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(Mini review)

Phytochemical diversity of *Malus baccata*: A mini review

Shaimaa E.A. Elish [1, *], Sherry T.F. Gabrah[1, *]

[1] *Department of Pharmacognosy, Faculty of Pharmacy, Egyptian Russian University, Badr City, Cairo-Suez Road, Cairo 11829, Egypt.*

*Corresponding author(s):

Shaimaa E.A. Elish, E-mail: shaimaa-essam@eru.edu.eg

Sherry T.F. Gabrah, E-mail: sherry-talaat@eru.edu.eg

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ABSTRACT

Malus baccata, commonly known as crab apple, is mostly found in the Kullu, Kinnaur, and Lahaul & Spiti districts of India. The fruit is known locally by the names palanu, sheed palek, and palek. The fruit belongs to the family Rosaceae, and its color is yellowish-green when mature. The fruit ripens in September. The taste of the Fruits ranges from subacid to sweet and has some astringency, and they are usually small in size. They are commonly used as a rootstock for apples. They are cheap, highly nutritious, and possess great therapeutic and medicinal value. The fruit is eaten to prevent diarrhea, constipation, and dysentery in infants. The consumption of apples also diminishes the risk of some cancers, asthma, cardiovascular diseases, and diabetes. Biochemical studies have observed that fruits contain significant amounts of amino and organic acids, fatty acids, sugars, phenolic compounds, and soluble solids. This review aims to present an overview of the Phytochemical composition of *Malus baccata* species.

Keywords: Phytochemicals, Rosaceae; *Malus;* flavonoids; saponins.

1-Introduction

Phytochemicals are natural compounds produced by plants as secondary metabolites. Thousands of these metabolites were identified in plants. Based on phenolic databases such as the phenol explorer database there are around 502 phenolics found in around 452 different foods, which were well documented previously (1). The family Rosaceae is a medium sized family of flowering plants, containing about 81 genera and 4828 species (2) with universal distribution. The family consists of shrubs, herbs, and trees (3), and it produces *palatable* fruits (4). The fruits have morphological diversity, such as fleshy, drupe, pome, dry, and achenetum (5, 6). *Malus* species (apples) are recognized for their phytochemical abundance and are consumed entirely except for seeds. Additionally, apples are the second-highest consumed fruit distributed in the world. Most apple phytochemicals are found in the skin and pulp of the fruit. Wild crab apple fruits are rich with phenolic compounds, including dihydroxy chalcones; phloridizin, phloretin, phenolic acids; gallic acid, chlorogenic acid, coumaric acid, and flavonoids; catechin, and epicatechin (1). *Malus baccata* is the central species in a taxonomically difficult group of small-fruited East Asian crabs. In gardens it makes a round-headed tree with arching lower branches; it has notably early white flowers with a good fragrance, and pea-sized red or yellow fruits (7). Pulp and seeds of crab apple contained various kinds of phenolics including p-coumaric acid, gallic acid, cinnamic acid, caffeic acid, protocatechuic acid, rutin, phloretin, and phloridzin which contributed to antioxidants, possibly so far well detected and quantified (8).

2. Review Methodology

This review was searched in Google Scholar, ScienceDirect, Scopus, and Reaxys databases. The search was accomplished using the keywords "*Malus baccata*", "phytochemical", "chemical compounds" and "chemical composition", considering published papers from 2000 to May 2023.

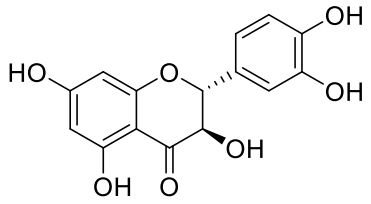
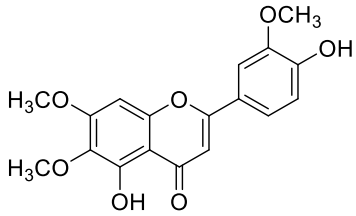
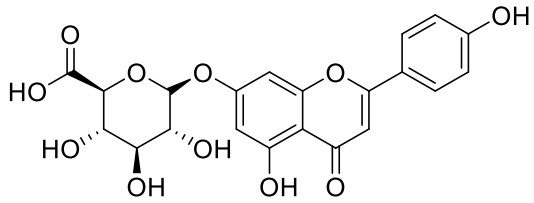
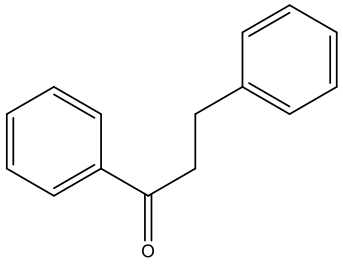
3. Phytochemical constituents of *Malus baccata*

