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REVIEW ARTICLE

RECORDS OF PHARMACEUTICAL AND BIOMEDICAL SCIENCES

Chemistry of Mandarin *Citrus reticulata*

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Abstract

Nature remains a valuable source for many phytochemicals that provide different physiological activities. *Citrus reticulata* (Rutaceae) or Mandarin is a widespread plant used worldwide in food, beverages, perfumes, and folk medicine, including cancer prevention, flu treatment, inflammation, and generally in body healing and strengthening. *Citrus reticulata* have also been used for treating indigestion, bronchitis and asthma. Phytochemical investigation of the Citrus genus has revealed the existence of a broad range of bioactive compounds, including flavonoids, flavonoid glycosides, sterols, fatty acids, and alkaloids, along with many other miscellaneous compounds. Among these diverse bioactive compounds, flavonoids (e.g., polymethoxylated flavones, glycosylated flavanones, flavonoids and limonoids), were found to be the largest group of phytochemicals in the Citrus genus. These flavonoids have been reported to have antioxidant, anti-inflammatory, anti-allergic, anti-atherogenic, anti-proliferative, antibacterial, antiviral, and antifungal activities. Additionally, they have a role in preventing atherosclerosis as they reduce total blood cholesterol, showing also anti-hypertensive, hypolipidaemic, diuretic and analgesic properties. This review study summarizes the secondary metabolites identified in *Citrus reticulata* (Rutaceae) or Mandarin.

Keywords: *Citrus reticulata*, mandarin, *Secondary metabolites*, flavonoids.

1. Introduction

Nature remains a valuable source for many phytochemicals that provide different physiological activities. More than 40% of newly approved medications have been made up of these natural compounds. Even now, a wide range of chemical structures found in nature remain unapproachable to highly engineered synthetic standards. Additionally, the introduction of unique therapeutic modalities by natural products has aided in the development of pioneering biochemical approaches **(Ibrahim, Abdelhameed, Habib, & Badr, 2021)**.

Citrus reticulata (Rutaceae) or Mandarin is native to China and was introduced to Africa between the 15th and 19th centuries **(Ramon-Laca, 2003).** Since then, Citrus has been used as food, folk medicine, beverages, and perfumes **(Han, Kim, Lee, Mok, & Lee, 2010; Marín, Soler-Rivas, Benavente-García, Castillo, & Pérez-Alvarez, 2007).**

Citrus species are now used in traditional medicine all over the world for a variety of ailments, such as prevention of cancer, flu treatment, inflammation, and generally in body healing and strengthening.

As a result, their pharmacological potential has been extensively studied in recent decades, leading to hundreds of publications **(Tahsin et al., 2017)**.

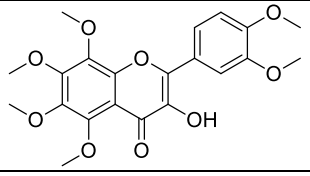
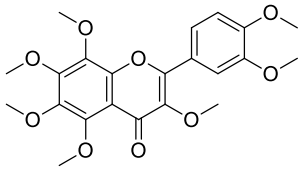
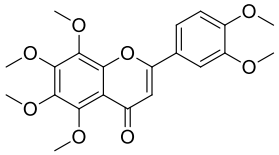
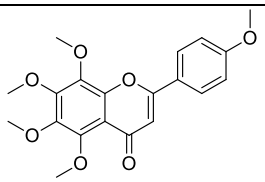
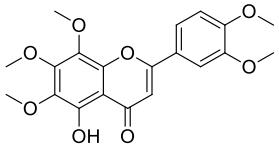
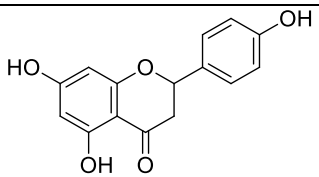
Numerous diverse secondary metabolites were identified from Citrus genus, including flavonoids, flavonoid glycosides, alkaloids, limonoids, sterols and fatty acids, in addition to its essential oil **(Ye, Xu, & Li, 2022; Zheng et al., 2020)**.

