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REVIEW ARTICLE

The forgotten fruit (*Cydonia oblonga* Mill.) and its chemical composition: a review

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Abstract
Natural plant sources, particularly the fruits of several lesser-known species, are receiving increasing amounts of attention because they contain a variety of bioactive compounds that are advantageous to human health. The production of easy-to-grow, already-used, and full of nutrients crops could be a solution to the growing problem of a lack of healthful food. One such fruit is the quince (*Cydonia oblonga* Mill.), which belongs to the *Rosaceae* family that originated in the Caucasian area and extends to other parts of the world. Quince has been studied for decades because of its unique importance in food and medicine. The characteristic pear-shaped fruit is golden yellow in appearance and has an aromatic, and acidic flavour. The low-fat fruit is rich in numerous necessary nutrients, minerals, dietary fibre, and antioxidants that have significant positive effects on health, but due to its bitterness, it is underutilized. Quince can be utilised as a raw material to create a variety of food products and is a good source of natural phenolic antioxidants, providing significant functional characteristics.

Keywords Quince · Chemical composition · Polyphenols · Antioxidants

Introduction

People use various natural materials, especially fruits and vegetables, which are good natural sources of antioxidants to prevent several diseases. Fruits and vegetables that are recommended for health and fibre have historically had a place in dietary habits, due to their concentrations of vitamins, minerals and phytochemicals, especially antioxidants [1]. Quince (*Cydonia oblonga* Mill.) is considered a health-promoting fruit, although it is mainly consumed in processed form. Thermally stable polyphenols are responsible for most of their beneficial effects. Because quince fruits are a rich source of organic acids, sugars, fibres, and minerals, they have a significant nutritional value. They also contain compounds, the most significant of which are phenolic compounds, that have antioxidant and functional properties. The health benefits of quince fruit consumption have been linked to its hypoglycemic, anti-inflammatory, antibacterial, and anticancer properties [2, 3].

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This review aimed to obtain a comprehensive overview of the beneficial properties of quince by studying the available literature and also an overview of its use in the food industry.

Methodology

Scientific literature review encompasses the results obtained through searching the keywords "*cydonia oblonga*," "quince," "characterization," "chemical composition," "phytochemical," "storage," and "utilization" in major databases such as Web of Science, Scopus, Elsevier, Springer, Google Scholar, up until December 2023.

All used articles are published and reviewed by several experts in the field. Summarization of the articles took place on the basis of the use of the same methodologies for determining the content of individual components for the objective compilation of this review article.

Characteristics of quince (Cydonia *oblonga* Mill.)

Rather et al. [4] classify the *Cydonia oblonga* Mill. in the taxonomic order as follows:

Kingdom: *Plantae*
Division: *Magnoliophyta*
Class: *Magnoliopsida*
Subclass: *Rosidae*
Order: *Rosales*
Family: *Rosaceae*
Subfamily: *Maloideae*
Genus: *Cydonia*
Species: *Cydonia oblonga*

Quince grows as a dense small or medium-sized deciduous tree with a height of 5–8 m and a crown width of 4–6 m. As a Rosaceae family species, it is closely related to apples and pears. The root is a superficial and facilitated system with a sinuous trunk with brownish bark. The leaves are intense green, and simple, with the entire margin measuring 6–11 cm and 4–6 cm in length and width. The leaves are oblong or ovate and tomentose on the underside with an alternate arrangement. The flowers sprout after the leaves in spring or mid-April in the Northern Hemisphere. They have a pinkish or white colour with a size of 4–5 cm in diameter [4–6].

The unripe fruit is green in colour with fine thick whitish hairs (puberty), which fall to maturity in late autumn. Ripe fruits are fragrant pyriform (pear-shaped) or spherical kernels (4–8 cm) weighing 100–280 g with a strong yellow colour. The fruit is softer and juicier in warmer regions of the world, and in colder regions, it has a hard stony, very fragrant, unpleasant, sour, astringent flesh [4].

The fruit has many seeds, almost up to 50. The seeds are brownish, compressed on both sides and attached to a white mucilage [5]. After ingestion, the nitriles in these seeds are hydrolyzed by enzymatic or acidic action in the stomach, leading to the formation of hydrogen cyanide (HCN), a known volatile toxic gas, it is not recommended to consume them in large quantities [4].

