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# Pharmacognostic and clinical aspects of *Cydonia oblonga*: A review

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ABSTRACT

*Cydonia oblonga* Miller (*C. oblonga*) is considered as an important medicinal plant throughout the world. It is native to Mediterranean region and Central Asia having a long term history of medicinal and ethnobotanical use. *C. oblonga* is well known for its antidiabetic, antioxidant, antimicrobial, antiallergic, antihemolytic, aphrodisiac and UV protectant activity. It is a good and low cost natural source of metabolites with interesting biological properties. Extensive research has been performed on the metabolic profile and biological potential of this species. In particular, quince leaves reveal to constitute a promising natural source of bioactive phytochemicals and are suitable for application in nutritional/pharmaceutical fields. Mostly it is grown for fruit and also serves as rootstock for pear. This paper gives an overview of scientific literature available on plant *C. oblonga*.

## 1. Geographical distribution

*Cydonia oblonga* Miller (Quince) (*C. oblonga*) belonging to family Rosaceae is most likely originated from the Caucasian area (Western and Eastern Ante-Caucasus, Daghestan, Eastern and Southern Transcaucasia, Talysh) and spread to the Greece, Middle East and around the Mediterranean and Central Asia (Kopetdagh-the ravine of Aydere). However the distribution of wild-growing quince in other areas of Central Asia has not been proven. It also grows in Iran, Turkey, Afghanistan and Pakistan. Now this species is widespread, due to cultivated forms, and it is naturalized over almost entire Mediterranean region. Quince also has been cultivated in the north European Baltic countries for its fruit production[1]. As far as the world yield of quince fruits is concerned among all countries, Turkey is the largest producer followed by China, Iran, Argentina, and Morocco[2].

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## 2. Historical background

The name of the *Cydonia* genus is derived from the name of a region Kydonia in the northwestern Coast of Crete Greece, where this tree has been cultivated since the ancient times. It is believed that the quinces were the "golden apples" of Hesperides featured in the eleventh labor of Hercules, and it's also the fruit that was offered to Aphrodite the goddess of love, by Paris, prince of Troy, to gain her favor for provoking the Trojan War. In England, the quinces were first reported in about 1275, the time when King Edward I had some plantations at the Tower of London and they are still grown productively in Scotland. In older Greek ritual these fruits were offered in wedding as they symbolized fertility[3]. During olden times, quince was spread from wild center of origin to the countries which adjoined the Himalaya Mountains to the east, and all through Europe to the west. Several current United States Department of Agriculture funded plant collecting expeditions to Azerbaijan, Armenia, and Georgia returned with quince seeds and cuttings from all these countries and the availability of *Cydonia* germplasm in the United States increased considerably from 2002 to 2006 as a result

of all these collections[4].

## 3. Taxonomic position and morphology of plant

*Cydonia* is a monotypic genus (containing single species) which belongs to family Rosaceae, subfamily Spiraeoideae, tribe Pyreae, and subtribe Pyrinae. Mostly it grows as shrub or small tree. It comprises pubescent to tomentose buds, petioles, leaves, and fruit. Leaves are ovate to oblong, about 2 inches across and 4 inches long. The solitary white flowers are 1.5–2.0 inches across, having 5 petals, 20 or more stamens, 5 styles, an inferior ovary with many ovules, and are borne on current season of growth (Figure 1). Bloom time overlaps with that of apples, usually at the beginning of April in the central latitudes of the Northern Hemisphere. The fruit is aromatic having many seeds, pome and its shape varies from round to pear with yellow colored flesh[2] (Figure 2).

**Figure 1.** Flowers of *C. oblonga.*

**Figure 2.** Fruit of *C. oblonga.*

## 4. Chemical conclusion

### *4.1. Organic acids present in C.oblonga*

The organic acid profiling of *C. oblonga* leaves was found to be diverse from seeds, pulps and peels. Different amounts of citric, malic, quinic, shikimic and fumaric acids were fractionated from the fruits and leaves (Figure 3). Ascorbic acid is found only in fruits' peels and pulps, absent in seeds. Organic acid profiling of quince jam revealed the organic acid total content to be lower than pulps and peels and greater than that of the seeds. Leaves have relatively higher proportions of quinic acid and are characterized by having lower amounts of shikimic and fumaric acids. In comparison with fruits, leaves contain lower amounts of malic and quinic acids and higher proportions of citric, oxalic, fumaric and shikimic acids. Moreover this matrix has smaller citric and fumaric acids relative percentages and higher malic plus quinic and shikimic acids contents than seeds. Harvesting stages and geographical origin strongly effect the total phenolic and organic acids content in leaves' samples. The amount of different organic acids such as quinic acid decreases with harvesting time. The substantial influence of geography and harvesting stage on the organic acids profiling of quince leaves focus towards its future use as geographical origin and/or maturity marker[5-8].