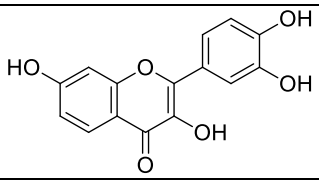
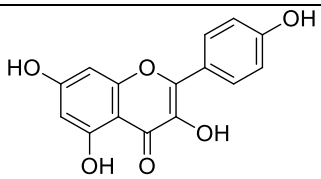
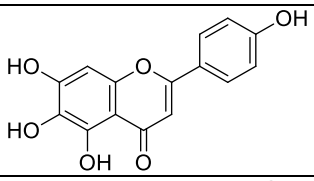
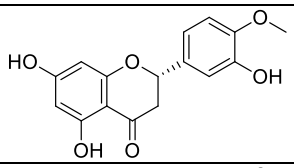
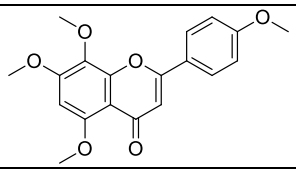
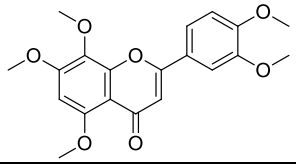
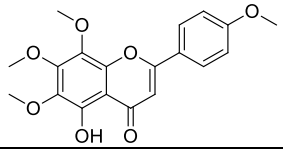
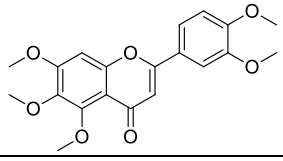
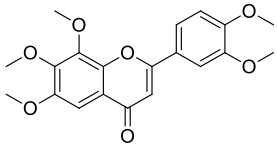
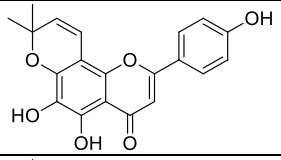
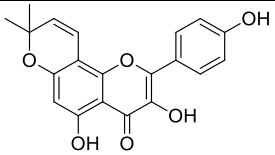
Among these diverse bioactive compounds, flavonoids were the largest number of components in the Citrus genus.

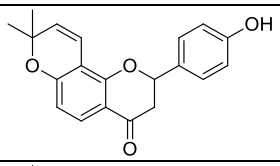
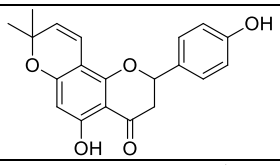
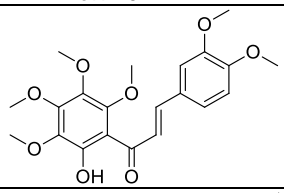
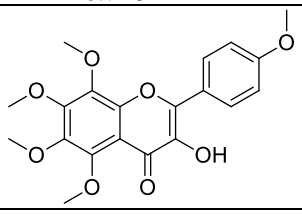
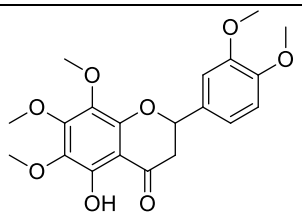
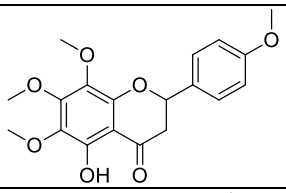
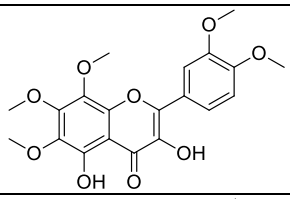
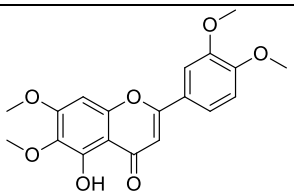
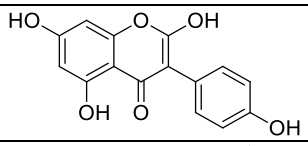
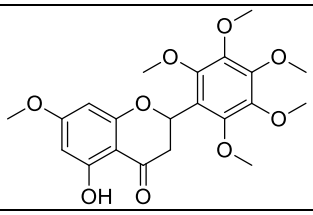
In our ongoing investigation of the medical potential of *Citrus reticulata* (Mandarin), Most of the compounds isolated from the plant were collected and summarized in this study.