The fruit is not highly valued in the fresh market due to the hardness of the pulp, bitterness and astringency. However, when quinces are ripe, they bring a pleasant, long-lasting and strong taste. They are in great demand for processing marmalades, jams, jellies and cakes [7].

Quince has a low-fat content and is an important source of organic acids, sugars, fibre and minerals such as potassium, phosphorus and calcium. It is also known for its health-promoting components such as phenolic compounds with antioxidant activity and is known to have hypoglycemic, anti-inflammatory, anti-carcinogenic, antimicrobial, anti-allergic and anti-ulcer properties and acts as a heart and brain tonic [8–10].

History of cultivation

Transcaucasia is considered the main centre of origin of quince. Countries such as Iran, Armenia, Azerbaijan, southwestern Russia and Turkmenistan are included in the Transcaucasia region. Quince originally grew on the rocky foothills and forests of Western Asia. It can tolerate different climatic conditions and latitudes, thanks to which it has spread from its centre of origin to the countries under the Himalayan mountains reaching as far as China, and in the west, it has spread to Europe and the Mediterranean region. Scientists estimate that it began to be cultivated in Transcaucasia around 4000 BC [4, 5, 11].

It is possible that the Akkadian civilization (2334–2154 BC) in Mesopotamia was the first to domesticate wild quince species. After domestication in the Middle East, quince arrived in Europe. The import of fruit from the East to the West intensified with Alexander the Great's invasion of the Middle East, so quinces were directly introduced to the Mediterranean. The generic name of quince (Cydonia) is derived from the name of a city on the island of Crete (Cydonea). In ancient Greece, quinces were eaten at wedding feasts. Quince fruits were used in ancient wines and were also preserved in buried vessels. The Greeks and Romans kept quince fruits in terracotta containers [6, 12].

In the Middle Ages, quinces were often served on the tables of royal families and aristocrats, who consumed them at banquets. Quince was also valued and recognized by the Arabs, for its many healing properties. In the thirteenth century, quinces spread from France to Britain. In 812 AD, Emperor Charlemagne, after discovering the value of quinces, ordered them to be planted in the royal garden. European settlers brought the quince tree to America and it is still grown here in several US states (e.g. California, Pennsylvania, Ohio). In the fourteenth century, quinces were considered protective against the plague and the Black Death [4].

Collection and storage

Quince is a climacteric fruit that should be harvested after physiological ripening to allow for maximum shelf life. It is usually collected from October to November [13]. Generally, harvesting begins when the fruits start to change colour from the basic dark green colour to light green to yellow. It is also possible to use a tool to correctly determine harvest maturity, namely to monitor the colour change of the fruit stem. If the fruit is ripe, the stem will be yellow and stronger at the interface with the wood [10, 14]. When harvesting quinces, it is necessary to handle the fruits carefully, they are very susceptible to bruises.

If climacteric fruits were harvested before physiological ripening, they would not have a unique taste and aroma due to their small size and high firmness at harvest. On the other hand, if these fruits were harvested after full ripening, their shelf life would be short. One of the main strategies is to harvest the fruits at their stage of maturity. Factors measured

to determine fruit maturity stage and harvest time included fruit firmness, skin and flesh colour, total soluble solids, titratable acids, chlorophyll and carotene content. For this purpose, days from full bloom to ripening and thermal units during special periods of vegetation are also used [15].

The most used method for extending the shelf life of fruits and vegetables is refrigeration. Low temperatures slow down the metabolism of the product and the activity of microorganisms, which are responsible for quality deterioration. Thus, refrigerated storage maintains a lower rate of respiration, as a result of which ethylene production is minimized, which in turn slows down the ripening process. The vapour pressure between the products and the surrounding atmosphere is also minimized, reducing water loss [16].

Fruit storage at low temperatures is another important method of horticultural crop storage that can reduce some of the metabolic reactions leading to natural decay, loss of crop quality, respiration, ethylene production, senescence and decay. The shelf life of quince cultivars is more than three months [15]. The optimal temperature for storage is − 0.5 to 0 °C, with an air humidity of 90%, under these conditions quinces can last 2–3 months [17].

