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A review of nutritional value and putative health-effects of quince (*Cydonia oblonga* Mill.) fruit

Hegedűs, A.[1], Papp, N.[2] & Stefanovits-Bányai, É.[2]

[1]*Corvinus University of Budapest, Faculty of Horticultural Science, Department of Genetics and Plant Breeding, 1118 Budapest, Villányi út 29., Hungary; E-mail: hegedus.attila@uni-corvinus.hu*
[2]*Corvinus University of Budapest, Faculty of Food Science, Department of Applied Chemistry, 1118 Budapest, Villányi út 29., Hungary*

Summary: Quince (*Cydonia oblonga* Mill.) has been long regarded to be a health-promoting fruit. Although it is mainly consumed in processed form, its relatively heat-stable polyphenolics were confirmed to be responsible for most of the beneficial effects. This review aims to show basic nutritional information on quince fruit such as carbohydrate, fibre, pectin and mineral element contents. In addition, vitamin and polyphenolic contents and composition as well as the physiological effects of quince consumption were also surveyed. Information on presumable protective effects against several diseases including inflammation, atopic dermatitis, ulcers and cancer is summarized. Potential antibacterial effects of quince polyphenolics were also considered. Polyphenolics are supposed to be responsible for the major part of beneficial health-effects, and phenolic compounds predominantly accumulate in peel. There exists a considerable extent of genetic variation in phytochemical composition among cultivars, which might be exploited in designing future breeding programs for quince improvement and opening new ways for health-related uses.

Key words: *Cydonia oblonga,* health, nutrients, polyphenolics, quince

Introduction

Quince might be used in a several ways, many processed forms of this fruit gained worldwide popularity. Fruits can be processed into juices, jams and spirits. Persian physicians advised patients suffering from chronic recurrent headache to eat a quince before breakfast due to its apparent prophylactic effects (*Gorji*, 2003). Others suppose quince jam is beneficent in gastrointestinal disorders. In many countries throughout Europe, Asia and Africa, quince is used as a component in traditional dishes.

Nutritional composition

The nutritional composition of quince is compared with apple, a close relative of this fruit crop but consumed in great quantities. All data are expressed for 100 g fresh weight of whole fruits according to *Bíró and Lindner* (1999). Energy, protein, acid, carbohydrate, ash and fibre contents in quinces are higher than those in apples, while quince fruit contains less water (*Table 1*).

The contents of pectins in fruits ranged between 1.75 and 3.51 g/100 g FW, and cultivar 'Hruškovita' accumulated pectins in greatest amount (*Rop* et al., 2011). The quince pectin had a high galacturonic content (78%), and a degree of methoxylation of about 60% corresponding to a medium-high methoxyl pectin (*Forni* et al., 1994).

Table 1. Main nutritional composition of quince and apple ('Jonathan') fruits in 100 g fresh weight (*Bíró and Lindner*, 1999)

	Energy (kJ)	Protein (g)	Acid (g)	Carbo-hydrate (g)	Water (g)	Ash (g)	Fibre (g)
Apple	130	0.4	0.4	7.0	90.5	0.4	1.3
Quince	176	0.6	0.9	9.1	86.9	0.6	1.9

Vitamin C content of quince is nearly two-times higher than in apple (*Bíró and Lindner*, 1999) (*Table 2*), while other authors reported nearly identical quantities of ascorbic acid in quinces and apples (13 and 12 mg/100 g, respectively) (*Souci* et al., 2002). According to *Bíró and Lindner* (1999) apple contains more from most of the vitamins, while *Souci* et al. (2002) determined nearly identical amounts of vitamins in both fruit crops.

For Czech cultivars, the vitamin C contents in quince ranged from 50 to 80 mg/100 g intact fruit (flesh and peel together). Fruits of the cultivar 'Muškatová' contained the highest amount, 79.31 ± 2.01 g/100 g FW of acorbic acid (*Rop* et al., 2011). This value is definitely higher than those specified in *Table 2* or compared with the USDA reference value of 15 mg (*USDA*, 2012), which confirms that quince

Table 2. The vitamin contents in 100 g fresh quince and apple ('Jonathan') fruit according to *Bíró and Lindner* (1999) and *Souci* et al. (2002)