2. Chemical constituents reported from some species of the genus *Citrus*:

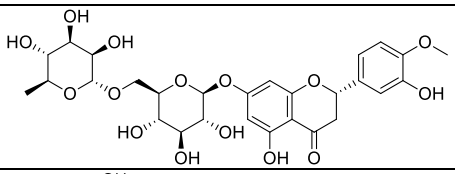
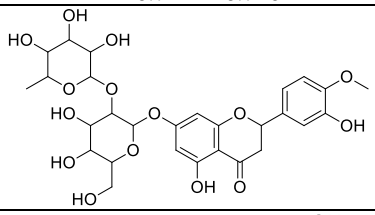
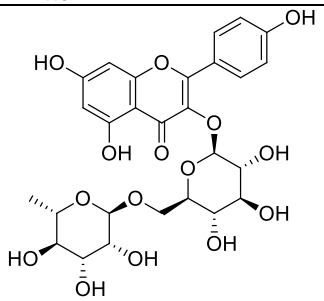
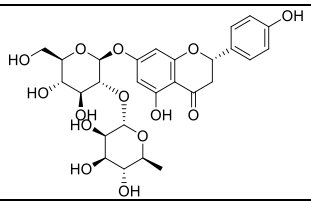
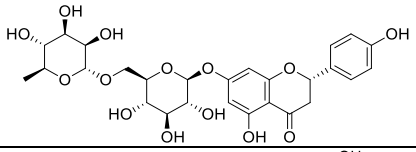
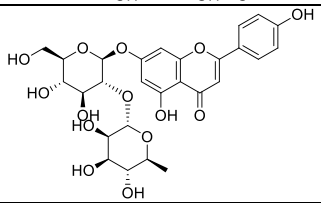
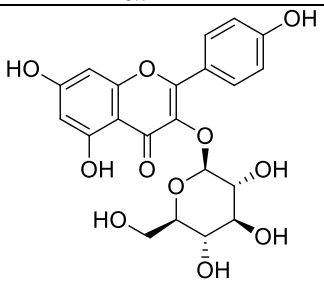
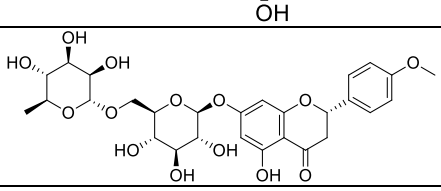
2.1. Flavonoids:

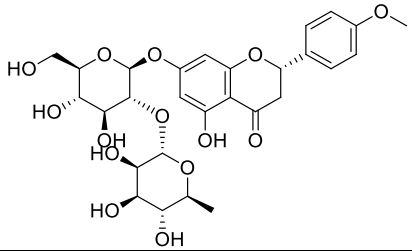
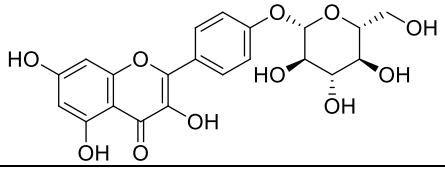
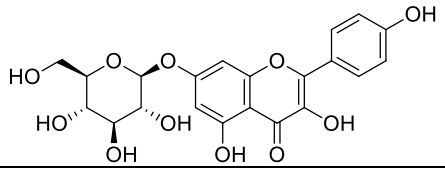
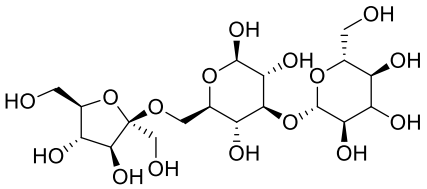
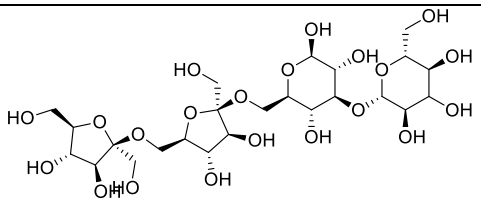
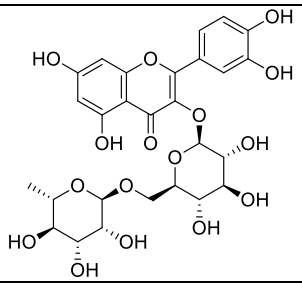
Species	Compound Name	Compound Structure	Reference
Citrus reticulata	Natsudaidai		**(Qian & Chen, 1998; Ye et al., 2022)**
Citrus reticulata	3, 5, 6, 7, 8, 3', 4'-heptamethoxyflavone		**(Qian & Chen, 1998; X. Wang et al., 2005; Zheng et al., 2020)**
Citrus reticulata	Nobiletin		**(Guo, Wang, Guo, & Chen, 2000; Qian & Chen, 1998; X. Wang et al., 2005; Zheng et al., 2020)**
Citrus reticulata	Tangeretin [5,6,7,8,4' -pentamethoxyflavone]		**(Guo et al., 2000; X. Wang et al., 2005; Zheng et al., 2020)**
Citrus reticulata	Desmethylnobiletin [5-hydroxy- 6,7,8,3',4' -pentamethoxyflavone]		**(Jayaprakasha, Negi, Sikder, Mohanrao, & Sakariah, 2000; X. Wang et al., 2005; Zheng et al., 2020)**
Citrus reticulata	Naringenin		**(Zheng et al., 2020)**

