidan	27.2	328.8	NF	0.97	NF	NF	NF	1.11	25.26	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Daheung	3.8	NF	NF	0.14	NF	NF	NF	NF	NF	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Haenam	4.2	NF	NF	0.07	NF	NF	NF	NF	NF	(Park et al., 2011; Park et al., 2013; Leontowicz et al.,

										2016)
Hort16A	6.4	NF	NF	NF	NF	NF	NF	NF	NF	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
SKK12	9.8	NF	NF	NF	NF	NF	NF	NF	NF	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Hwamei	8.8	NF	NF	NF	NF	NF	NF	NF	NF	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)

[a]DW: dry weight
[b]FW: fresh weight
NF: Not found

Table 3.

Individual phenolics found in persimmon and kiwifruit.

Phenolic compounds	Persimmon	Kiwifruit	Ref.
(+)-Catechin	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Anisic acid		x	(Wojdyło et al., 2017; Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016)
Bergapten		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Caffeic acid	x		(Pu et al., 2013; Chen et al., 2007; Veberic et al., 2010)
Caffeic acid-*O*-hexoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Caffeoylhexoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Caffeoyl-quinic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Chlorogenic acid	x	x	(Chen et al., 2007; Veberic et al., 2010; Park et al., 2011; Park et al., 2013; Pu et al., 2013; Leotowicz et al., 2016; Wojdyło et al., 2017)
Cinnamoyl glucose		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Cirsimaritin		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
cis-*p*-Coumaroyl quinic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Cryptochlorogenic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Cyanidin-3-*O*-sambubioside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Di-O-caffeoylquinic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Epigallocatechin gallate		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Epigalocatechin	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Ferulic acid	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Feruloylquinic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Gallic acid	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Genistin		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Kaempferol-3-*O*-(acetyl-rhamnoside)-(1 → 6)-galactoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Kaempferol-3-*O*-(acetyl-rhamnoside)-(1 → 6)-glucoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Keampferol-3-*O*-(acetyl)-glucoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Keampferol-3-*O*-galactoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Keampferol-3-*O*-glucoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Keampferol-3-*O*-rutinoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Methyl (epi)afzelechin-3-O-gallate		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)

Neochlorogenic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
n-Triacontanol		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
o-Phthalic acid	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
p-Coumaric acid	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Phenylnaringenin		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Phloridzin	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
p-Hydroxybenzoic acid	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Protocatechuic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Quercetin-3-*O*-(acetyl)-galactoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-(acetyl)-rutinoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-(acetyl-rhamnoside)-(1 → 6)-galactoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-(acetyl-rhamnoside)-(1 → 6)-glucoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-galactoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-glucoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-hexoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-rutinoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-rutinoside-7-*O*-glucoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quercetin-3-*O*-rutinoside-7-*O*-rhamnoside		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Quinic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Rutin	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Sinenstin		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Syringic acid	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)
Tangeretin		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
trans-*p*-Coumaroyl quinic acid		x	(Park et al., 2011; Park et al., 2013; Leontowicz et al., 2016; Wojdyło et al., 2017)
Vanillic acid	x		(Chen et al., 2007; Veberic et al., 2010; Pu et al., 2013)

Table 4.

Biological properties of bioactive compounds found in persimmon and kiwifruit.

Bioactive compound	Biological activity	Reference
Vitamin C	Antioxidant against free radicals and maintaining glutathione reduced	(Gregory, 2007)
Phenolic acids	Antioxidants and exhibit potential antifungal, antibacterial, anti-inflammatory, and anti-cancer activity	(Achiwa et al., 1997; Suh et al., 2011; Pu et al., 2013; Kometani et al., 2016)
Flavonoids	Antioxidant capacity against free radicals and reduce risk of cancer. Examples found in bibliography: -**Rutin:** Flavonol that could protect against spatial memory impairment accompanying hippocampal pyramidal neuron loss. -**Quercetin**: Seems to participate in vitamin E recovery after acting as antioxidant. Moreover, quercetin could protect against inflammation, tumorogenesis and other damages that can occur to cell structures due to oxidation. -**Catechins**: Antioxidant, antiangiogenic, chemopreventive and anti cancer, induction/inhibition of some enzymes, antiinflammatory, obesity, diabetes, antimicrobial, antiviric, anticariogenic, anti-osteoporosis, anti-allergenic, photoprotective, antiestrogenic, neuroprotective.	(Jung et al., 2013; Pu et al., 2013; Lee et al., 2014; Park et al., 2015; Abuajah et al., 2015; Pal et al., 2016; Syed et al., 2016; Prasath et al., 2016; Yaqub et al., 2016; Direito et al., 2017)
Tannins	Improve urinary tract health; Reduce risk of cardiovascular disease, antidiabetic, anti-obesity	(Lee et al., 2007; Mure et al., 2007; Gato et al., 2013; Pu et al., 2013; Abuajah et al., 2015 Yaqub et al., 2016)
Phloridzin	Dihydrochalcone with potentially antidiabetic activity thanks to its ability to reduce glucose absorption in the small intestine through a competitive mechanism via sodium D-glucose cotransporter 1.	(Pu et al., 2013)
Carotenoids	Neutralization of free radicals (antioxidant), reduce risk of muscular degeneration, reduce risk of some cancer, cellular aging protection	(Rao and Rao, 2007; Abuajah et al., 2015; Yaqub et al., 2016)

Table 5.
Fiber content of different kiwifruit cultivars (Park et al., 2011; Leontowicz et al., 2016; United States Department of Agriculture, Agricultural Research Service, Food Composition Database, 2017).

	TDF[a], % DW[b]	IDF[c], %DW	SDF[d], % DW	IDF/SDF
Bingo	25.86	20.43	5.43	3.76
M1	27.11	21.40	5.71	3.75
Anna	24.75	18.26	6.50	2.81
Weiki	24.58	17.61	6.97	2.53
Jumbo	19.78	14.02	5.76	2.43
Geneva	19.86	14.09	5.77	2.44
Hayward	9.39	6.08	3.31	2.01
Bidan	9.95	7.01	2.93	2.38
Daheung	8.05	5.64	2.41	2.34
Haenam	8.04	5.63	2.41	2.34
***Actinidia deliciosa* (mean)**	11.11	8.33	2.78	2.99
***Actinidia chinensis* (mean)**	7.40	5.55	1.85	3.00

[a]TDF: total dietary fiber
[b]DW: dry weight
[c]IDF: insoluble dietary fiber
[d]DSDF: soluble dietary fiber