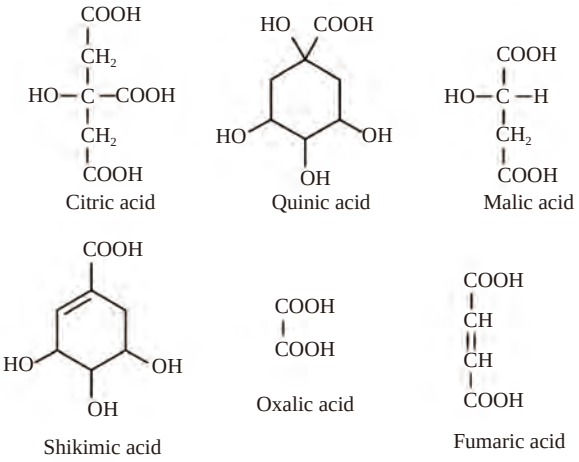


**Figure 3.** Organic acids presented in quince.

### *4.2. Phenolic profile of quince*

Quince fruits and leaves contain mono and dicaffeoylquinic acids such as 3-O-caffeoylquinic, 4-O-caffeoylquinic, 5-Ocaffeoylquinic, and 3,5-O-dicaffeoylquinic acids (Figure 4). In both fruits and leaves, quercetin and kaempferol derivatives are present such as quercetin-3-O-galactoside, quercetin-3-O-rutinoside, kaempferol-3-O-rutinoside and kaempferol-3-O-glucoside. Quince peels also contain several quercetin and kaempferol derivatives acylated with *p*-coumaric acid. Quince seed keeps a discrete phenolic profile, composed by numerous C-glycosil flavones such as lucenin-2, stellarin-2, vicenin-2, isoschaftoside, schaftoside, 6-C-pentosyl-8-C-glucosyl chrysoeriol and 6-C-glucosyl- 8-C-pentosyl chrysoeriol[5,9].

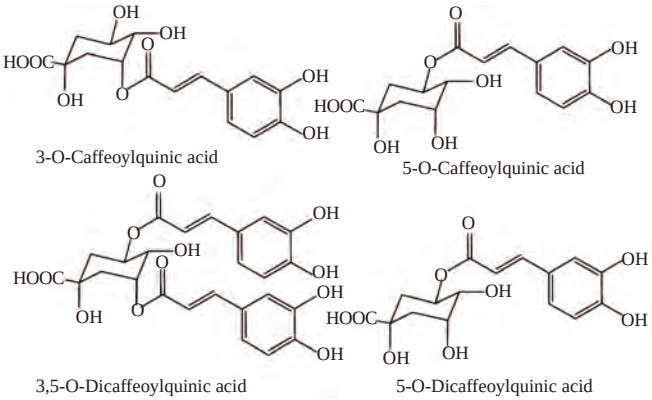


**Figure 4.** Phenolic compounds present in quince.

### *4.3. Sugars in quince*

Sugars were also testified to be present in quince. Aldobiouronic acids, cellulose and d-xylose were found to be major constituents of seeds and small amount of L-arabinose was also found to be present. The major hydrophillic polysaccharide was a 4-O-methyl-D-glucurono-D-xylan having remarkably greater percentage of glycuronic acid derivatives. The presence of sorbitol and methyl-α-D-galactose was noted in leaves[10].

### *4.4. Amino acids in quince fruit*

Twenty-one different types of free amino acids were recorded in numerous samples of quince fruits which were investigated by using gas chromatography-flame ionization detector analysis. The highest content of free amino acids was detected in peels. Major free amino acids were found to be hydroxyproline, aspartic acid and asparagine. Likewise, in quince jams, major fractions of aspartic acid, asparagine, and glycine orhydroxyproline were recorded[11].