Citrus reticulata	Fisetin		**(Zheng et al., 2020)**
Citrus reticulata	Kaempferol		**(Al-Warhi et al., 2022; Zheng et al., 2020)**
Citrus reticulata	Scutellarein		**(Zheng et al., 2020)**
Citrus reticulata	Hesperetin		**(Al-Warhi et al., 2022; Zheng et al., 2020)**
Citrus reticulata	6-Demethoxytangeretin		**(Zheng et al., 2020)**
Citrus reticulata	Isosinensetin		**(Zheng et al., 2020)**
Citrus reticulata	5-hydroxy-6,7,8,4′-tetramethoxyflavone		**(Duan et al., 2017; Ye et al., 2022)**
Citrus reticulata	5,6,7,3′,4′-pentamethoxyflavanone		**(Duan et al., 2017)**
Citrus reticulata	6,7,8,3′,4′-pentamethoxyflavanone		**(Duan et al., 2017)**
Citrus reticulata	5,6,4′-trihydroxypyranoflavone		**(Ye et al., 2022)**
Citrus reticulata	Citrusinol		**(Ye et al., 2022)**

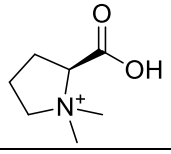
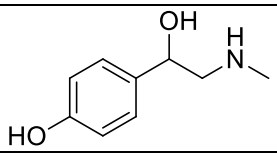
Citrus reticulata	4′-hydroxyisolonchocarpin		**(Ye et al., 2022)**
Citrus reticulata	Citflavanone		**(Ye et al., 2022)**
Citrus reticulata	Chalcone		**(Ye et al., 2022)**
Citrus reticulata	3-hydroxytangeretin		**(Ye et al., 2022)**
Citrus reticulata	5-hydroxy-6,7,8,3′,4′-pentamethoxyflavanone		**(Ye et al., 2022)**
Citrus reticulata	5-hydroxy-6,7,8,4′-tetramethoxyflavanone		**(Ye et al., 2022)**
Citrus reticulata	Sudachitin		**(Ye et al., 2022)**
Citrus reticulata	Sinensetin		**(Ye et al., 2022)**
Citrus reticulata	2-hydroxygenistein		**(Al-Warhi et al., 2022)**
Citrus reticulata	5-hydroxy-7,2′,3′,4′,5′,6′-hexamethoxyflavanone		**(Chen et al., 2021)**

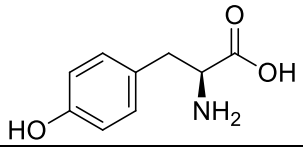
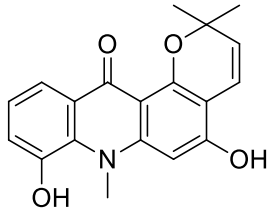
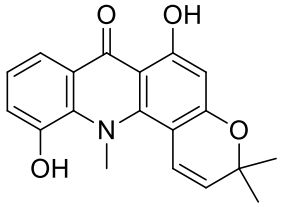
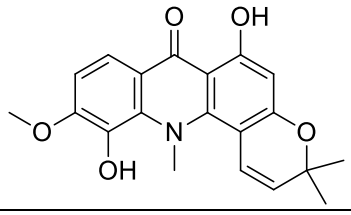
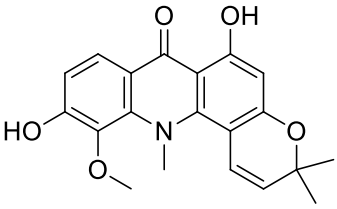
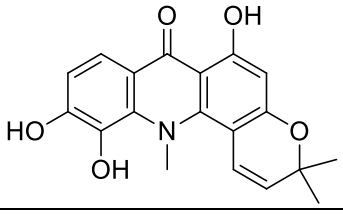
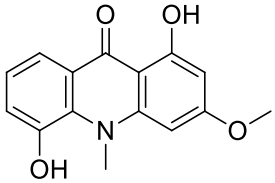
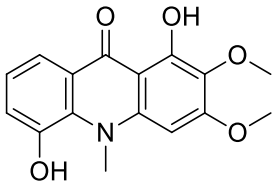
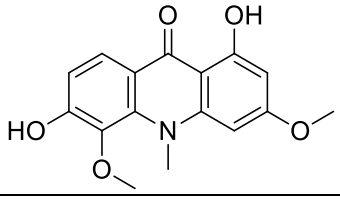
2.2. Flavonoid glycosides:

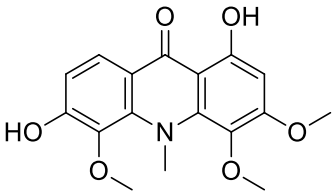
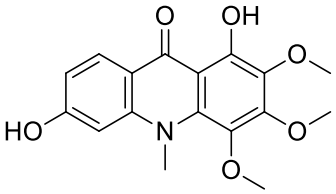
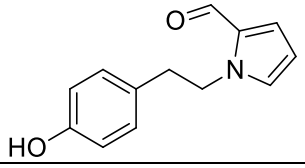
Species	Compound Name	Compound Structure	Reference
Citrus reticulata	Hesperidin		**(Guo et al., 2000; Zheng et al., 2020)**
Citrus reticulata	Neohesperidin		**(Guo et al., 2000; Zheng et al., 2020)**
Citrus reticulata	kaempferol-3-*O*-rutinoside		**(Zheng et al., 2020)**
Citrus reticulata	Naringin		**(Zheng et al., 2020)**
Citrus reticulata	Narirutin		**(Zheng et al., 2020)**
Citrus reticulata	Rhoifolin		**(Zheng et al., 2020)**
Citrus reticulata	Astragalin		**(Zheng et al., 2020)**
Citrus reticulata	Didymin		**(Zheng et al., 2020)**

Citrus reticulata	Poncirin		**(Zheng et al., 2020)**
Citrus reticulata	kaempferol-4′-*O*-*β*-*D*-glucopyranoside		**(Al-Warhi et al., 2022)**
Citrus reticulata	kaempferol-7-*O*-*β*-*D*-glucopyranoside		**(Al-Warhi et al., 2022)**
Citrus reticulata	3‴ (1‴-*O*-*β*-*D*-glucopyranosyl)-sucrose		**(Al-Warhi et al., 2022)**
Citrus reticulata	6(1‴-*O*-*β*-*D*-fructofuranosyl)-3′ (1″-*O*-*β*-*D*-glucopyranosyl)-sucrose		**(Al-Warhi et al., 2022)**
Citrus sinensis	Rutin		**(Raza & Shahwar, 2013)**

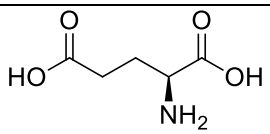
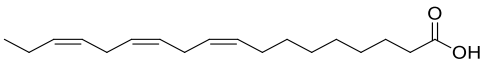
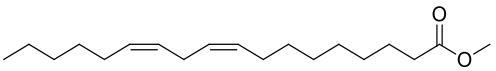
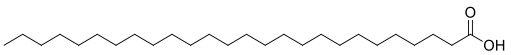
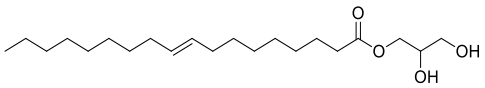
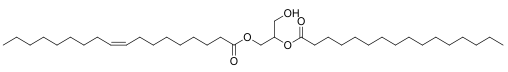
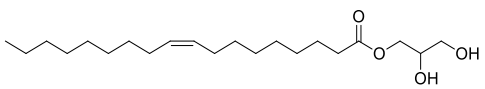
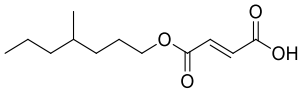
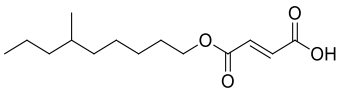
2.3. Alkaloids:

Species	Compound Name	Compound Structure	Reference
Citrus reticulata	Stachydrine		**(Zheng et al., 2020)**
Citrus reticulata	Synephrine		**(Zheng et al., 2020)**