	Vitamin	Dimension	Bíró and Lindner (1999)		Souci et al. (2002)	
			Apple	Quince	Apple	Quince
Retinol	A	µg	0.0	0.0	5.7	5.5
Carotene		mg	0.05	nd	0.04	0.03
Calciferol	D	µg	0	0	nd	nd
Tocopherol	E	mg	0.60	nd	0.49	nd
Thiamine	B_1	µg	50	25	35	30
Riboflavin	B_2	µg	50	25	32	30
Niacin	B_3	mg	0.5	0.2	0.3	0.2
Pantothenic acid	B_5	mg	0.09	nd	0.10	nd
Pyridoxine	B_6	mg	0.070	nd	0.103	nd
Biotin	B_7	µg	1.0	nd	4.5	nd
Folic acid	B_9	µg	6.0	nd	7.5	nd
Cyanocobalamin	B_{12}	µg	0.0	0.0	nd	nd
Ascorbic acid	C	mg	5	10	12	13

nd: non-detected

cultivars are characterized by a great genetic variability. It was also confirmed by determining fruit antioxidant capacity and total polyphenolic contents in 12 commercial cultivars (*Papp* et al., in press).

Quince is a richer source of mineral elements compared to apple. The summarized quantity of the measured mineral elements is almost two-times higher in quince than apples (*Table 3*).

Table 3. Mineral element contents in 100 g quince and apple ('Jonathan') fruits (*Bíró and Lindner,* 1999)

	Dimension	Apple	Quince
Na	mg	2.0	9.2
K	mg	112	189
Ca	mg	5.5	66.0
Mg	mg	6	10
Fe	mg	0.3	1.1
P	mg	8	25
Cu	mg	0.028	0.006
Zn	mg	0.046	0.013
Mn	mg	0.037	0.002
Co	mg	0.001	nd
Cr	mg	0.002	nd
Ni	mg	0.011	nd
Total quantity	mg	133.9	300.3

The unique fragrance of quince fruit is attributable to the specific composition of its essential oil (*Schreyen* et al., 1979; *Tsuneya* et al., 1983) in which the characteristic compounds were thought to be monoterpenic lactones and oxides (*Tsuneya* et al., 1983). In the early nineties, *Lutz* et al. (1991) indicated the presence of monoterpenic glucosides in quince, which were supposed to be the putative precursors of the lactones and oxides.

Polyphenolic composition of quince fruit

Qualitative and quantitative analyses of phenolic compounds were carried out on quince fruit samples from seven different geographical origins in Portugal (*Silva* et al., 2002). Both fruit flesh and peel were analyzed by reversed-phase high performance liquid chromatography (HPLC) coupled with diode array detector or mass spectrometry. Differences were noted between the phenolic profiles of flesh and peel in all studied cases. The flesh contained mainly caffeoylquinic acids (3-, 4-, and 5-O-caffeoylquinic acids and 3,5-dicaffeoylquinic acid) and rutin (quercetin 3-*O*-rutinoside). The peel presented the same caffeoylquinic acids and several flavonol glycosides: quercetin 3-galactoside, kaempferol 3-glucoside, kaempferol 3-rutinoside, and several unidentified compounds. The highest content of phenolics was found in peels.

In Tunisian quinces, total phenolic contents of the flesh and peel parts ranged from 37 to 47 and 105 to 157 mg/100 g of fresh weight, respectively (*Fattouch* et al., 2007). Chlorogenic acid (5-*O*-caffeoylquinic acid) was the most abundant phenolic compound in flesh (37%), whereas rutin was the main one in peel (36%).

A total of 26 polyphenolic compounds found in quince tissues were identified (*Wojdylo* et al., 2013): 9 flavan-3-ols including (–)-epicatechin, procyanidin B2, 3 procyanidin dimers and trimers, and 1 tetramer; 8 hydroxycinnamates (derivatives of caffeoylquinic and coumaroylquinic acid) and 9 kaempferol and quercetin derivatives. The content of total polyphenols ranged between 1709 and 3437 mg/100 g dry weight ('Leskovač'). Flavan-3-ols, which form the major class of quince polyphenols, represented approx. the 78 and 94% of the total polyphenolic content.

Putative health-effects of quince consumption

Quince was reported to have antiulcerative effects (*Hamauzu* et al., 2006). However, the strongest antiulcerative effect was declared for Chinese quince (*Pseudocydonia sinensis* C. K. Schneid.) on ethanol-induced gastric ulcers in rats. Pre-administration of Chinese quince and quince phenolics suppressed the occurrence of gastric lesions in rats, whereas apple phenolics seemed to promote ulceration. The antioxidative property of rat blood increased in all rats fed by quince phenolics. Ferulic acid and isoferulic acid were detected as major metabolites in rats consuming apple phenolics, quince phenolics, and 5-caffeoylquinic acid standard. (-)-Epicatechin and its 3'-O-methyl ether were detected in rats administered apple phenolics and (-)-epicatechin standard. The results showed that Chinese quince and quince phenolics might have health benefits by acting both in blood vessels and on the gastrointestinal tract.