### *4.5. Essential oils composition in C. oblonga leaves*

The essential oil analysis of leaves was carried out at flowering and fruiting stages by gas chromatograph-mass spectrometer analysis. A total of 47 components were identified representing 95.7% oil of quince leaves of flowering stage and 40 representing 64.5% of quince leaves of the fruiting stage. The common main constituents of the essential oil of leaves at flowering period are: high percentage of aromatic aldehyde (benzaldehyde 12.8%), followed by fatty acid (hexadecanoic acid 7.2%), oxygenated monoterpene (linalool 5.7%), norisoprenoid (E-B-lonone 5.1%) and sesquiterpene hydrocarbon (germacrene D 8.6%)[12].

## 5. Biological activities

### *5.1. Antidiabetic activity*

The antidiabetic activities of quince leaves hydro-ethanolic extract have been studied along three herbal remedies used in Turkish traditional medicine on normal and streptozocin-induced diabetic rats. There was no noteworthy effect on normal rats after intake of 2 g/kg glucose. Though a considerable fall in the blood glucose levels of diabetic rats was reported at a time period of 0 to 3 h, the beneficial effect of the extract (250 or 500 mg/kg dried extract) was the same as a standard antidiabetic drug and there was no noteworthy difference between glucose levels of the extract and tolbutamide treated rats. The antioxidant activity of the quince extract was evaluated by glutathione and thiobarbituric acid reactive substance (TBARS) contents of kidney, liver and heart of diabetic rats. As a result, there was no significant decrease in glutathione contents of diabetic and non-diabetic rats, while significant decreases were observed in TBARS of heart tissue of diabetic rats when equated with diabetic control group. The low dose of quince extract (250 mg/kg) revealed a slight and non-significant decrease on kidney TBARS, whereas the higher dose (500 mg/kg) showed significant decrease in TBARS content of kidney ($P < 0.01$). So long term use of quince is recommended in type II diabetic patients to protect against the complications of diabetes mellitus[13].

### *5.2. Antimicrobial and antioxidant activity*

Different microbial strains were examined for antibacterial activities of quince. Fruit peel extract showed significant decrease in bacterial growth and the minimum inhibitory concentrations were in the range of $10^2 – 5 \times 10^3$ μg polyphenol/mL. Chlorogenic acid is regarded as the major component which acts in co-ordination with other components of the extract for inhibition[14].

Phenolic fraction of quince was found to have better antioxidant activity than the crude methanolic extract. It represents that the phenolic fraction gives a higher depiction for the radicle scavenging potential of quince fruit and jam[15]. The antioxidant activities of quince in comparison with green tea were evaluated by Folin-Ciocalteu reducing capacity assay, by 2,2′-diphenyl-1-picrylhydrazyl assay and by the ability to inhibit the 2,2′-azobis (2-amidinopropane) dihydrochloride-induced oxidative hemolysis of human erythrocytes. Major phenolic compound 5-O-caffeoylquinic acid in quince leaf extract caused significantly higher reduction power than green tea. Quince leaf extract acts as defensive or therapeutic agent against radicles[16].

### *5.3. Antiallergic activity*

The antiallergic properties of hot-water extract of quince fruit were tested *in vivo* and *in vitro*. The release of β-hexosaminidase was decreased considerably after addition of 50, 100 and 200 μg/mL of hot-water extract to cell culture. As a result, atopic dermatitis occured like marks appeared on the face, ear, nose, neck and dorsal skin of mice in control group after three weeks, whereas the severity of the signs in quince treated mice were significantly low. The immunoglobulin E levels of control and quince treated animals with 5% hot-water quince extract orally were (1 635 ± 289) and (994 ±

205) ng/mL, respectively, in which the variation was statistically significant ($P < 0.01$)[8,17].

### 5.4. Healing activity

The healing effect of quince seed mucilage was studied on the skin lesions which were induced by T-2 toxin. The rabbits were divided into five groups. Group 1 received the poison as positive control; Group 2 received eucerin as negative control; Groups 3 to 5 received 5%, 10%, and 15% mucilage treatment, respectively. A solution of T-2 toxin (83 mg/mL) in methanol was prepared and applied on skin twice with 24 h interval. On the 8th day, erythema and inflammation were observed in Groups 1, 2 and 3, but the complete healing of the skin damage treated by 10% and 15% quince seed (Groups 4 and 5) was observed. Normal skin with grown hairs was the consequence of treatment with quince seed mucilage.