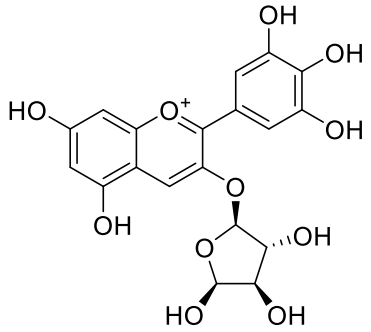
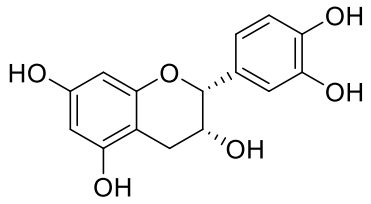
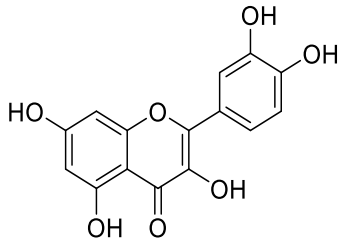
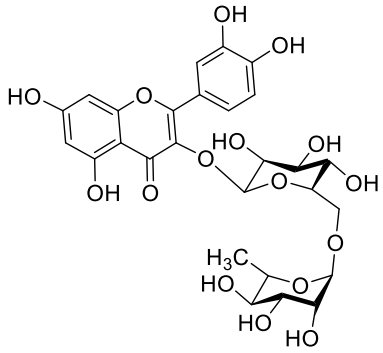
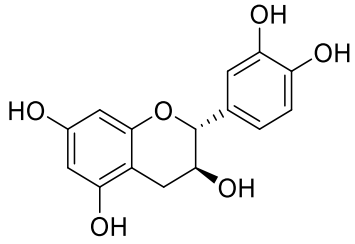
3.1. Flavonoids

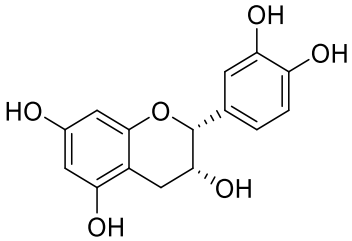
Flavonoids are hydroxylated secondary metabolites, isolated from a wide range of plants, and occur as free aglycones, glycosides, sulfated, or methylated forms (9). More than 8150 different flavonoids have been reported. Flavonoids act in plants as antioxidants, antimicrobials, visual attractors, photoreceptors, and feeding repellents (10). According to their structures, flavonoids are classified into six major classes: flavones, isoflavones, flavan-3-ols, flavanones,

flavonols, and anthocyanins (11). Flavonoids that have been isolated from Malus baccata species are listed in (Table 1).

Table 1. Flavonoids reported from *Malus baccata*

Compound	Part	Methods	Reference
 Dihydroquercetin	Pulp and skin	UHPLC-QTOF-IMS	(1)
 Cirsilineol			
 Apigenin-7-O-glucuronide			
 Dihydrochalcone			

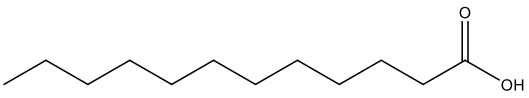
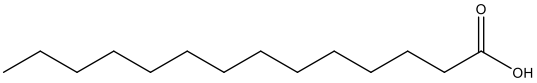
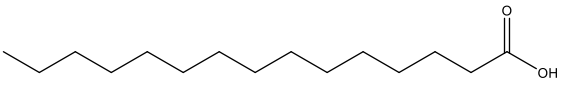
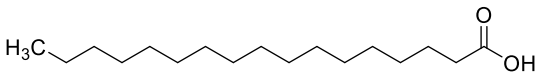
 Delphinidin-3-O-xyloside			
 Procyanidins	Fruit	UPLC and HPLC	(12)
 Quercetin	Pulp and skin	UHPLC-QTOF-IMS	(1, 12)
 Rutin	Pulp and skin	UHPLC-QTOF-IMS, UPLC and HPLC	(1, 8)
	Pulp and skin	UHPLC-QTOF-IMS	(1)

