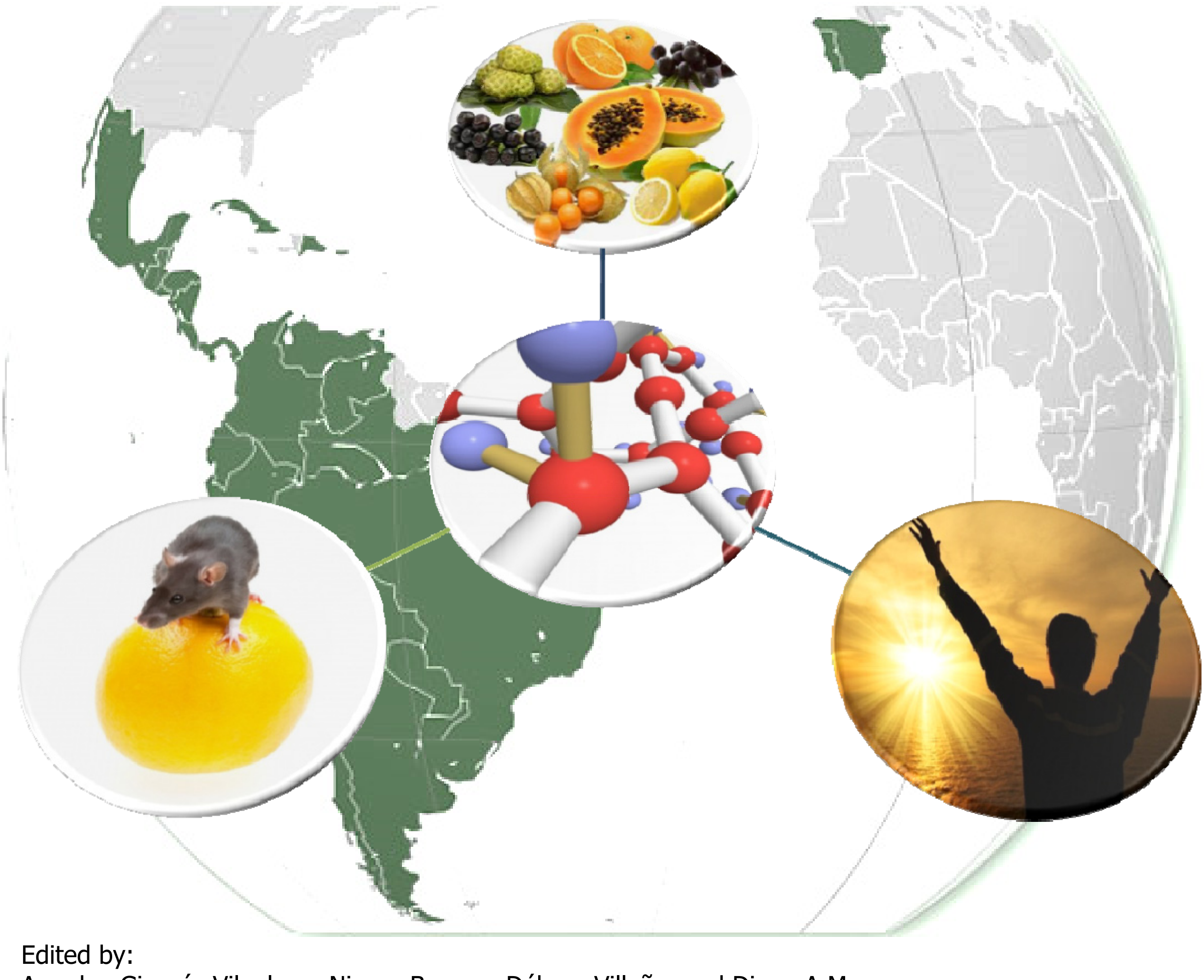
Iberian-American Fruits Rich in Bioactive Phytochemicals for Nutrition and Health



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First Edition, 2014

Amadeo Gironés-Vilaplana, Nieves Baenas, Débora Villaño and Diego A. Moreno

On behalf of the CYTED ACTION 112RT0460 "CORNUCOPIA" THEMATIC NETWORK on "Characterization and Functional and Safety Evaluation of Fruit Bioactive Phytochemicals from Iberian-American Regions for Food Ingredients"

I.S.B.N. (Electronic, PDF): 978-84-15413-24-0

I.S.B.N. (Printed): 978-84-15413-25-7

Printed by: LIMENCOP S.L., Alicante, Spain

Contact:
Diego A. Moreno
CEBAS-CSIC - Spanish National Research Council
Food Sci. & Technol. Dept.
Campus de Espinardo 25, 30100 Espinardo, Murcia, Spain

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QUINCE

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Scientific name: *Cydonia oblonga* Mill. (Family Rosaceae)

Common name: Quince

Origin

The quince tree is native to a wide area that includes Caucasus, Transcaucasia and Central Asia (Georgia, Armenia, Azerbaijan, Uzbekistan, Turkmenistan, Tajikistan, Iran, Afghanistan and Pakistan). Nowadays, there are still wild quince plants in Dagestan, Azerbaijan, Turkmenia and Iran (Zhukovsky, 1964; Postman, 2012).

