REVIEW
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The Presence of Flavonoids in Some Products and Fruits of the Genus *Eugenia*: An Integrative Review

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The Myrtaceae family, one of the most prominent botanical families, is represented in Brazil with different fruit species, rich in bioactive compounds and gastronomically appreciated. This study aimed to carry out an integrative review on the genus *Eugenia*, highlighting the pitangueira (*E. uniflora* L.), cagaiteira (*E. dysenterica*), grumixameira (*E. brasiliensis*), pereira (*E. klotzschiana* O. Berg), and uvaieira (*E. pyriformis* Cambess) and which flavonoids are present in these fruits. Articles published between 2016 and 2021 were selected from the following databases: Google Scholar, Periódicos CAPES, Scielo, and Science Direct. According to each database, the descriptors used as a search strategy addressed the popular and scientific names of the five selected species, associated or not with the term "flavonoid," according to each database. The results showed that quercetin was the main flavonoid identified in the fruits, and the principal extraction method used was HPLC. Other interesting compounds, such as catechin, epicatechin, rutin, myricetin, and kaempferol, were also found. However, the amount and type of flavonoids detected varied according to the applied methodology. Hence, these studies highlight the importance of species of the genus *Eugenia*, which promotes beneficial health effects and possible applicability to the food and pharmaceutical industry.

Keywords: bioactive compounds, myrtaceae, *Eugenia dysenterica*, *Eugenia brasiliensis*, *Eugenia klotzschiana*, *Eugenia uniflora*, *Eugenia pyriformis*

INTRODUCTION

Brazil is recognized worldwide for its sizeable territorial extension and its rich biodiversity of plants filling its distinct and harmonious biomes, which sometimes diverge, sometimes converge in various forms. Among the rich diversity of Brazilian flora, the *Myrtaceae* family, one of the most prominent botanical families, is characterized by 132 genera and 5,671 species in Brazil (Lucena et al., 2014), and have species-rich in bioactive compounds and gastronomically appreciated (Veloso, 2015). Among the species of the Myrtaceae family, the genus *Eugenia*, which represents a third of its species, is widely distributed across the country with their diversity and frequency of occurrence (Romagnolo and Souza, 2006).

The Brazilian species of *Myrtaceae* comprise several arboreal and shrub plants that, due to the quality of their fruits, can be used to produce fruits for fresh consumption or industrial process, in the

FIGURE 1 | Pitanga (*Eugenia uniflora* L.). Source: Illustration made by the Ribeiro, L. V. (2022).

FIGURE 2 | Cagaita (*Eugenia dysenterica*). Source: Illustration made by the Ribeiro, L. V. (2022).

production of pharmaceuticals, and in urban afforestation (Delgado and Barbedo, 2007). They occur mainly in tropical and subtropical regions of the world, often being one of the dominant families in the Brazilian Atlantic Forest (Stefanello et al., 2011).

The genus *Eugenia*, with more than a hundred species, comprises some natives of Brazil e with great economic importance, such as *E. brasiliensis* (grumixameira), *E. pyriformis* C. (uvaieira), *E. uniflora* L. (pitangueira), *E. dysenterica* (cagaiteira), *E. klotzchiana* O. Berg (cerrado's pereira). These species produce fleshy, yellow, and red fruits (Lamarca et al., 2011). A characteristic of this genus is the low number of seeds in its fruits, which makes it challenging to plant large areas to produce on a commercial scale (Scalon et al., 2012; Filho, 2021).

Many species of *Eugenia* are also rich in essential oils and tannins and are frequently used in folk medicine (Lunardi et al., 2001). In addition to being food sources for both fauna and industrial processing, these species generate extra income for rural families. They can be used in urban and rural ornamentation and afforestation, woods, gardens, botanical gardens, and projects for inclusion and reforestation of degraded areas (Scalon et al., 2012; Filho, 2021).