The healing mechanisms of effects of quince seed mucilage involve the following effects: (1) preventing impaired protein synthesis by T-2 toxin; (2) acting as a hindrance between T-2 toxin and skin along with dropping water evaporation; (3) acting as antioxidant and growth factor; (4) affecting fibroblast activities and enhancing collagen production; (5) enabling the construction of granulation tissue and promoting blood circulation; (6) counter balancing dermal toxicity of the toxin[18,19].

### 5.5. UVA protective activity

*C. blonga* leaf extract has potential to be used for defense as well as mitigation of harmful impacts of UVA on a few hematological and biochemical aspects of the reasonably important African catfish, *Clarias gariepinus*. Blood parameters are helpful for the measurement of physiological disorders in stressed fish and consequently offer information about the extent of damage in the fish. The considerable decline ($P < 0.05$) in the red blood cell was detected in the groups exposed to UVA in contrast to the control groups. Exposure to UVA resulted in noticeable red cell shrinkage and increased mean cell hemoglobin concentration and revealed an increase in mean cell volume and mean cell hemoglobin in the blood of the exposed fish compared to the control. A substantial decline ($P < 0.05$) in the total white blood cells was traced in the exposed fish contrast to the control. Methanolic extract of quince leaf (before fruits ripening) used for the mitigation of harmful UVA effected on catfish by preventing hematotoxic stress induced by UVA[10].

### 5.6. Aphrodisiac activity

*C. oblonga* is considered as a powerful libido invigorator in Tib-e-Nabvi and Unani System of Medicine. The aphrodisiac activity of the quince hydroalcoholic extract of the fruits has been studied in Wistar rats and the extract was administered orally in the dosage of 500 mg/kg and 800 mg/kg body weight per day for 28 days. After administration of the extract mounting frequency and the mating performance of the rats improved remarkably ($P < 0.01$)[13].

## 6. Medicinal uses

In Italy, quince leaves have been utilized in folk medicine for the cure of diverse skin as well as cardiovascular diseases. However, in Portugal decoctions or infusions of leaves are consumed in traditional medicine owing to their antitussive antipyretic, antidiarrheic, and sedative properties[6,20].

Traditionally the seeds of *C. oblonga* are used for treatment of cough, dysentery, sore throat, bronchitis and diarrhea[21,22].

It is used as demulcent for curing asthma. In Iran as well as other areas of the Middle East, the dried up pits of the fruit are used to cure cough and sore throat. The fruit pits are immersed in water and the viscous product is then drunk like cough medicine. It is considered safe for children, as it is alcohol free. In Afghanistan the quince seeds are boiled and consumed for curing pneumonia. In Chinese medicine, the stem bark is used as astringent for ulcers, and the fruits are utilized for their carminative, peptic, antivinous, and astringent qualities. When the seeds soaked or boiled in water, they release the mucilage from the seed coat and make a jelly-like product which can be applied for eye lotions and sore throats. In Europe, extract of *C. oblonga* in conjunction with lemon juice namely Gencydo, is one of the admired remedy used for curing asthma and allergic rhinitis[11].

In alternative medicine fruit and seeds are used to treat many diseases, including canker sores, sore throat, dysentery and gum problems. Quince is also used in the production of wine alleged to benefit asthma sufferers and medicine as a digestion relieve. Quinces have many health promoting effects owing to their antioxidant capacity, phenolic composition, and hypoglycemic, anti-ulcerative, anti-carcinogenic, antimicrobial, anti-inflammatory, and anti-allergic activities. This acts like stimulant for heart and brain. In addition, quince has squat fat content and it is a main source of crude fiber organic acids, sugars, and minerals like calcium, phosphorous and potassium. Owing to these healthy properties, quince extracts have been conventionally utilized as dietary supplements in addition to medical treatment for inflammatory diseases and infections[15,23,24].

### 6.1. Ethnobotanical uses

Quince plant is used like a resource of liqueur, candies, flavor in marmalade, jelly and brandy and also acts the same as preservative[19]. While raw fruit is not agreeably eatable due to its stiffness, acrimony and astringent property. Therefore, valued for making jam “marmalade” as well as it is used as a supplement to main dishes and for flavoring pies. When production of quince is squat, the jam is simply admixed by addition of apple (*Malus communis* Lamk) because it is inexpensive and its quality is comparable to quince. Nevertheless, this type of adulteration can be identified by the presence of phloretin 2′-glucoside and phloretin xylosyl glucoside both dihydrochalcones are present in apple and these are regarded as chemical markers[25].