During ancient times, quince spread from its centre of origin to the east, to the region of the Himalaya Mountains, and has been cultivated for thousands of years in central Asia and in the Middle East. It was also grown on the islands of ancient Greece. The name "Cydonia" was assigned to the quince probably due to the name of an ancient city-state ("Cydonia" or "KYDONIA") of Crete, where the quince was abundantly grown in the 1st century BC. The Romans cultivated quince on a large scale and studied the plant, having described different cultivars.

Quince is naturalized throughout the Mediterranean, temperate regions of Asia and southern and central regions of Europe. It is currently cultivated in many European countries (up to Scotland and Norway), North and South Africa, North and South America, Australia and Oceania.

It is the sole member of the genus *Cydonia*, but various subspecies and forms have been described (Lobachev and Korovina, 1981).

Production

Quince grows usually as a multi-stemmed shrub but can be pruned to form a small tree. The plant size can reach 5 to 7 m in height but in Mediterranean conditions does not exceed 3 m in height. In intensive orchards plants are even smaller.

The world production of quince has been increasing over the past decades and is currently around half a million tonnes. There are significant productions of this fruit in about 50 countries. The top two producers of quince are Turkey and China. Other major producers are Uzbekistan, Morocco, Iran, Argentina, Azerbaijan, Spain and Serbia (FAO, 2011).

Quince is grown in many countries for use as a dwarfing pear and loquat rootstock.

Varieties

Although the number of quince cultivars is quite lower than in other fruit crops, such as apple and pear, there is a great diversity of genotypes of quince. Usually we consider two groups of cultivars: apple-shaped and pear-shaped. Some authors consider a larger number of subspecies, botanical varieties and forms, based on fruit shapes: pyriformis or typical (pear-shaped), maliformis (apple-shaped), lusitanica (the so-called Portuguese ribbed, pear-shaped fruit), marmorata (variegated) and pyramidalis (pyramidal fruit) (Bell and Leitão, 2011).

The fruit pulp varies in colour, density, juiciness, flavour, presence of granulation (stony cells) and taste. Most varieties are too hard, astringent and sour to eat raw unless 'bletted' (softened by frost and subsequent decay). Some cultivars have little or no astringency and the fruit can be eaten fresh. Most cultivars are considered self-fertile but cross-pollination seems to increase the productivity of the orchards.

Nutrition

Quince fruit is a valuable dietary product. The fruit contains good amount of ascorbic acid (vitamin C), pectins (fibres) and minerals and low in calories, carbohydrates, lipids and proteins (Ronzio, 2003; Kumar *et al.,* 2013).

The fruit has several phenolic compounds that contribute for its antioxidant capacity along with ascorbic and citric acid (Silva *et al*., 2004), as well as a large number of volatile compounds responsible for its characteristic fragrance (Tateo and Bononi, 2010).

Besides ascorbic acid, quince fruits also have oxalic, citric, ascorbic, malic, quinic, shikimic and fumaric acids (Silva *et al*., 2002b, 2004b, 2005).

Concerning free amino acids, 21 are described in quince fruits. In peels and pulps, aspartic and glutamic acids, cysteine, serine and hydroxyproline are the most abundant ones (Silva *et al*., 2004a, 2004b), while seeds are rich in glutamic and aspartic acids and asparagine (Silva *et al*., 2005).

Quince fruit	
Energy	48 - 57 Kcal
Water	72.9 g
Protein	0.4 - 0.6 g
Carbohydrates	15.3 g
Fat	0.1 - 0.5 g
Fiber	1.9 - 3.6 g
Cholesterol	0 g
Sodium	4 - 14 mg
Potassium	144 - 197 mg
Calcium	11 - 23 mg
Phosphorous	17 - 24 mg
Iron	0.7 – 3.0 mg
Zinc	0.04 mg
Copper	0.13 mg
Selenium	0.6 mg
Folates	3 µg
Riboflavin	0.03 – 0.04 mg
Niacin	0.1 – 0.2 mg
Pantothenic acid	0.081 mg
Pyridoxine	0.04 mg
Thiamin	0.02 mg
Vitamin A	40 IU
Vitamin C	15 - 23 mg
Vitamin E	0.12 – 0.4 mg
Vitamin K	4.5 µg

Food values on 100g of dry weight
Source: USDA, 2013; Skurikhin and Tutelyan, 2007

Culinary uses

Quince fruits are consumed fresh, cooked, baked and frozen, in various dishes or as a condiment (Caucasus, Central Asia), good for drying, making jam, fruit puree, stewed fruit, jelly, marmalade and candied fruit. They are used to produce syrup, pasteurized juice, wines (mixed with apple) and room aromatization (China), and in medicine (seeds and broth from cooking the fruits).

The fruits have been used for centuries in the preparation of a cheese quince, made by prolonged cooking (several hours) of quince with water and sugar (initially may have been made with honey), called "marmelada" in Portuguese. “Marmelada” derived from the word "marmelo", which means quince. The terms "marmalade", "marmelade" and "marmelad", used in different European languages, with different meanings, derived from the Portuguese word "marmelada".