A pitangueira (*Eugenia uniflora* L.) (**Figure 1**) has a sweet and sour flavor with an intense aroma. The fruit is a berry of approximately 30 mm in diameter, flattened at the ends and with eight to ten longitudinal grooves (Pimentel Gomes, 2007; Celli, 2011). With maturation, the epicarp develops from green to red or almost black. Its leaves are popularly used for their diuretic, astringent, antipyretic effects, and the treatment of digestive disorders (Fiuza et al., 2008; Celli, 2011). It is composed, on average, of 77% pulp and 23% seed, being rich in calcium, phosphorus, flavonoids, carotenoids, and vitamin C, which indicates its high antioxidant power (Silva, 2006; Celli, 2011; Silva S. P. et al., 2021).

FIGURE 3 | Grumixama (*Eugenia brasiliensis*). Source: Illustration made by the Ribeiro, L. V. (2022).

Eugenia dysenterica (**Figure 2**) is a fruit plant native to the Cerrado biome, popularly known as cagaiteira (Bueno et al., 2017). The fruit has laxative properties, is widely used for medicinal purposes, and is appreciated in natura form. It produces a yellow, globular, and flattened fruit with an acidic flavored pulp (Bueno et al., 2017; Guedes et al., 2017; Rodrigues D. B. et al., 2021; Silva P. R. D. et al., 2021). Green and ripe fruits of cagaita are rich in phenolic compounds such as gallic acid, caffeic acid, *p*-coumaric acid, and quercetin. In addition to its mineral content, it makes the fruit a promising source of bioactive compounds, with antioxidant, anti-obesity, and nutritive action (Bueno et al., 2017; Guedes et al., 2017; Silva P. R. D. et al., 2021).

FIGURE 4 | Pêra do Cerrado (*Eugenia klotzschiana*). Source: Illustration made by the Ribeiro, L. V. (2022).

FIGURE 5 | Uvaia (*Eugenia pyriformis* Cambes). Source: Illustration made by the Ribeiro, L. V. (2022).

Eugenia brasiliensis (**Figure 3**), commonly known as grumixameira, comes from trees that grow in Brazilian rainforests. The grumixama is a cherry-like fruit, approximately 2.0 cm in diameter, containing one or several seeds, and is slightly sweet. The purple variety is the most common and is known as the Brazilian cherry (Flores et al., 2012). This plant has economic potential due to its composition's attractive sensory attributes and phenolic compounds, including ellagitannins and flavonoids (Abe et al., 2012). In general, the fruits of this family are known to be good sources of bioactive compounds (Fracassetti et al., 2013). The purple grumixama fruit was rich in anthocyanins, mainly cyanidin-3-glycoside, and carotenoids, mainly monohydroxy carotenoids, such as all-trans-β-cryptoxanthin (Silva et al., 2014).

Eugenia klotzschiana Berg is a tree native to the Cerrado, known as the pereira do Cerrado, which is very little explored (Xavier Mariano et al., 2020). Characterized by a bushy tree, measuring 1–2 m in height, the ripe fruits vary in size from six to 10 cm in length by four to 7 cm in diameter. The fruits have velvety characteristics, thin peel of yellow color when ripe and soft pulp with a certain astringency and acid flavor (Carneiro, 2015).

Regarding the consumption of *E. klotzschiana* fruits (**Figure 4**) in *natura*, knowing their maturation stages is essential to establish their shelf-life and post-harvest quality (Carneiro, 2015; Sanches et al., 2021). It has significant nutritional value, including the content of polyphenolic compounds and flavonoids, in addition to a considerable content of ascorbic acid and dietary fiber (Mariano et al., 2022).