Firmness, water loss and physiological disorders in the initial stages of quince storage are lower than those of apples and pears. One of the important problems when selling quince cultivars is enzymatic browning, which leads to physiological disorders occurring after storage. It is affected by the growing season, harvest date and storage conditions. The browning of the surface is caused by the activity of the polyphenol oxidase enzyme. During enzymatic browning, phenolic compounds such as chlorogenic acid are oxidized to *o*-quinone by polyphenol oxidase, and then *o*-quinone is converted to melanin by a non-enzymatic polymerization process, resulting in fruit destruction and yellow or brown pigments. Phenolic compounds are substrates for polyphenol oxidase. Late harvest and long-term storage of quince reduced fruit firmness and promoted surface browning [15].

Majeed et al. [16] proved that quince properties were ideally preserved at 1 °C even during 2 months of storage, after which significant loss was observed. This was followed by the browning of the fruit skin, a change in aroma, a decrease in the vitamin C content and an increase in the turbidity of the juice. However, at 5 °C, significant changes were observed in all parameters during the entire storage period. Quince can be stored for 4 weeks at a temperature of 5 °C without a significant loss of internal quality (browning speed of the fruit pulp, titratable acidity, ascorbic acid content, etc.), while at 1 °C the storage period can be extended up to 9 weeks.

Quince is susceptible to browning due to the presence of a high amount of phenolic compounds. The percentage of flesh browning depends on the type, amount and activity of polyphenol oxidase, peroxidase and phenylalanine ammonium lyase. Browning percentage is influenced by pre- and post-harvest factors, variety, inherent properties, amount of polyphenols at the time of harvest, storage temperature, storage time, transportation and mechanical damage during harvest. Quince is also susceptible to many pathogenic attacks in the field, which can be treated using various chemical pesticides and fungicides [16].

Chemical composition

Quince is one of the highly nutritious and underutilized horticultural commodities that, thanks to its nutritional components, have positive effects on human health [18]. Quince is considered important in the food and pharmaceutical industries because it is the richest source of phytochemicals and pectin [19]. *Cydonia oblonga* Mill. it has a low-fat content and is a rich source of carbohydrates, fibre, protein, vitamins, minerals and various organic acids [18, 20]. In addition, due to the high content of phenolic compounds, it has a strong antioxidant capacity and can be used as a source of antioxidants in food and healthcare products [20].

Minerals

Worldwide, there is a growing interest in minerals found in food for the prevention of several diseases [21]. The macroelements found in quince are potassium, calcium, magnesium, sodium, and phosphorus. Higher amounts of macroelements are in the seeds than in the pulp and skin. The content of macroelements also depends on the location of cultivation. Essential elements such as copper, iron, nickel and zinc are also contained in the pulp, peel and seeds of quince [22–24]. Compared to apples, quince is a richer source of minerals, in some cases twice as much [10, 25]. High iron contents have been reported in quince leaves, which is very valuable information, especially for people with high iron needs (i.e. pregnant women, and women of childbearing age) [21]. Compared to apples and pears, quince fruits contain a high amount of calcium and phosphorus (Table 1).

The pome fruits have high nutritional properties, but the leaves should be classified as a source of minerals. Differences in mineral content can also be attributed to different species, fruit maturity, agricultural practices, and ecological conditions such as climate, altitude, soil fertility, and seasonal variations. Micronutrients are involved in many biochemical processes, and adequate intake of certain micronutrients is associated with the prevention of deficiency diseases [21].