Chronic inflammation is a hallmark of several diseases including diabetic complications, rheumatoid arthritis, inflammatory bowel disease, atherosclerosis and cancer. *Essafi-Benkhadir* et al. (2012) reported the anti-inflammatory effect of a polyphenolic extract from Tunisian quince. Lipopolysaccharide (LPS) treatment of human THP-1-derived macrophages induced the secretion of high levels of the pro-inflammatory cytokine TNF- and IL-8, which was inhibited by quince peel polyphenolic extract in a dose-dependent manner. Quince polyphenols also enhanced the level of the anti-inflammatory cytokine IL-10 secreted by LPS-treated macrophages. Quince polyphenols inhibited the LPS-mediated activation of three major cellular pro-inflammatory effectors (nuclear factor-kappa B, p38MAPK and Akt). These data indicate that quince peel polyphenolic extract induces a potent anti-inflammatory effect and that a quince-rich diet may help to prevent and improve the treatment of inflammation-associated diseases.

Shinomiya et al. (2009) examined the effect of a crude hot-water extract (HW) of quince fruit on type I allergy *in vivo* and *in vitro*. The oral administration of the quince HW-added diet to NC/Nga mice (NC/Nga mice are known to exhibit spontaneous development of dermatitis) for 63 days showed a significant decrease in the development of atopic dermatitis-like skin lesions under conventional conditions. The concentration of IgE in the serum collected from mice fed with quince HW was lowered in a dose-dependent manner. Moreover, quince HW inhibited the release of beta-hexosaminidase from rat basophilic leukaemia cells after a 24-hour treatment. The quince HW fraction of less than 3 kDa reduced the mRNA expression of the high-affinity IgE receptor (Fc RI) subunit. These results suggest that quince HW had an inhibitory effect on type I allergy by suppressing IgE production and IgE-mediated degranulation.

Alesiani et al. (2010) identified several compounds with antiproliferative effects from quince peels although *Carvalho* et al. (2010) could not show inhibitory effects of quince fruit flesh and peel on human kidney and colon cancer cells. However, the extracts from leaf showed concentration-dependent growth inhibitory activity toward human colon cancer cells, while no effect was observed in renal adenocarcinoma. Seed extracts exhibited no effect on colon cancer cell growth, whereas strong antiproliferative efficiency was observed against renal cancer cells for the highest concentration tested (500 μg/mL).

The antimicrobial activity of quince extracts against different microorganism strains was investigated by *Fattouch* et al. (2007). Quince peel extract was the most active for inhibiting bacterial growth. It seems that chlorogenic acid acts in synergism with other components of the extracts to exhibit total antimicrobial activities. Thirty-four polyphenols were detected by *Karar* et al. (2013), nine of which were not reported previously in quince. The crude extract of quince fruit polyphenols showed antibacterial activity against the Gram-negative bacterium *Escherichia coli*. Five polyphenols, 5-*O*-caffeoylquinic acid, quinic acid, quinic acid derivative, proanthocyanin B1 and methyl 5-*O*-caffeoylquinate were isolated and tested for their antibacterial activity. Quinic acid and a quinic acid derivative showed strong inhibition against *E. coli*.

An interesting study was published on the comparison of the phenolic profile and antioxidant potential of quince leaf and green tea (*Camellia sinensis*) (*Costa* et al., 2009). Quince leaf exhibited a significantly higher reducing power than green tea (mean value of 227.8 ± 34.9 and 112.5 ± 1.5 g/kg dry leaf, respectively). Quince leaf extracts showed similar 2,2'-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activities but significantly lower than that presented by green tea extract. Under the oxidative action of 2,2'-azobis(2-amidinopropane) dihydrochloride, quince leaf methanolic extract significantly protected the erythrocyte membrane from hemolysis in a similar manner to that found for green tea. These results point to the fact that quince leaf may be applied as a preventive or therapeutic agent in diseases associated with free radical damage.

In conclusion, the review of the papers focused on quince phytochemical composition indicates a considerable extent of genetic variations among cultivars and also allowed to identify perspective therapeutic targets. Since polyphenolics are supposed to be responsible for the major part of beneficial health-effects, this information might be exploited in designing future breeding programs for quince improvement and opening new ways for health-related uses including the development of quince-based functional foods.

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