Quince fruit has many culinary uses. Quince made paste is much admired in European countries, mostly in Spain as well as in parts of Latin America. This saccharine, sweet-smelling, akin to jelly confection is cut into pieces and frequently serves up along a spicy cheese. Quince is used in several salty and sweet dishes, and is recurrently cooked with lamb in Armenia[18].

In different areas of France, especially Angers, it was utilized as pear rootstock before 1500 years. The French people were growing quince plants from the healthy cuttings and layering in stool beds by the early 1600s. France supplies major rootstocks to entire world[26,27].

The seeds of *Cydonia vulgaris* are well recognized as quince seeds in English and "Beedana" in Gujarati. Seeds contain an elevated quantity of mucilage acquired from the seed coat which is utilized as gum arabic alternate to putting in gloss to a material. It can be used in tablet formulations and furthermore utilized as a suspending agent[28].

Quince is also used in agriculture mainly as a pear rootstock that improves fruit productivity and quality and can be easily propagated by using moreover traditional or modern techniques[29].

### 6.2. Toxic effects of quince

Quince fruit seeds are dangerous to ingest in case of breast-feeding because the seeds have nitriles, which are commonly present in seeds of the Rosaceae. In stomach, the enzymes and stomach acid both hydrolyze nitriles and ultimately produce hydrogen cyanide. This hydrogen cyanide is a poisonous volatile gas and the seeds are prone to be toxic if excess amount is consumed. Several studies with *C. oblonga* fruits illustrated the presence of cyanogenic glycosides such as amygdalin and prunasin[30].

### 6.3. Available germplasm of quince

The quince germplasm collection was founded in Izmir, Turkey in 1964 comprising numerous regionally extended fruit cultivars and landraces[17]. In Karaj, Iran, a compilation of over fifty *Cydonia* accessions are preserved, containing both cultivated as well as wild types[31]. The lesser quince collections are growing in Greece, Spain, Italy, and other European countries. There are some more significant collections in Southwest Russia and Ukraine. The Oregon facility is one of a number of *ex situ* genebanks lodging temperate fruit and nut collections for the National Plant Germplasm System, United States Department of Agriculture[22]. The germplasm is now accessible in the United States for inflating the utilization of *Cydonia* both as a rootstock for pear and as a fruit producing tree[26].

### 6.4. Threats and need for genetic improvement

Quince is adapted to hot and dry climates as well as to acidic soils. It is scrutinized that in northern latitudes or else chilly climates the fruits of several cultivars do not ripe completely. During arrival of winter fruit cracking is huge dilemma there. Though most commercial quince production today is situated in incredibly hot areas, largest quince orchards in 1895 was a 60 acre (24 ha) planting near Waterport New York[32]. Whether it is grown for fruit production or else for use as a pear rootstock, quince is crashed by numerous disease problems. Fire blight which is caused by the bacterium *Erwinia amylovora* checks the cultivation of quince either for its fruit or as a pear rootstock, particularly in regions with hot, humid summers. The *Cydonia* is one of the most susceptible genus to fire blight in Rosaceae, the plant family including numerous vulnerable and susceptible hosts[33,34].

### 6.5. Molecular studies

*C. oblonga* is an agronomically important plant having lots of uses but to certain extent limited information is available concerning its morphology and genetic variability. Nearby 33 morpho-agronomical traits (descriptors) are recorded by direct observation of the trees under field conditions in the quince orchard. These observations are registered in the European Minor Fruit Tree Species Database supporting the conservation, assessment, management, and compilation of negligible fruit tree species (EC Project GENRES 29). The data of genetic assortment is helpful in the recognition of replica varieties, confirmation of synonyms and homonyms and evaluation of wrong identified varieties. Inter simple sequence repeat markers are utilized to identify the breach in the gene pool and sort out the prospect additions. The application of the inter simple sequence repeat markers approach is also used to forecast top association between molecular marker records and morpho-agronomical descriptors on a species that is anticipated to attract much attention in the near future. The complete genome sequencing of a closely related species, such as apple, will help the wide use of molecular study on quince in the upcoming years[5].