Table 1 Comparison of the nutritional composition

Nutritional elements	Quince	Apple	Pear
Carbohydrates	15.3 g/100 g [23]	9.5–15.03 g/100 g [40]	14.3 g/100 g [41]
Fibre	1.9 g/100 g [23]	2.5 g/100 g [42]	3.16 g/100 g [41]
Lipids	0.1 g/100 g [23]	0.7–3.5 g/100 g [43]	0.1 g/100 g [41]
Protein	0.4 g/100 g [23]	0.26 g/100 g [44]	0.3 g/100 g [41]
Pectin	20% [10]	10–15% [42]	25% [45]
Vitamins			
Ascorbic acid	13 mg/100 g [18]	5.7 mg/100 g [46] 6.18 mg/100 g [40]	4 mg/100 g [41] 3.8 mg/100 g [47]
Vitamin A	5.5 µg/100 g [18]	3 µg/100 g [44]	20 IU [48]
Thiamine	30 µg/100 g [18]	17 µg/100 g [44]	9 µg/100 g [47]
Riboflavin	30 µg/100 g [18]	26 µg/100 g [44]	5.6 mg/100 g [49] 100 µg/100 g [47]
Niacin	0.2 mg/100 g [18]	0.091 mg/100 g [44]	4 mg/100 g [49] 0.219 mg /100 g [47]
Organic acid	6.9–14.2 g/kg [23]	1.72–44.63 g/kg [50]	148.7 g/kg [51]
Minerals			
Na	9.2 mg/100 g [37]	0.72 mg/100 g [46]	70 mg/100 g [52]
K	189 mg/100 g [37]	107.25 mg/100 g [46]	170 mg/100 g [52]
Ca	66 mg/100 g [37]	5.8 mg/100 g [46]	23 mg [52]
Mg	10 mg/100 g [37]	5.07 mg/100 g [46]	16 mg [52]
Fe	1.1 mg/100 g [37]	0.123 mg/100 g [46]	4.32 mg/100 g [52]
P	25 mg/100 g [37]	10.87 mg/100 g [46]	8.97 mg/100 g [53]
Cu	0.006 mg/100 g [37]	0.027 mg/100 g [46]	1.2 mg/100 g [52]
Zn	0.013 mg/100 g [37]	0.043 mg/100 g [46]	3.01 mg/100 g [52]
Mn	0.002 mg/100 g [37]	0.035 mg/100 g [46]	1.11 mg/100 g [52]

Pectin

Pectins are a class of polysaccharides found in plant cell walls that are extensively dispersed and include galacturonic acid connected at both positions 1 and 4. Pectins include a class of structurally diverse polysaccharides that are extensively found in the intermediate lamella and primary cell walls of higher plants. Pectic polysaccharides, which are essential structural elements of plant cell walls, are frequently linked to other polysaccharides found in cell walls, including cellulose and hemicelluloses [26]. Depending on its location and molecular structure, pectin serves a variety of biological purposes. Pectin can act as a gel, which helps cells adhere to one another and softens their walls to allow for cell elongation [27].

Pectin is naturally found in products of plant origin, such as apples, onions, carrots, tomatoes, chestnuts, quinces and others. Pectin is one of the soluble dietary fibres that, after intake into the body, exhibits a large number of physiological effects, such as the effect of reducing cholesterol and glucose in the body, slowing down gastric emptying, and a prebiotic effect. For these reasons, pectins are an important ingredient in the pharmaceutical, food, nutraceutical and medical industries, primarily because pectin is a cheap raw material obtained from citrus peel waste [28].

Pectins are used in the food industry due to their gelling properties. Quince fruit is known primarily for its high content of pectin substances, thanks to which it can be used for the production of fruit spreads and in the canning industry. The average content of pectin in quince fruits of different cultivars is 2 g/100 g [10]. The content of pectin in quince fruits depends on the stage of fruit ripening [29].

Carbohydrates

Sugars, also known as carbohydrates, are necessary for the basic processes that lead to the growth of plants. Consequently, the availability of photosynthate, environmental cues, and the timing of critical developmental programmes must all be carefully synchronised with the production, metabolism, and utilisation of carbohydrates. In general, sugars can function as global regulators of gene expression and/or signalling molecules. For instance, they can function as hormones and translate nutrient status to control growth and the transition from one floral phase to another [30].

A variety of chemically unique carbohydrate compounds with varying gastrointestinal and metabolic characteristics can be found in food. Furthermore, the physiological handling of food can be significantly influenced by the

physico-chemical properties of carbohydrates in food and the overall attributes of the food matrix, which are largely determined by their biological origin and food processing [31].

The total sugar content of the fruit is around 9%, while the reduced sugar content is around 5%. Monosaccharides present in the fruit include rhamnose, mannose, D-glucose, L-arabinose and galactose. The main sugars of quince are fructose, glucose and sucrose [23].

Differences in the content of carbohydrates in fruits are caused by genetic and environmental factors, as well as the degree of maturity of fruits, in which carbohydrates naturally accumulate during storage and ripening and the profile of their representation in fruits changes [22].

In the leaves, the primary sugar is fructose, and glucose is found here only in trace amounts. Trace amounts of sorbitol were also found in the fruit, which is synthesized in the leaves from glucose-6-phosphate by the enzyme sorbitol-6-phosphate dehydrogenase, from where it is transferred to the fruit [21]. Cellulose and D-xylose are the main components of the seeds, and a small amount of L-arabinose is also present [32].