Eugenia pyriformis Cambess species (**Figure 5**) is well known for its edible fruits, popularly known as "uvaieira." At botanical community is classified as a medium-sized arboreal species between 5 and 15 m in height, with a rounded and elongated crown. Have solitary white flowers and golden-yellow fruits, being slightly aromatic, fleshy, and

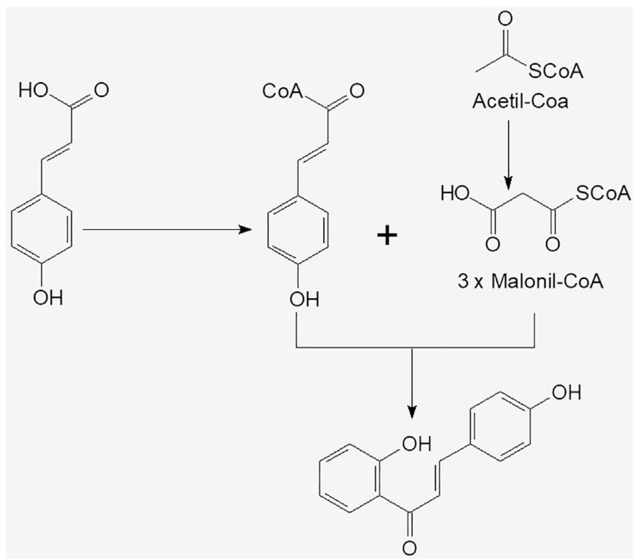


FIGURE 6 | Simplified biosynthetic pathway of flavonoids. Source: Authors (2022).

hairy, with a sweet and slightly acidic flavor in the various stages of maturation (Silva et al., 2015; Filho, 2021). The seeds corresponding to approximately 16% of the total fruit weight (Rodrigues D. B. et al., 2021). Several phenolic compounds were isolated from uvaia, among which are flavonoids (quercetin, kaempferol, and rutin) and phenolic acids (gallic, chlorogenic, and caffeic acids) (Rodrigues L. M. et al., 2021).

Many classes have medicinal and antioxidant properties, characteristics associated with the presence of essential oils and polyphenols, such as tannins and flavonoids, especially anthocyanins (Queiroz et al., 2015). The fruits of *Eugenia*

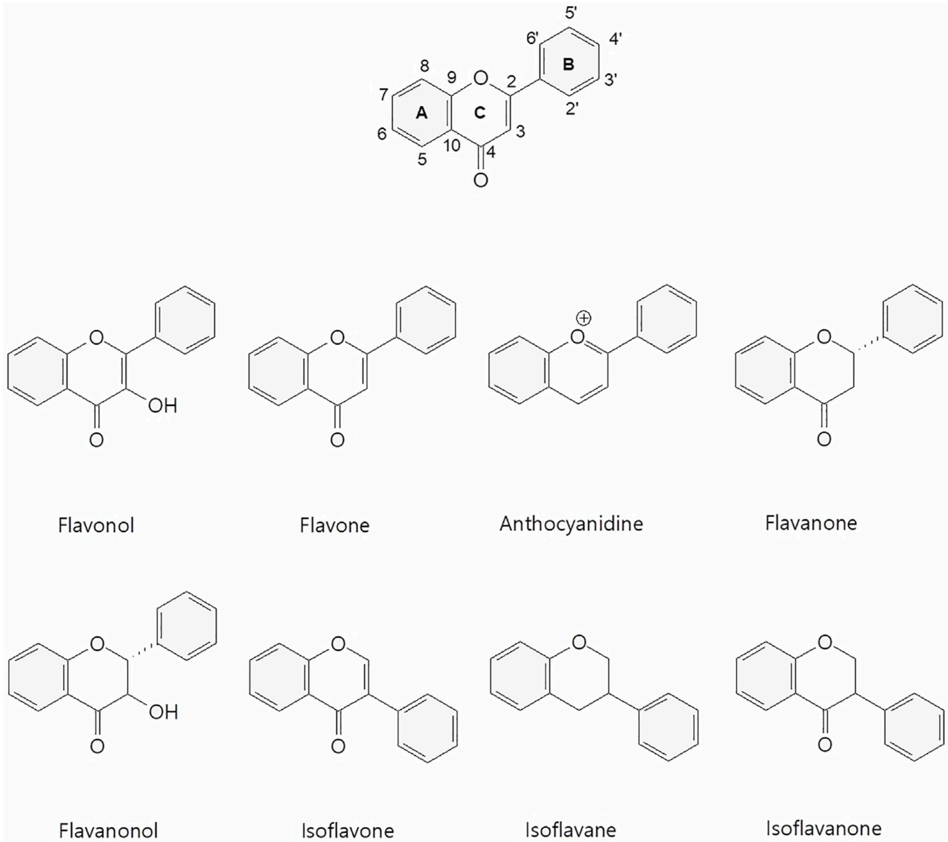


FIGURE 7 | The basic nucleus of some classes of flavonoids. Source: Authors (2022).