Phytochemicals and health

Quince fruits contains several metabolites, including phenolic compounds, terpenes and other volatile compounds and organic acids.

Pulps are rich in caffeoylquinic acids (3-, 4-, and 5-*O*-caffeoylquinic acids and 3,5-dicaffeoylquinic acid) and quercetin-3-*O*-galactoside and quercetin-3-*O*-rutinoside (in low amount) (Silva *et al*., 2002a, 2004b), the major compound being 3-*O*-caffeoylquinic acid (45%). In peels, besides these compounds, kaempferol-3-*O*-glucoside, kaempferol-3-*O*-rutinoside, one kaempferol glycoside, two quercetin glycosides acylated with *p*-coumaric acid and two kaempferol glycosides acylated with *p*-coumaric acid are also present (Silva *et al*., 2002a, 2004b). Quercetin-3-*O*-rutinoside is the major compound in quince peels. Other phenolic compounds were also detected in the whole fruit by Wojdyło *et al*. (2013), including procyanidins dimers, trimmers and tetramers, (-)-epicatechin and quercetin-3-*O*-robinoside.

Seeds contain the same hydroxycinnamic acids plus lucenin-2, vicenin-2, stellarin-2, isoschaftoside, schaftoside 6-*C*-pentosyl-8-*C*-glucosyl chrysoeriol and 6-*C*-glucosyl-8-*C*-pentosyl chrysoeriol. 5-*O*-Caffeoylquinic acid and isoschaftoside are the most abundant hydroxycinnamic acid and C-glucosyl flavone, respectively (Silva *et al*., 2005).

The total phenolic content is in the range of 0.2-1.7 g/kg, 0.011-0.3 g/Kg and 0.1 g/Kg for peels, pulps and seeds, respectively (Silva *et al*., 2002a, 2005).

More than 160 volatile compounds have also been identified in quince fruit (whole fruit and peels), comprising hydrocarbons, esters, alchools, aldehydes, ketones, lactones, monoterpenes, C_{13} norisoprenoids, among others (Schreyen *et al*., 1979; Ulmano *et al*., 1986; Winterhalter and Schreier, 1988; Winterhalter *et al*., 1990; Guldner and Winterhalter, 1991; Tateo and Bononi, 2010). According to Tateo and Bononi (2010), the whole fruit contains high amounts of α-farnesene, while Schreyen *et al*. (1979) and Umano *et al*. (1986) reported ethyl 2-methyl-2-propenoate and ethyl propionate as the major compounds, respectively.

The content of organic acids is 6.9-14.2 g/kg for pulps, 7.8-14.0 g/kg for peels and 0.5-0.8 g/kg for seeds (Silva *et al*., 2002b, 2004b, 2005). Pulps and peels contain oxalic, citric, ascorbic, malic, quinic, shikimic and fumaric acids, the sum of malic plus quinic acids representing more than 90% (Silva *et al*., 2002b, 2004b). Seeds does not contain oxalic acid and the content of malic acid plus quinic acid is lower (45-61%) (Silva *et al*., 2005).

Quince fruit has several medicinal usages, such as carminative, expectorant, anticancer (Duke *et al*., 2002), antibacterial (Fattouch *et al*., 2007), antidiabetic (Tahraoui *et al*., 2007) and laxative (Agelet *et al*., 2003), being also used for the treatment of skin lesions (Hemmati *et al*., 2012), migraine, cold, influenza (Hilgert *et al*., 2001), inflammatory bowel disease (Rahimi *et al*., 2010) and conjunctivitis (Siddiqui *et al*., 2002), among other disorders.

These bioactivities have been mainly ascribed to the high content of phenolic compounds. For instance, Fattouch *et al*. (2007) tested the antimicrobial activity of quince polyphenolic extracts and reported that peel was more active than pulp due to the highest amount of phenolics. Hamauzu *et al*. (2005) also observed a moderate anti-influenza activity of quince fruit extract due to the presence of polymeric procyanidins.

Concerning the antioxidant activity, the activity displayed by several extracts is correlated with the amount of caffeoylquinic acids and total phenolic content or with the content of ascorbic and citric acid (Silva *et al*., 2004; Magalhães *et al*., 2009). However, an extract rich in phytosterols, triterpenoic acids, glycerides of oleic and linoleic acids, *n*-aldehydes, *n*-alcohols and free *n*-alkanoic acids was more efficient at preventing the formation of thiobarbituric reactive species (Pacifico *et al*., 2012).

Moreover, the anti-allergic activity of phenolic rich extracts from quince fruit was demonstrated by their effect against IgE-mediated degranulation in basophilic cell line (RBL-2H3) and against the elevation of prostaglandins, leukotrienes, interleukins and tumor necrosis factor-α expression levels in different mast and basophilic cell lines (Shinomiya *et al*., 2009; Huber *et al*., 2012; Kawahara and Iizuka, 2012).

Phenolic rich extracts of quince seeds also displayed strong antiproliferative efficiency against cancer cell lines (Carvalho, 2010; Pacifico *et al*., 2012).

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