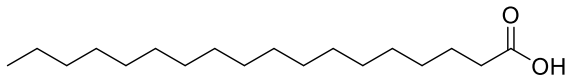
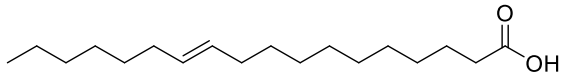
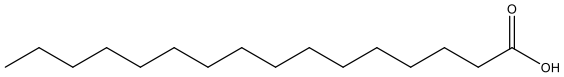
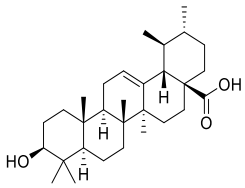
Catechin			
 Epicatechin	Pulp and skin	UHPLC-QTOF-IMS	(1)

3.2. Fatty acids

Fatty acids are carbon chains with a methyl group free and, as part of complex lipids, play several important roles in metabolism (13). The antifungal and bactericidal properties of fatty acids are well known. Fatty acids occur mainly in bound form in plants, esterified to glycerol, as fats or lipids. Fatty acids from several plants showed interesting antibacterial activity. They are used therapeutically in topical treatments for bacterial or fungal diseases (14). Fatty acids that have been isolated from Malus baccata species are listed in (Table 2).

Table 2. Fatty acids reported from *Malus baccata*

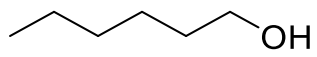
Compound	**Part**	**Methods**	**Reference**
 Lauric acid	Fruit	GC-MS	(15)
 Myristic acid			
 Pentadecanoic acid			
 Margaric acid			

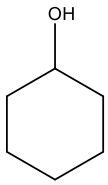
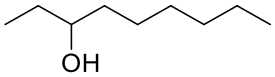
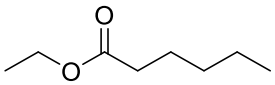
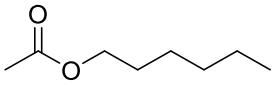
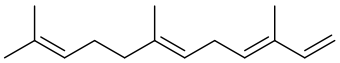
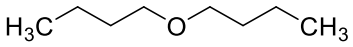
 Stearic acid			
 Vaccenic acid			
 Palmitic acid			(8, 15)
 Ursolic acid			

3.3. Volatile compounds

Volatile compounds are one of the most important secondary metabolites produced by plants. They are compounds that have high vapor pressures at room temperature and low molecular weight. More than 1700 volatile compounds have been identified in different species, including a total of 90 families and 38 orders. They are released from fruits, flowers, leaves, stems, and even roots. Floral volatile compounds are involved in plant defense against herbivores and protection from pathogens. Plant volatile compounds have an important effect on plant-pollinator, plant-plant, plant-herbivore, and other interactions. They play a crucial role in plant evolution and climatic adaptation (16). Moreover, they have different therapeutic activities, such as anti-inflammatory, hypolipidemic, neuroprotective, anti-cancer, anti-oxidative, and anti-asthmatic effects (17). Volatile compounds that have been isolated from Malus baccata species are listed in (Table 3).

Table 3. Volatile compounds reported from *Malus baccata*

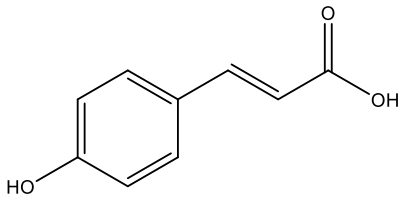
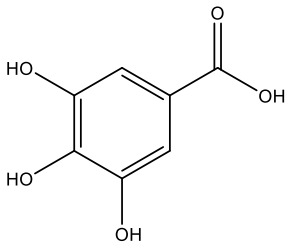
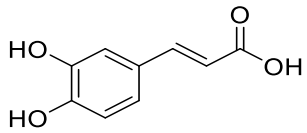
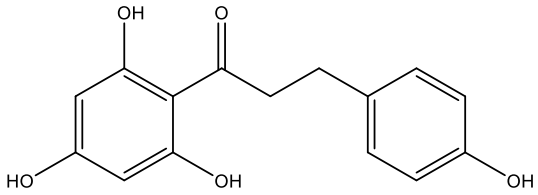
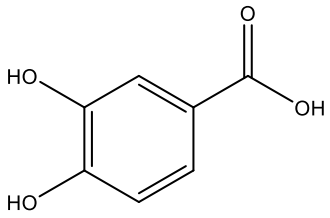
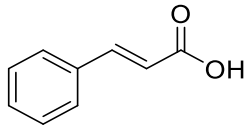
Compound	**Part**	**Methods**	**Reference**
 1-Hexanol	Fruit	GC-MS	(18)