species tend to have vibrant colors ranging from yellow to purple, indicating the presence of compounds such as anthocyanins and other phenolic derivatives (Queiroz et al., 2015; Rosa, 2021). The antioxidant activity of these fruits is related to the presence of phenolic compounds (Rosa, 2021). Among the flavonoids, the presence of quercetin, methoxyquercetin, myricetin, and kaempferol stands out (Queiroz et al., 2015).

This group provides fruits much appreciated by Brazilians and others still relatively unknown, such as pitanga (*Eugenia uniflora* L.), cagaita (*Eugenia dysenterica*), grumixama (*Eugenia brasiliensis*), cerrado pear (*Eugenia klotzschiana* O. Berg), and uvaia (*Eugenia pyriformis* Cambess) (Romagnolo and Souza, 2006; Lucena et al., 2014; Veloso, 2015; Helt et al., 2018; Pereira et al., 2020; Ramos et al., 2020; Xavier Mariano et al., 2020; Rodrigues D. B. et al., 2021). These fruits can be consumed fresh or in the form of jellies, jams, and liqueurs (Bueno et al., 2017; Silva et al., 2019; Ramos et al., 2020; Rodrigues D. B. et al., 2021).

Some of the medicinal properties attributed to Eugenics fruits are biological actions that promote beneficial health effects. These are related to antioxidants that come from vitamins, carotenoids, and phenolic compounds such as flavonoids (Helt et al., 2018; Mendonça and Vieites, 2019; Castelucci et al., 2020; Ramos et al., 2020; Sobral - Souza et al., 2020; Rosa, 2021; Silva M. et al., 2021). The term flavonoid was derived from the Latin "*flavus*," which means yellow, and they are essential in the color of flowers. Flavonoids are biosynthesized from the phenylpropanoid route, a mixed route, in which part of the flavonoid skeleton is derived from shikimic acid and the other from acetyl-CoA (Pereira et al., 2016) (**Figure 6**).

Flavonoids make up a large part of phenolic compounds. They are low molecular weight molecules consisting of polyphenols characterized by 15 carbon atoms in their fundamental nucleus. Besides, that presents two aromatic rings joined by a chain of three carbon atoms (C_6-C_3-C_6), basic nucleus, and its main nuclei of some classes of flavonoids that may or may not form a third ring (Souto, 2017; Castelucci et al., 2020) (**Figure 7**).

In this context, the present study aimed to carry out an integrative review on the genus *Eugenia*, highlighting the pitangueira (*E. uniflora* L.), cagaiteira (*E. dysenterica*), grumixameira (*E. brasiliensis*), pereira do cerrado (*E. klotzschiana* O. Berg), and uvaieira (*E. pyriformis* Cambess) and which flavonoids are present in these fruits.

METHODOLOGY

The present study consists of an integrative review, which sought articles published between 2016 and 2021 in the following

TABLE 1 | Search strategies used for each database.

