Food Research International 105 (2018) 461–472

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Review

Relationship between composition and bioactivity of persimmon and kiwifruit

S. Pérez-Burillo[a], M.J. Oliveras[b], J. Quesada[a], J.A. Rufián-Henares[a,c,*], S. Pastoriza[a]

[a] Departamento de Nutrición y Bromatología, Facultad de Farmacia, Universidad de Granada, Granada, Spain
[b] Departamento de Biología Molecular e Ingeniería BIoquímica, Universidad Pablo de Olavide, Sevilla, Spain
[c] Instituto de Investigación Biosanitaria ibs. GRANADA, Universidad de Granada, Spain

A R T I C L E   I N F O

Keywords:
Persimmon
Kiwifruit
Antioxidant capacity
Polyphenols
Functional properties

A B S T R A C T

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 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.

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, 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, Koo, & Min, 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 (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, & Niky, 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 transform their components (Abellan, Garcia-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

* Corresponding author at: Dpto. Nutrición y Bromatología, Facultad de Farmacia, Universidad de Granada, Campus de Cartuja, 18012 Granada, Spain.
E-mail address: jarufian@ugr.es (J.A. Rufián-Henares).

https://doi.org/10.1016/j.foodres.2017.11.022
Received 28 September 2017; Received in revised form 7 November 2017; Accepted 19 November 2017
Available online 22 November 2017
0963-9969/

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 5,190,624 t, obtained from a harvested area of 1,025,989 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 250 kt, which gives an idea of how important this crop has become. For example, during 2015, in Spain alone, 4424 million kg were consumed, which meant an expenditure of 5973 million euros (MERCASA, 2017). 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 mucilages as part of the soluble fiber and a large amount of insoluble fiber (Spanish Ministry of Agriculture, Fisheries, Nutrition and Environment, MAPAMA, 2016a). Regarding micronutrients, persimmon is an exceptional source of provitamin A as β-carotene (with 160 μg/100 g of fresh weight) and also a good source of vitamin C (16 mg/100 g of fresh weight). Persimmon has important amounts of potassium but rather low quantities of other minerals such as magnesium and phosphorus (MAPAMA, 2016a). 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 are 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/100 g 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/100 g of fresh weight).

Table 1
Generic composition of persimmon and kiwifruit.
(Barea-Álvarez et al., 2016; MAPAMA, 2016a; United States Department of Agriculture, Agricultural Research Service, Food Composition Database, 2017)

	Kiwifruit		Persimmon	
	100 g of edible portion	By unit (100 g)	100 g of edible portion	By unit (100 g)
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

2.2.1. Carotenoids

Carotenoids are responsible of the color 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).

2.2.2. 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.

2.2.3. 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