## 7. Conclusion

*C. oblonga* belonging to family Rosaceae is most likely originated from the Caucasian area (Daghestan, Talysh, Eastern and Southern Transcaucasia, Western and Eastern Ante-Caucasus) and spread to Greece, Middle Eastand around the Mediterranean and Central Asia. However the presence of wild growing quince in other areas of Central Asia has not been verified yet. *C. oblonga* is well known for its antidiabetic, antioxidant, antimicrobial, antiallergic, antihemolytic, aphrodisiac and UV protectant activity. This plant is an excellent and inexpensive natural resource of metabolites with remarkable biological properties. It possesses great medicinal and ethnobotanical uses. Jams and jellies are made from its fruits. Still more research is required to evaluate its medicinal potential and its conservation is also needed because it is an economically important plant.

## Conflict of interest statement

We declare that we have no conflict of interest.

## References


[1] Roach FA. *Cultivated fruits of Britain*: *their origin and history*. London: Blackwell; 1985, p. 220-5.

[2] Postman J. The USDA quince and pear genebank in Oregon, a world source of fire blight resistance. *Acta Hort* 2008; **793**: 357-62.

[3] Ganopoulos I, Merkouropoulos G, Pantazis S, Tsipouridis C, Tsaftaris A. Assessing molecular and morpho-agronomical diversity and identification of ISSR markers associated with fruit traits in quince (*Cydonia oblonga*). *Genet Mol Res* 2011; **10**(4): 2729-46.

[4] Magalhães AS, Silva BM, Pereira JA, Andrade PB, Valentão P, Carvalho M. Protective effect of quince (*Cydonia oblonga* Miller) fruit against oxidative hemolysis of human erythrocytes. *Food Chem Toxicol* 2009; **47**(6):1372-7.

[5] Ferreres F, Silva BM, Andrade PB, Seabra RM, Ferreira MA. Approach to the study of C-glycosyl flavones by ion trap HPLC-PAD-ESI/MS/MS: application to seeds of quince (*Cydonia oblonga*). *Phytochem Anal* 2003; **14**(6): 352-9.

[6] Oliveira AP, Pereira JA, Andrade PB, Valentão P, Seabra RM, Silva BM. Phenolic profile of *Cydonia oblonga* Miller leaves. *J Agric Food Chem* 2007; **55**(19): 7926-30.

[7] Silva BM, Andrade PB, Ferreres F, Seabra RM, Oliveira MB, Ferreira MA. Composition of quince (*Cydonia oblonga* Miller) seeds: phenolics, organic acids and free amino acids. *Nat Prod Res* 2005; **19**(3): 275-81.

[8] Silva BM, Valentão P, Seabra RM. Quince (*Cydonia oblonga* Miller): an interesting dietary source of bioactive compounds. In: Papadopoulos KN, editor. *Food chemistry research developments.* New York: Nova Science Publishers, Inc.; 2008, p. 243-66.

[9] Legua P, Serrano M, Melgarejo P, Valero D, Martínez JJ, Martinez R, et al. Quality parameters, biocompounds and antioxidant activity in fruits of nine quince (*Cydonia oblonga* Miller) accessions. *Sci Hortic* 2013; **154**: 61-5.

[10] Oliveira AP, Pereira JA, Andrade PB, Valentão P, Seabra RM, Silva BM. Organic acids composition of *Cydonia oblonga* Miller leaf. *Food Chem* 2008; **111**: 393-9.

[11] De Bruin D, Baars E. *Citrus/Cydonia comp. use in general practice. A survey among anthroposophic physicians*. Driebergen: Louis Bolk Instituut; 2001.

[12] Erdoğan T, Gönenç T, Hortoğlu ZS, Demirci B, Başer KH Kıvçak B. Chemical composition of the essential oil of quince (*Cydonia oblonga* Miller) Leaves. *Med Aromat Plants* 2012; **1**: 134.

[13] Aslan S, Lu H. On the sensitivity of ASL MRI in detecting regional differences in cerebral blood flow. *Magn Reson Imaging* 2010; **28**(7): 928-35.

[14] Fattouch S, Caboni P, Coroneo V, Tuberoso CI, Angioni A, Dessi S, et al. Antimicrobial activity of Tunisian quince (*Cydonia oblonga* Miller) pulp and peel polyphenolic extracts. *J Agric Food Chem* 2007; **55**(3): 963-9.

