



Comparative evaluation of the nutritional value and the content of bioactive compounds in the fruit of individual species of chaenomeles and quince

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ABSTRACT

The objective of this study was to evaluate the nutritional value and the content of bioactive compounds in the fruit of individual species of chaenomeles and quince. The experimental material were the fruits of four species of chaenomeles (*Chaenomeles ×superba*, *Chaenomeles japonica* apple-shape, *Chaenomeles japonica* pear-shape and *Chaenomeles ssp.*) and quince (*Cydonia oblonga*). The fruit were analyzed for dry matter, vitamin C, polyphenols, carotenoids and chlorophyll content. The obtained results showed that the species has an impact on the nutritional value and the content of bioactive compounds in the chaenomeles and quince fruits. The highest content of dry matter, total polyphenols, total phenolic acids as well as more total and individual phenolic acids (caffeic and p-coumaric acid) were found in quince fruits (*Cydonia oblonga*). Quince fruits *Cydonia oblonga* also contained the highest content of total flavonoids and individual flavonoids: quercetin-3-O-rutinoside, myricetin and quercetin. The highest content of lutein and zeaxanthin was observed in fruits of *Chaenomeles ×superba* but *Cydonia oblonga* fruits contained significantly more beta-carotene and chlorophyll, both the total chlorophylls and individual chlorophylls: chlorophyll a and chlorophyll b. In contrast, the highest content of vitamin C was found in fruits *Chaenomeles Japanese* pear-shape.

Keywords: nutritional value, bioactive compounds, chaenomeles, quince, dry matter, vitamin C, polyphenols, carotenoids, chlorophyll

1. INTRODUCTION

The content of bioactive compounds in fruits and vegetables have attracted a great deal of attention mainly concentrated on their role in preventing diseases. Several studies have consistently shown that there is a clear significant positive association between intake of these natural food products, consumed regularly as part of diet, and reduced rate of heart disease mortalities, common cancers, and other degenerative diseases. The diseases have been recognised as being a consequence of free radical damage. The proportion of oxidants and antioxidants in humans are maintained in balance, which is important for sustaining optimal physiological conditions. Overproduction of oxidants in certain conditions can cause an imbalance, leading to oxidative damage to large biomolecules such as lipids, DNA, and proteins [1]. The protective role of fruits and vegetables provide against those diseases has been attributed to several antioxidants, especially to antioxidative vitamins, including vitamin C, polyphenols and carotenoids. Individual species of chaenomeles and quince are an excellent natural source of antioxidants, which can scavenge free radicals.

Chaenomeles obtained its name from the Greek *chaino*, “to gape,” and *melon* “apple”. Chaenomeles species have been known in China for thousands of years. The interest in these fruits has increased again in the last twenty years due to the possibility of cultivation in Europe, mainly in the Baltic countries. Chaenomeles has been cultivated in Europe since 1874 and since 1978 its antioxidant properties and use in the food industry have been researched in Poland. Chaenomeles belong to the rose family (*Rosaceae*), the apple subfamily (*Pomoideae*). The fruits are characterized by irregular shape and varying size. They usually have apple shape with a diameter of approximately 4 cm and a weight less than 50 g. The flesh is pale yellow and hard and contains large content of essential oils thus ripe fruit are very flavorful [2]. Chaenomeles is a shrub which is not demanding in terms of cultivation and is resistant to disease, pests and environmental factors. Large potential utility of chaenomeles fruits caused that it is now grown throughout the temperate zone due to its properties, decorative and edible fruits, which are used in food, pharmaceutical and cosmetic industries. They contain large amounts of vitamin C and polyphenols, can therefore be a valuable component in the human diet. The high content of antioxidant compounds in fruits makes them a good addition to functional foods and supplements. The content of vitamin C in chaenomeles fruits stands at 55-92 mg / 100 g of raw material. They also contain a large amount of phenolic compound (645 mg / 100 g FW focused as total polyphenols) [3]. These are phenolic acids and flavonoids [4]. In comparison with other fruits chaenomeles have a high content of minerals. These are mainly iron and molybdenum. What is noteworthy is the high content of magnesium, sodium, copper, zinc and phosphorus [5].