Proteins and amino acids

The nutritional quality of a protein source varies significantly based on its bioavailability, digestibility, amino acid profile, purity, anti-nutritional factors, and processing effects. Proteins are essential macronutrients for human nutrition. Plant proteins are frequently regarded as incomplete or less nutritious than animal proteins, even though numerous studies show that the majority of plant protein sources supply the necessary amounts of essential amino acids for human needs. Plant proteins do, however, certainly have a significant impact on human nutrition [33, 34].

Numerous essential functions of amino acids are involved in the central metabolism of plants. Because neither humans, as well as animals, are able to synthesise essential amino acids, these nutrients must be obtained through diet. On the other hand, deficiencies in specific essential amino acids frequently result in imbalances in plant nutrition. Additionally, amino acids participate in the regulation of multiple metabolic pathways, and other physiological and biochemical pathways, and act as intermediates of final metabolites in certain metabolic pathways. As a result, they have an impact on a variety of physiological processes in plants [35].

The total protein content in quince fruits is low, around 0.4 g/100 g of fresh fruit weight. Quince fruits contain 21 free amino acids, which are divided into essential (histidine, isoleucine, leucine, lysine, phenylalanine, threonine, tryptophan, valine, methionine), conditionally essential (arginine, glutamine, glycine, proline, tyrosine) and non-essential (alanine, asparagine, aspartic acid, cysteine, glutamic acid, serine). Glutamic acid, asparagine and aspartic acid are the three main free amino acids found in quinces in amounts of about 60 to 75%, while the other amino acids are in smaller amounts. The content of essential amino acids is important for humans because these amino acids are synthesized only by plants, and humans are still looking for new rich sources of these types of amino acids. In addition to nutritional properties, amino acids also affect the taste, as many of them have a distinctly bitter taste (e.g. tyrosine, arginine, leucine, valine, methionine and histidine). In addition, amino acids show various effects beneficial to human health, such as the prevention of cardiovascular diseases, improvement of digestion, and protection against arteriosclerosis and diabetes mellitus [21, 23, 36, 37].

Vitamins

Groups of intricate organic compounds called vitamins are present in food and are necessary for normal metabolism. While deficiencies can lead to disorders, deficiencies can be treated with a replenishment of these nutrients. Because of their unique organic nature, vitamins differ from other dietary nutrients. Their classification is based on their chemical structure and function. Tiny amounts of vitamins are needed for growth, development, health, and reproduction [38].

The most common water-soluble substance that participates in one-electron reactions is vitamin C. It is a crucial micronutrient and part of the metabolism of practically all living things. Among its many roles in humans, vitamin C primarily serves as an antioxidant and a cofactor for the enzymes mono- and dioxygenases [39].

Quince fruits are a rich source of vitamin C. The content of vitamin C in quinces is twice as high as in apples. Other vitamins that are represented in higher amounts are vitamins A, K and E [23]. Vitamin content in 100 g of fresh fruit is: retinol 5.5 µg, carotene 0.03 mg, thiamin 30 µg, riboflavin 30 µg, niacin 0.2 mg and ascorbic acid 13 mg [18]. Compared to apples and pears (Table 1), quince fruits contain higher amounts of vitamins. In the case of ascorbic acid (vitamin C), the content in quince fruits is up to twice as high as in apples, and up to three times higher than in pears.

Organic acids

Organic acids are the primary metabolites found in all plants, especially in fruits. Due to their antioxidant properties, organic acids such as phenols can also have a protective role against various diseases [54]. Organic acids are important secondary plant metabolites with antioxidant properties [55]. Organic acids are important for human and animal organisms because they can favourably influence the microflora in the

gastrointestinal tract, thereby improving nutrient intake and health [21]. Fruits and vegetable's colour, flavour, and aroma are all impacted by organic acids. Additionally, organic acids indirectly affect phenolic metabolism by modifying precursors and pH levels [56]. Seven organic acids were identified in *Cydonia oblonga* Mill.: oxalic, citric, ascorbic, malic, quinic, shikimic and fumaric acids. Malic and quinic acids are the most abundant in the pulp and peel of quince fruits [18, 36]. The acid content is higher in the flesh of the fruit than in the skin [37, 57]. Malic acid is responsible for the bitter taste of the fruit [23]. The simplest dicarboxylic acid is oxalic acid, which has a strong chelating ability for polyvalent cations [54].