[15] Kirtikar KR, Basu BD. *Indian medicinal plants.* Vol. 3. Dehradun: International book distributors; 1999, p. 985-6.

[16] Costa RM, Magalhães AS, Pereira JA, Andrade PB, Valentão P, Carvalho M, et al. Evaluation of free radical-scavenging and antihemolytic activities of quince (*Cydonia oblonga*) leaf: a comparative study with green tea (*Camellia sinensis*). *Food Chem Toxicol* 2009; **47**(4): 860-5.

[17] Silva BM, Casal S, Andrade PB, Seabra RM, Oliveira MB, Ferreira MA. Free amino acid composition of quince (*Cydonia oblonga* Miller) fruit (pulp and peel) and jam. *J Agric Food Chem* 2004; **52**(5): 1201-6.

[18] Ghazarian B. *Simply quince*. Monterey: Mayreni Publishing; 2009, p. 216.

[19] Aslam M, Sial AA. Effect of hydroalcoholic extract of *Cydonia oblonga* Miller (Quince) on sexual behaviour of Wistar rats. *Adv Pharma Sci* 2014; **2014**: 282698.

[20] Sykes JT. A description of some quince cultivars from Western Turkey. *Econ Bot* 1972; **26**: 21-31.

[21] Duke JA, Bogenschutz-Godwin MJ, duCelliar J, Duke PA. *Handbook of medicinal herbs*. 2nd ed. Boca Raton: CRC Press; 2002, p. 605.

[22] Postman J, Hummer K, Stover E, Krueger R, Forsline P, Grauke LJ, et al. Fruit and nut genebanks in the U.S. National Plant Germplasm System. *HortScience* 2006; **41**(5): 1188-94.

[23] Seigler DS. Plants of the Northeastern United States that produce cyanogenic compounds. *Econ Bot* 1976; **30**: 395-407.

[24] Tukey HB. Dwarfing rootstocks for the pear. Ch. 11. In: *Dwarfed fruit trees*. New York: Collier Macmillan Ltd; 1964, p. 182-99.

[25] Andrade PB, Carvalho ARF, Seabra RM, Ferreira MA. A previous study of phenolic profiles of quince, pear, and apple purees by HPLC diode array detection for the evaluation of quince puree genuineness. *J Agric Food Chem* 1998; **46**: 968-72.

[26] Prajapati ND, Purohit SS, Sharma AK, Kumar T. *A handbook of medicinal plants*. Jodhpur: Agrobios; 2007; p. 184.

[27] De Tommasi N, De Simone F, Pizza C, Mahmood N. New tetracyclic sesterterpenes from *Cydonia vulgaris*. *J Nat Prod* 1996; **59**: 267-70.

[28] Sharma R, Joshi VK, Rana JC. Nutritional composition and processed products of quince (*Cydonia oblonga* Mill). *Indian J Nat Prod Res* 2011; **2**: 354-7.

[29] Rumpunen K, Kviklys D. Combining ability and patterns of inheritance for plant and fruit traits in Japanese quince (*Chaenomeles japonica*). *Euphytica* 2003; **132**: 139-49.

[30] Schucha MW, Cellinib A, Masiab A, Marino G. Aluminium-induced effects on growth, morphogenesis and oxidative stress reactions in *in vitro* cultures of quince. *Sci hort* 2010; **125**: 151-8.

[31] Amiri ME. The status of genetic resources of deciduous, tropical, and subtropical fruit species in Iran. *Acta Hort* 2008; **769**: 159-67.

[32] Postman J. *Cydonia oblonga*: the unappreciated quince. *Arnoldia* 2009; **67**(1): 2-9.

[33] Patel NC, ShahVN, Mahajan AN, Shah DA. Isolation of mucilage from *Cydonia vulgaris* Pers. seeds and its evaluation as superdisintegrant. *J Appl Pharm Sci* 2011; **1**(4): 110-4.

[34] Bunnag S, Dolcet-Sanjuan R, Mok DW, Mok MC. Responses of two somaclonal variants of quince (*Cydonia oblonga*) to iron deficiency in the greenhouse and field. *J Am Soc Hortic Sci* 1996; **121**: 1054-8.