Chaenomeles fruits are often confused with quince (*Cydonia oblonga*), belonging to the genus *Pseudocydonia* and have different structure and chemical composition of fruits. Quince is a white flowering small tree and chaenomeles is a shrub. [6]. The quince fruit is a very good source of bioactive compounds, especially antioxidants, which have the ability to neutralize free radicals. Such a broad therapeutic effect of quince fruit makes the raw material possible to be used in numerous industries, both in the pharmaceutical and food industries, in which pro-health and functional food has an increasing participation. Quince trees are also grown for their attractive pale pink blossom and other ornamental qualities. Quince fruits are similar in appearance to a pear and are golden-yellow. The fruits are 7 to 12 cm long and 6 to 9 cm across, can weight 300 g to 1 kg and their peel is covered with hair, which disappears

when the fruit is ripe. Quince peel is inedible because it contains a lot of cellulose. Ripe fruits have an agreeable, long-lasting and powerful flavor. As they are not edible unprocessed because of their very hard, tough, and fibrous consistency, they are often used for preparing jam, marmalade or jellies. Quinces are important for the canning industry, also due to high contents of pectins. Quince is a seasonal fruit and is cultivated on all continents in warm-temperate and temperate climates. Quince is an enduring, drought-tolerant tree which adapts to many soils of low to medium pH. It tolerates both shade and sun, but sunlight is required in order to produce larger flowers and ensure fruit ripening. These are harvested at a time similar to most winter pear cultivars i.e. from October to November. There is no specific maturity index for quince fruit; however harvest begins when fruit change their ground colour from green to yellow [7].

The objective of this study was to evaluate the content of nutrients and antioxidants such as vitamin C, polyphenols, carotenoids and chlorophyll in the fruit of individual species of chaenomeles and quince. An additional objective was to investigate whether the species has an impact on the nutritional value and the content of bioactive compounds in chaenomeles and quince fruits.

2. MATERIALS AND METHODS

The experimental material were the fruits of four species of chaenomeles (*Chaenomeles* ×*superba*, *Chaenomeles japonica* apple-shape, *Chaenomeles japonica* pear-shape and *Chaenomeles* ssp.) and quince (*Cydonia oblonga*).

Fruit was derived from a private farm, where different species of *Chaenomeles* were cultivated. Grajewo, region Podlaskie (North-east Poland).

The experimental fruits were cut into small pieces (internal part of fruits with seeds were removed). Fruit cubes were put to plastic containers and freeze dried in LabconCo freeze drier 2.5, with parameters: pressure 0.100 mBar, temperature -40 °C. After 72 hours samples were milled to powder and kept in -80 °C to prevent uncontrolled bioactive compounds losses.

The fruit were analyzed for dry matter, vitamin C, polyphenols, carotenoids and chlorophyll content.

Analysis of dry matter. The fruit was analyzed for dry matter by scale method according to Polish Norm (PN-R-040133:1988) [8]. Fruits were crushed into pulp. Fruit pulp was dried at 105 °C, under constant pressure, for 24 h by using a dryer with free air circulation. After 1 day, the samples were cooled in a desiccator and weighed to determine the weight loss. This procedure was repeated three times to achieve constant weight. Then, the content of dry matter was calculated in g/100 g fresh weight.

Analysis of vitamin C. The weighed lyophilisate fruit was extracted in 2% oxalic acid. The solution was filtered. The filtrate was collected and then titrated with the 2,6-dichlorophenylindophenol. Polish Norm (PN-A-04019:1998) [9].

Analysis of polyphenols, carotenoids, chlorophyll. Polyphenols and carotenoids, as well as chlorophylls by HPLC method [10].

Statistical analysis. For statistical calculations one-way analysis of variance was selected with the use of the Tukey's test ($\alpha = 0.05$). A standard deviation was given at the mean value. All results for the content of the examined compounds are specified in fresh matter.

3. RESULT / EXPERIMENTAL

Nutritional value and content of bioactive compounds in chaenomeles and quince fruits are shown in Table 1.