All the above-mentioned organic acids, except for oxalic acid and ascorbic acid, are found in the seeds of quince [32, 36]. The content of organic acids in quince leaves differs from the content of acids in skins, pulp and seeds. The leaves have a higher proportion of quinic acid and a lower proportion of shikimic and fumaric acids. Harvest stage and geographical origin significantly influence the total phenolic and organic acid content of leaves [21, 32].

During the pre- and post-harvest stages of food production and processing, organic acids have been used either directly or indirectly as nutrients, flavouring agents, antioxidants, pH adjusters, acidulants, or as components of food due to microbial activity, hydrolysis, and biochemical metabolism. Organic acids have long been used in the food and pharmaceutical industries as preservatives [56]. Organic acids can maintain a healthy intestinal microbial balance, increase the activity of digestive enzymes, improve the utilization of minerals and, last but not least, stimulate immune functions. They are able to reduce pathogenic bacteria and at the same time can increase the digestibility of nutrients through their effect on the pH in the digestive tract, and also stimulate the growth of beneficial bacteria. They are also bacteriostatic and bactericidal for pathogenic bacteria. By lowering lipid peroxidation and activating antioxidant enzymes, organic acid products also contribute to an increase in antioxidant status. Furthermore, dietary organic acids can control cytokines in the host and enhance humoral and cell-mediated immunity [58, 59].

Polyphenols

Polyphenols are categorised as phytochemicals or secondary metabolites and have a variety of functions in plants. They are known to fend off pest attacks, provide colours that draw specific insects, and shield the plant from UV rays. But the main source of phenolic compound's nutritional effects is their production of metabolites when consumed as dietary components [60]. Secondary metabolites are important components of the human diet because they are present in everyday food products such as coffee, tea, soy, fruits and vegetables. Due to their benefits for human health, including the treatment and prevention of many diseases, phenolic compounds and flavonoids are well-known as antioxidants and other important bioactive substances. Various studies have shown that consumption of polyphenols has a protective effect against inflammation and cancer. Because they are known to scavenge and stop the formation of reactive oxygen and nitrogen species, the anti-inflammatory effects of polyphenols are attributed solely to their antioxidant activity [61].

Quince contains rich nutritional compounds such as phenolic acids, flavonoids, lignin and other active ingredients. Phenolic compounds mainly consist of caffeic acid and its derivatives, coumaric acids and other components. Flavonoids include flavanols, flavonoids and flavonoid glycosides, isoflavones [62]. Hydroxycinnamic acids (caffeic and *p*-coumaric acid esters) and flavonols (quercetin and kaempferol derivatives) are the main phenolic compounds, while flavanols (catechin and epicatechin) are found in lesser abundance [63]. Quince fruits contain important phenolic compounds including 3-*O*-caffeoylquinic acid (chlorogenic acid), 4-*O*-caffeoylquinic acid (cryptochlorogenic acid), 5-*O*-caffeoylquinic acid (neochlorogenic acid) and 3,5-di caffeoylquinic acid [64]. 5-*O*-caffeoylquinic acid is the main phenolic acid in quince fruits. This phenolic compound is the main substrate of the polyphenol oxidase enzyme, which explains the susceptibility of these fruits to enzymatic browning [2]. The dominant flavonoids in the fruits are epigallocatechin and rutin, with lower concentrations of catechin and quercetin. In addition, quince contains flavonoids such as lucenin, vicennin, stelarin and apigenin. The fruit also produces flavon-3-ols such as quercetin-3-*O*-galactoside (hyperoside), quercetin-3-*O*-rutinoside (rutin) and kaempferol-3-*O*-glucoside (astragalin) and kaempferol-3-*O*-rutinoside (nicotiflorin) [22, 64].

Polyphenols have several advantageous effects on the body, such as scavenging free radicals, reducing inflammation, and enhancing signal transduction and ocular blood flow [65]. Dietary polyphenols can help reduce systemic inflammation, blood pressure, insulin resistance, and lipid profiles. Enhancement of cardiovascular health has been associated with quercetin, resveratrol, and stilbene. Dietary polyphenol's potential to have therapeutic effects may be partly explained by their reciprocal relationship with the gut microbiota. This is due to the fact that polyphenols have been shown to have positive effects on human health by changing the composition of the gut microbiome. To be more precise, polyphenols are transformed into medicinally beneficial bioactive compounds by the gut microbiome [60].