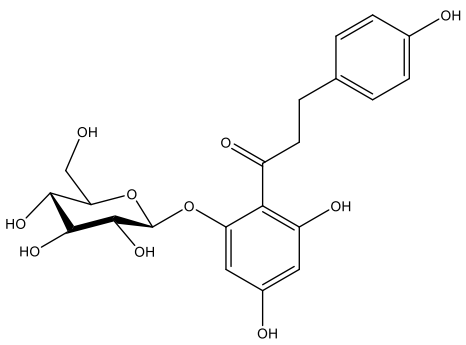
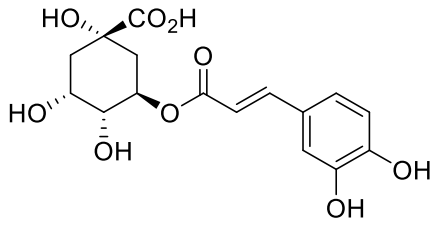
 Cyclohexanol			
 3-Nonanol			
 Ethyl hexanoate			
 Hexyl acetate			
 *α*-Farnesene			
 Di-n-butyl ether			

3.4. Phenolic acids

Phenolic acids are secondary metabolites widely distributed across the plant kingdom. They are a subclass of the larger phenolic category. They are compounds consisting of a phenolic ring and at least one organic carboxylic acid function, occurring in food plants as glycosides or esters conjugated with other compounds such as alcohols, flavonoids, sterols, hydroxy fatty acids, and glucosides. Phenolic compounds in many plants are polymerized into larger molecules such as proanthocyanidins (condensed tannins) and lignins. Fruits and vegetables have unique tastes, flavors, and health-promoting properties due to the presence of phenolic compounds. They have antioxidant properties that cause free radical scavenging, anti-aging, and can reduce the risk of cancer (19, 20). Phenolic acids that have been isolated from Malus baccata species are listed in (Table 4).

Table 4. Phenolic acids reported from *Malus baccata*

Compound	**Part**	**Methods**	**Reference**
 *p*-coumaric acid	Pulp and seeds	UHPLC-QTOF-IMS, UPLC and HPLC)	(1, 8)
 Gallic acid			
 Caffeic acid			
 Phloretin			
 Protocatechuic acid			
 Cinnamic acid	Pulp and seeds	UPLC and HPLC	(8)

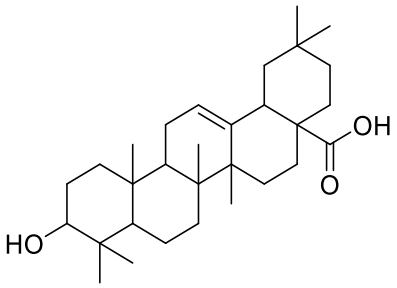
 Phloridzin	Pulp, skin, and seeds	UHPLC-QTOF-IMS, UPLC and HPLC	(1, 8, 12)
 Chlorogenic acid	Pulp, skin, and seeds	UHPLC-QTOF-IMS	(1, 12)

3.5. Saponins

Saponins are a diversified group of compounds abundant in the plant kingdom. Saponins are classified either as steroids or triterpenoids according to the aglycone skeleton present in their structure, attached to one or more sugar moieties (21). Their structural diversification is reflected in their biological and physicochemical properties, which are exploited in a few traditional (such as fish poison, soaps, and molluscicides) and industrial applications. Triterpenoids are one of the most structurally diverse groups of natural products. They play a wide variety of critical roles in the maintenance of cell membrane structure, biological defense, signal transduction, and ecological interactions. They are generated by the cyclization of two common linear C30 isoprenoid precursors, squalene and oxidosqualene (22). Saponins and their aglycons that have been isolated from Malus baccata species are listed in (Table 5).

Table 5. Saponins reported from *Malus baccata*

Compound	**Part**	**Methods**	**Reference**

 Oleanolic acid	Fruit	GC-MS	(15)

4. Conclusion

Malus baccata species have attracted the attention of several scientists due to their beneficial properties for human health. *Malus baccata* fruits, pulp, skin, and seeds are rich with diverse classes of valuable compounds such as flavonoids, saponins, terpenes, phenolic acids, fatty acids, and volatile compounds. *Malus baccata* species possess several biological activities, such as an antioxidant effect, an anti-inflammatory effect, and antifungal activity. This review introduces the *Malus baccata* species as a good source of bioactive metabolites with high health benefits for pharmaceutical formulation.

- **Conflict of Interest**

The authors declare no conflict of interest.

5. References

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