Dry matter content. The dry matter content was the highest in the quince fruit *Cydonia oblonga* (19,66 g/ 100 g FW). However, Tarko at al. demonstrated that *Chaenomeles Japanese* contained 12.89 g/100 g FW) of dry matter [5]. Due to high contents of dry matter and pectins, quinces are important for the canning industry. The content of dry matter in fruits mainly depends on the method of soil fertilization. Too high a dose of nitrogen used in the later phases of the growth may reduce the dry matter content in the fruit [11].

Vitamin C content. The highest content of vitamin C was observed in fruits *Chaenomeles Japanese* pear-shape (117,95 mg/ 100 g FW). In a study by Rubinskienė at al. the content of ascorbic acid in fruit *Chaenomeles Japanese* averaged from 18 to 233 mg/100 g DW [12]. The high content of vitamin C in fruits can be explained by the fact that the level of vitamin C increases if the plant is grown under the low nitrogen availability conditions [11].

Polyphenols content. The highest content of total polyphenols was found in fruits *Cydonia oblonga* (62,09 mg/100 g FW) while the fruit of quince *Chaenomeles Japanese* examined by Nahorska at al. was characterized by the highest content of polyphenols (284 mg / 100 g FW) [13]. The content of total phenolic acids was significantly higher (34,69 mg/100 g FW) in fruits *Cydonia oblonga*. The fruits *Cydonia oblonga* also contained a higher level of individual phenolic acids: caffeic and p-coumaric. Quince fruits *Cydonia oblonga* also contained the highest content of total flavonoids (27,40 mg/ 100 g FW) and individual flavonoids: quercetin-3-O-rutinoside, myricetin and quercetin. Recent studies [14-18] have shown that it is mainly the polyphenols, particularly quercetin, chlorogenic acid, catechin contained in fruits, characterized by a potent anticancer properties. Polyphenols constitute a large class of compounds present in plants. Experimental research has demonstrated that each plant species is characterized by the presence of a limited number of compounds. Within each species, the nature of these compounds can vary from organ to organ. Factors contributing to the variability in polyphenols distribution include cultivar and genetics, geographical origin, maturity, climate, position on trees, and agricultural practices [19].

Carotenoids content. *Chaenomeles ×superba* was characterized by the highest content of lutein (1,73 mg/100 g FW) and zeaxanthin (3,01 mg/100 g FW) The fruits *Cydonia oblonga* contained significantly more beta-carotene (1,34 mg/100g FW) compared to the other species of chaenomeles in which the content of this compound was at a similar level from 0,85 mg/100 g FW to 1,23 mg/100 g FW. As reported by Nahorska at al., chaenomeles fruit contains on average 1,07 mg/100 g beta-carotene [13]. The content of carotenoids in fruits mainly depends on the method of cultivation, including the level of nitrogen in soil. The increase in carotenoids content along with more intense nitrogen fertilization is justified as follows: nitrogen is the main element that forms Acetyl-CoA enzyme which plays a central

role in the synthesis of carotenoid pigments and converts beta-carotene into lycopene. The higher carotenoids content, the more yellow and darker fruits are [20].

Chlorophyll content. Quince fruits in their composition also contained the highest amounts of chlorophyll, both the total chlorophylls (3,66 mg/100 g FW) and individual chlorophylls: chlorophyll a (1,9 mg/100 g FW) and chlorophyll b (1,76 mg/100 g FW). Chlorophyll is the green pigment in parts of plants. Chlorophyll is essential in photosynthesis, allowing plants to absorb energy from light. Chlorophyll content in the fruit depends on the amount of sunlight. There are two forms of chlorophyll: chlorophyll a and chlorophyll b. Chlorophyll a contributes to the observed green color of most plants. Land plants usually contain the majority of chlorophyll b, which is yellow. Therefore, quince, which contained the highest content of total chlorophyll were also more yellow [21].

4. CONCLUSIONS

The analysis results showed that the species has an impact on the nutritional value and the content of bioactive compounds in the chaenomeles and quince fruits. The highest content of dry matter, total polyphenols, total phenolic acids as well as more total and individual phenolic acids (caffeic and p-coumaric acid) were found in quince fruits (*Cydonia oblonga*). Quince fruits *Cydonia oblonga* also contained the highest content of total flavonoids and individual flavonoids: quercetin-3-O-rutinoside, myricetin and quercetin. The highest content of lutein and zeaxanthin was observed in fruit *Chaenomeles ×superba* but the fruits *Cydonia oblonga* contained significantly more beta-carotene and chlorophyll, both the total chlorophylls and individual chlorophylls: chlorophyll a and chlorophyll b. In contrast, fruits of *Chaenomeles Japanese* pear-shape include the highest content of vitamin C.