Carotenoids

Natural pigments called carotenoids can be found in fish, algae, fungi, birds, fish flesh, and the cuticles of crustaceans and insects. Because of their distinctive colours, which fall between yellow and red, they are known as pigment [66].

Fruit and vegetable carotenoid concentrations vary depending on the type of plant, level of ripeness, harvesting period, and growing and storage conditions [67].

Carotenoids are associated with chlorophylls in the photosynthetic apparatus of plants and play a key role in protection against photooxidation. The dominant carotenoids are β-carotene, chlorophyll a and chlorophyll b. Other carotenoids in quince fruits are zeaxanthin and lutein [21, 22]. Because of their anti-inflammatory and antioxidant properties, carotenoid pigments are a class of bioactive compounds that food scientists, nutritionists, and the food industry are interested in. They are acknowledged as being crucial in preventing illnesses in people and preserving their health. Their ability to act as an antioxidant mitigates the damaging effects of free radicals, which may shield people from weakened immune systems, early ageing, some types of cancer, heart disease, and arthritis [66]. The yellow macular pigments, lutein and zeaxanthin, function as powerful antioxidants and blue light filters [67].

Utilization of quince

This plant is a great source of metabolites with amazing biological properties that are also reasonably priced. It has many ethnobotanical and medicinal applications. The main application for this fruit is in the making of jellies, jams, marmalade, pudding and candied fruit [32, 68]. Furthermore, the fruit is used to make wines, pasteurised juice, and syrups. Quince is also used as a raw ingredient in some nations to make quince cheese, which is made by cooking quince for an extended period with sugar and water [23].

Because they contain valuable bioactive, quince leaves have several medicinal uses, including their ability to prevent hypercholesterolemia-related spermatogenesis, their anti-fungal, renoprotective, anti-atherogenic, and hepatoprotective properties, as well as their antiproliferative and antioxidant properties [69]. Quince leaves have been used in traditional medicine to treat a variety of skin conditions as well as heart conditions. However, because of their sedative, antitussive, antipyretic, and antidiarrheic qualities, tinctures or infusions of leaves are used in traditional medicine in Portugal. The fruit's seeds have historically been used to treat diarrhoea, bronchitis, sore throats, coughs, and dysentery [32, 70].

Seeds are a good laxative and can help treat bronchitis because they contain large amounts of mucilage. Seeds possess mucilaginous and demulcent properties. They are used for fever, sore throat, diarrhoea, and dysentery. To get rid of dandruff, use powdered seeds. Owing to its mucilaginous nature, it is utilised as a soothing medium for various medications, particularly skin lotions that are used as a treatment for skin ailments and as cosmetic lotions. It is also utilised as a stabiliser in dairy products. Mucilage is applied externally to treat ulcers and burns [69, 70].

Conclusion

In recent years, plant commodities used in the ancient past have gained awareness again, especially for their unique nutritional and functional properties. One of these commodities is *Cydonia oblonga*. Despite all its nutritional composition and health benefits, quince is underutilised at the food processing level due to its sensory properties. This plant commodity represents an important source of chemical compounds that can be substituted for chemical medicines, pesticides, and chemical additives. It can enrich the diet with active ingredients such as essential vitamins, minerals, and antioxidants. Therefore, the inclusion of this commodity as an ingredient in innovative foods could be desirable in the food industry. Thanks to its antioxidant, anti-inflammatory, anti-cancer, and immunomodulating effects, it helps in the prevention and treatment of chronic diseases. However, many factors influence the content of important substances. Their content can be influenced by various internal and external factors, such as species, growing conditions, maturity at harvest, and post-harvest storage conditions. From the point of view of use and further recommendation, not only for the food industry but also ordinary consumers, further evaluation and research of different varieties is necessary to determine the variety with the most suitable content of bioactive substances. It is also necessary to monitor the influence of cultivation, storage conditions, and technological modifications, which affect not only the content of the mentioned compounds but also the representation of individual bioactive substances.

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Conflict of interest The authors declare no conflict of interest.

Compliance with ethics requirements This research does not contain any studies with human or animal subjects.

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