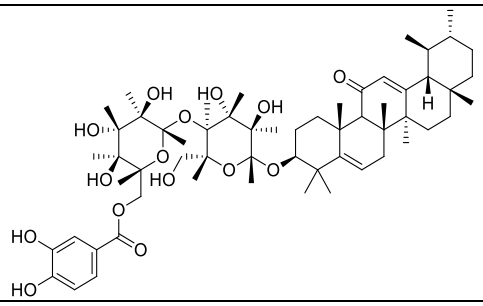
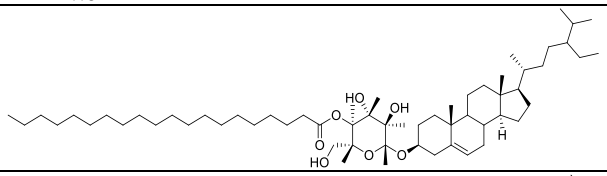
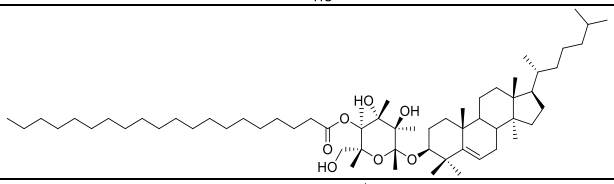
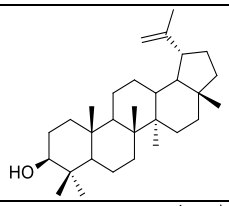
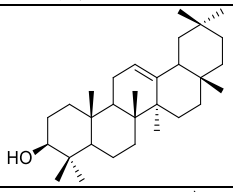
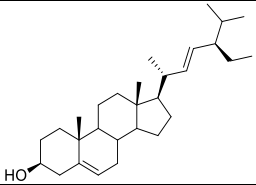
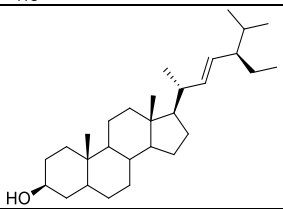
Citrus reticulata	Tyrosine		**(Zheng et al., 2020)**
Citrus reticulata	Reticarcidone A		**(Ye et al., 2022)**
Citrus reticulata	5-hydroxynoracronycin		**(Ye et al., 2022)**
Citrus reticulata	Citracridone-II		**(Ye et al., 2022)**
Citrus reticulata	Citracridone-I		**(Ye et al., 2022)**
Citrus reticulata	Citracridone-III		**(Ye et al., 2022)**
Citrus reticulata	Citrusamine		**(Ye et al., 2022)**
Citrus reticulata	5-hydroxyarboriarborine		**(Ye et al., 2022)**
Citrus reticulata	Citpressine-I		**(Ye et al., 2022)**

Citrus reticulata	Glycofolinine		**(Ye et al., 2022)**
Citrus reticulata	1,6-dihydroxy-2,3,4-trimethoxy-9(10H)-acridone		**(Ye et al., 2022)**
Citrus reticulata	Reticine A [1-(4-hydroxyphenethyl)-1*H*-pyrrole-2-carbaldehyde]		**(D. Wang, Liu, Ma, Feng, & Yan, 2021)**

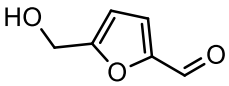
2.4. Fatty Acids:

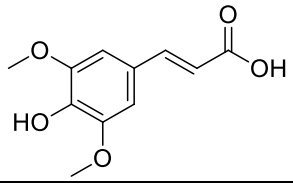
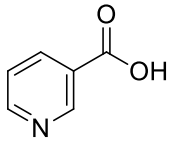
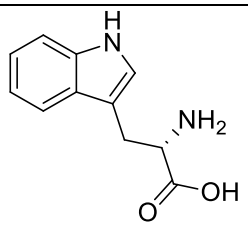
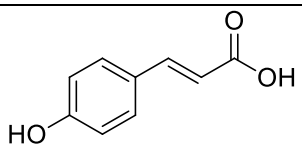
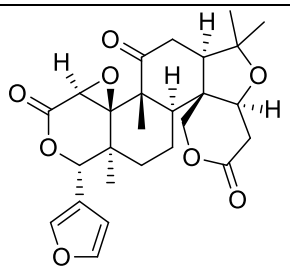
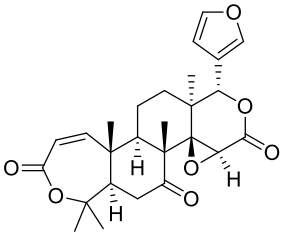
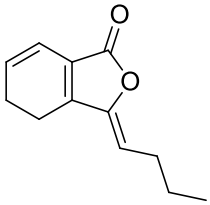
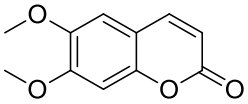
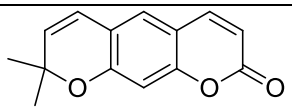
Species	Compound Name	Compound Structure	Reference
Citrus reticulata	Glutamic acid		**(Zheng et al., 2020)**
Citrus reticulata	linolenic acid		**(Zheng et al., 2020)**
Citrus reticulata	Methyl Linoleate		**(Zheng et al., 2020)**
Citrus reticulata	*n*-hexacosanoic acid		**(Khan, Ali, & Alam, 2010)**
Citrus reticulata	1-*O*-elaidoyl-glycerol		**(Al-Warhi et al., 2022)**
Citrus reticulata	1-*O*-oleoyl-2-palmitoyl-glycerol		**(Al-Warhi et al., 2022)**
Citrus reticulata	1-*O*-oleoyl-glycerol		**(Al-Warhi et al., 2022)**
Citrus reticulata	(*E*)-3-((4-methylheptyloxy)carbonyl)acrylic acid		**(Al-Warhi et al., 2022)**
Citrus reticulata	(E)-3-((6-methylnonyloxy)carbonyl)acrylic acid		**(Al-Warhi et al., 2022)**

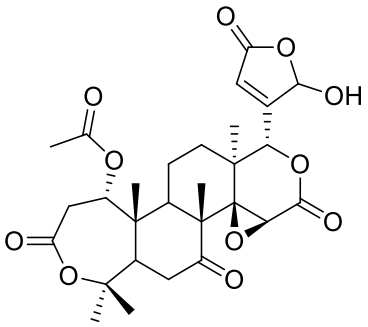
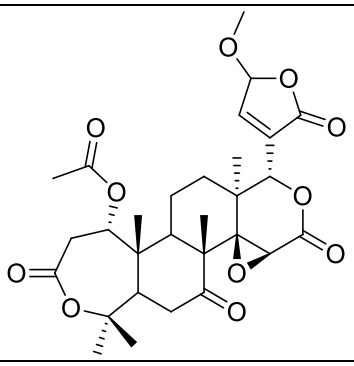
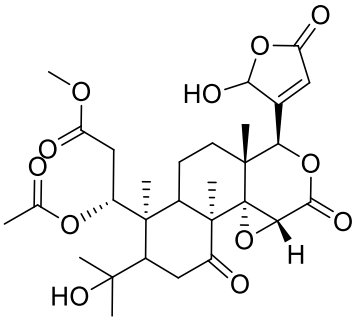
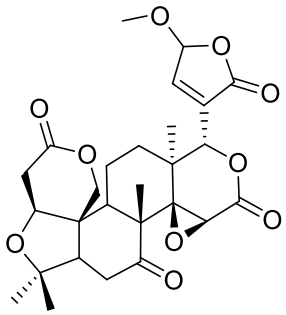
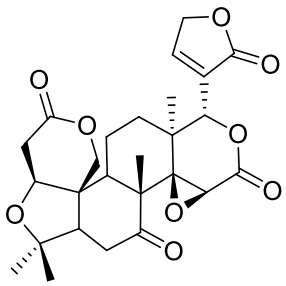
2.5. Sterols and steroids:

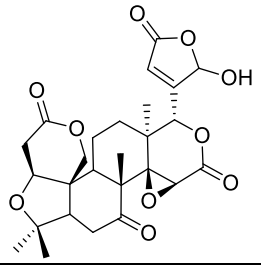
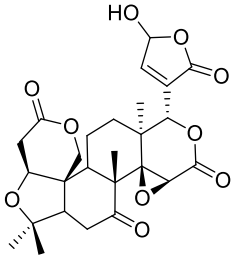
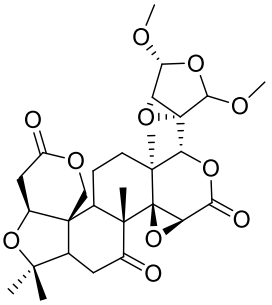
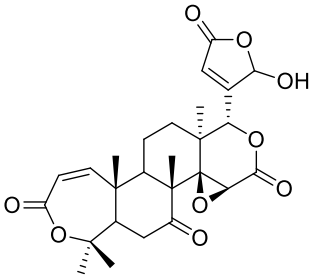
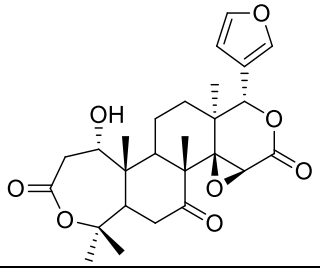
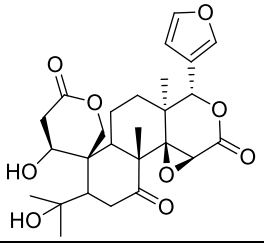
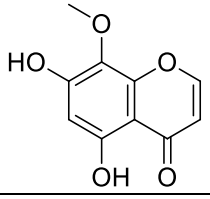
Species	Compound Name	Compound Structure	Reference
Citrus reticulata	Reticulataursenoside		**(Khan et al., 2010)**
Citrus reticulata	Citrusteryl arachidate		**(Khan et al., 2010)**
Citrus reticulata	Citruslanosteroside		**(Khan et al., 2010)**
Citrus reticulata	Lupeol		**(Tahsin et al., 2017)**
Citrus reticulata	*β*-amyrin		**(Tahsin et al., 2017)**
Citrus reticulata	Stigmasterol		**(Tahsin et al., 2017)**
Citrus reticulata	*β*-sitosterol		**(Al-Warhi et al., 2022; Tahsin et al., 2017)**

2.6. Miscellaneous compounds:

Species	Compound Name	Compound Structure	Reference
Citrus reticulata	5-Hydroxymethylfurfural		**(Zheng et al., 2020)**

Citrus reticulata	Sinapic acid		**(Zheng et al., 2020)**
Citrus reticulata	Nicotinic acid		**(Zheng et al., 2020)**
Citrus reticulata	Tryptophan		**(Zheng et al., 2020)**
Citrus reticulata	*P*-Coumaric acid		**(Zheng et al., 2020)**
Citrus reticulata	Limonin		**(Kikuchi et al., 2017; Zheng et al., 2020)**
Citrus reticulata	Obacunone		**(Zheng et al., 2020)**
Citrus reticulata	Ligustilide		**(Zheng et al., 2020)**
Citrus reticulata	Scoparone		**(Tahsin et al., 2017)**
Citrus reticulata	Xanthyletin		**(Tahsin et al., 2017)**

Citrus reticulata	21,23-Dihydro-21-hydroxy-23-oxonomilin		**(Kikuchi et al., 2017)**
Citrus reticulata	21,23-dihydro-23-methoxy-21-oxonomilin		**(Kikuchi et al., 2017)**
Citrus reticulata	21,23-dihydro-21-hydroxy-23-oxonomilinic acid methyl ester		**(Kikuchi et al., 2017)**
Citrus reticulata	21,23-dihydro-23-methoxy-21-oxolimonin		**(Kikuchi et al., 2017)**
Citrus reticulata	21,23-Dihydro-21-oxolimonin		**(Kikuchi et al., 2017)**

Citrus reticulata	Shihulimonin A		**(Kikuchi et al., 2017)**
Citrus reticulata	Limonexic acid		**(Kikuchi et al., 2017)**
Citrus reticulata	Evolimorutanin		**(Kikuchi et al., 2017)**
Citrus reticulata	Kihadanin A		**(Kikuchi et al., 2017)**
Citrus reticulata	Deacetylnomilin		**(Kikuchi et al., 2017)**
Citrus reticulata	Ichangin		**(Kikuchi et al., 2017)**
Citrus reticulata	5,7-dihydroxy-8-methoxychromone		**(Lin et al., 2016)**

3. Conclusion:

Mandarin (*Citrus reticulata*) exhibited the existence of diverse bioactive compounds, including flavonoids, flavonoid glycosides, sterols, fatty acids, and alkaloids, along with many other Miscellaneous compounds. This review study summarized the secondary metabolites reported in the Mandrin (*Citrus sp.)*.

4. References:

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