The content of the various compounds present in fruits may vary depending on the species. There are many factors influencing these differences, eg. the maturity of the fruit and agricultural practices. However, the results indicate the presence of many of bioactive compounds in the chaenomeles and quince fruits. In conclusion, this fruit can be used as good sources of antioxidants in diet and may have relevance in the prevention of diseases in which free radicals are implicated.

Table 1. The content of dry matter in (g/100 g FW) and the content of bioactive compounds (mg/100 g FW) in examined chaenomeles and quince fruits.

Examined compounds	Species					p-value species
	<i>Chaenomeles ×superba</i>	<i>Chaenomeles japonica apple-shape</i>	<i>Chaenomeles japonica pear-shape</i>	<i>Chaenomeles ssp.</i>	<i>Cydonia oblonga</i>	
dry matter	17,00±0,90 ^{1c2}	12,63±0,44a	16,21±0,51b	15,51±0,37bc	19,66±0,59d	<0,0001
vitamin C	100,53±8,42c	58,37±0,88b	117,95±4,97d	65,11±2,90b	39,96±2,39a	<0,0001
total polyphenols	18,34±0,65c	7,98±0,46a	21,84±2,52c	11,90±0,94b	62,09±2,48d	<0,0001

total phenolic acids	10,69±0,64c	3,18±0,16a	13,54±0,87d	8,13±0,97ab	34,69±1,95e	<0,0001
gallic	3,60±0,44c	0,95±0,06a	1,88±0,17b	1,20±0,08b	3,27±0,24c	<0,0001
chlorogenic	4,57±1,34b	1,30±0,24a	5,56±0,51b	4,58±0,85a	3,84±0,33ab	0,0027
caffeic	1,36±0,22a	0,65±0,01a	1,15±0,02a	0,37±0,01ab	6,82±1,84b	0,0001
p-coumaric	1,14±0,31ab	0,27±0,15a	4,93±0,23b	1,97±0,07a	20,75±2,66c	<0,0001
total flavonoids	7,64±0,37b	4,79±0,30a	8,30±1,86b	3,77±0,13a	27,40±0,53c	<0,0001
quercetin-3-O-rutinoside	3,83±0,14a	3,36±0,10a	7,36±1,89b	3,03±0,10a	8,57±0,54b	0,0002
myricetin	1,59±0,08b	0,20±0,04a	0,26±0,05a	0,34±0,19a	10,73±0,48c	<0,0001
quercetin	0,23±0,02a	0,27±0,08a	0,36±0,12a	0,08±0,00a	5,86±0,50b	<0,0001
luteolin	1,73±0,09c	0,48±0,015a	0,93±0,03bbc	1,02±0,09b	0,62±0,06a	<0,0001
zeaxanthin	3,01±0,13d	0,54±0,03a	1,69±0,06bc	1,93±0,05c	1,46±0,07bc	<0,0001
beta-carotene	1,23±0,06cd	0,85±0,03a	1,12±0,04b	1,07±0,02bc	1,34±0,05d	<0,0001
total chlorophylls	3,01±0,16b	2,21±0,08a	2,88±0,08b	2,72±0,06b	3,66±0,11c	<0,0001
chlorophyll a	1,48±0,07b	1,07±0,04a	1,43±0,04b	1,32±0,03b	1,90±0,05c	<0,0001
chlorophyll b	1,53±0,08b	1,13±0,03a	1,45±0,04b	1,39±0,03b	1,76±0,05c	<0,0001
ratio of chlorophyll a / b	0,96±0,00ab	0,95±0,01a	0,98±0,00b	0,95±0,00a	1,07±0,00c	<0,0001

¹Data are presented as the mean ± SD with ANOVA p-value;

² Means in rows followed by the same letter are not significantly different at the 5% level of probability (p<0.05).

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