Database	Search strategy	No of works
Google Scholar	Eugenia and flavonoid and uvaia or *eugenia pyriformis* Eugenia and flavonoid and cagaita or *eugenia dysenterica* Eugenia and flavonoid and grumixama or *eugenia brasiliensis* Eugenia and flavonoid and pitanga or *eugenia uniflora* Eugenia and flavonoid and pêra do cerrado or *eugenia klotzschiana*	1,390
Periódicos CAPES	Uvaia or *eugenia pyriformis* and flavonoid Cagaita or *eugenia dysenterica* and flavonoid Grumixama or *eugenia brasiliensis* and flavonoid Pitanga or *eugenia uniflora* and flavonoid Pera do cerrado or *eugenia klotzschiana* and flavonoid	150
Scielo	(*Eugenia pyriformis*) or (uvaia) (Cagaita) or (*Eugenia dysenterica*) (Grumixama) or (*Eugenia brasiliensis*) (Pitanga) or (*Eugenia uniflora*) (Pera do cerrado) or (*Eugenia klotzschiana*)	124
Science Direct	Eugenia and flavonoid and uvaia or *Eugenia pyriformis* Eugenia and flavonoid and cagaita or *Eugenia dysenterica* Eugenia and flavonoid and grumixama or *Eugenia brasiliensis* Eugenia and flavonoid and pitanga or *Eugenia uniflora* Eugenia and flavonoid and pêra do cerrado or *Eugenia klotzschiana*	121

Source: Authors (2022).

databases: Google Scholar, Periódicos CAPES, Scielo, and Science Direct. Researches were carried out related to the five selected fruits of the genus Eugenia, namely cagaiteira (*Eugenia dysenterica*), grumixameira (*Eugenia brasiliensis*), pereira do cerrado (*Eugenia klotzchiana* Berg), pitangueira (*Eugenia uniflora*) and uvaieira (*Eugenia pyriformis*).

For the elaboration of this work, the following steps were applied: formulation of the guiding question, specification of the strategy methods for researching articles, selection of articles, obtaining the articles that constituted the search criteria, interpretation of results, and presentation of the integrative review (Ramos et al., 2022).

For the first stage, the guiding question was elaborated, defined as: "What are the possible flavonoids present in certain fruits of the *Eugenia* genus?". The second step is the search for articles. In **Table 1**, it is possible to verify the search strategies used for each database and the number of studies found.

The third step consisted of selecting the articles, following the established inclusion and exclusion criteria, where the titles and abstracts of all scientific files, dissertations, and thesis were read. Also, at this stage, the following inclusion criteria were established: Studies published in the databases as mentioned earlier, scientific productions with published full texts, available in Portuguese, English, or Spanish, that address the use of flavonoids in certain fruits of the Eugenia genus and have been published between 2016 and 2021. As exclusion criteria: studies that did not meet the guiding question.

In the fourth stage, an analysis was carried out through the complete reading of the selected texts (in total) and definition of the studies included in the integrative review, extracting the highlighted information to answer the research objective. Finally, the fifth stage proceeded with the interpretation and discussion of the results, highlighting the works that brought the most significant answers to the proposed guiding question.

RESULTS AND DISCUSSION

The guiding question led to a return of 1785 articles in the following databases: Google Scholar, Periódicos CAPES, Scielo, and Science Direct. According to each database, the popular and scientific names of the five selected Eugenia fruits were used as descriptors in the search strategy, associated or not with the term "flavonoid."

The search strategy used for Google Scholar brought up 1,390 works. In Periódicos CAPES, 150 articles were found, while Science Direct returned 121 works, and in the Scielo platform, 124 studies were found. Of the 222 works retrieved in the third step, 65 duplicates were removed. A total of 157 works were selected for the subsequent stage. After a complete reading of 157 articles, 131 were excluded for not answering the guiding question. The 26 remaining articles went on to the last stage: interpretation and discussion of the results. This selection process is detailed in **Figure 8**.

Table 2 summarizes the data relating to the 26 articles that address the flavonoids present in Eugenia fruits. It is observed that most studies dealt with pitanga (*E. uniflora*) and cagaita (*E. dysenterica*). Articles from 2020 to 2021 corresponded to 42.3% of the selected works, and only two of the works that answered the guiding question were from the year 2016.

Flavonoids represent one of the most important phenolic groups, as they are an extensive class of antioxidants. In plants, they are essential for plant growth and reproduction. They are found in plant species such as fruits, seeds, peel, roots,

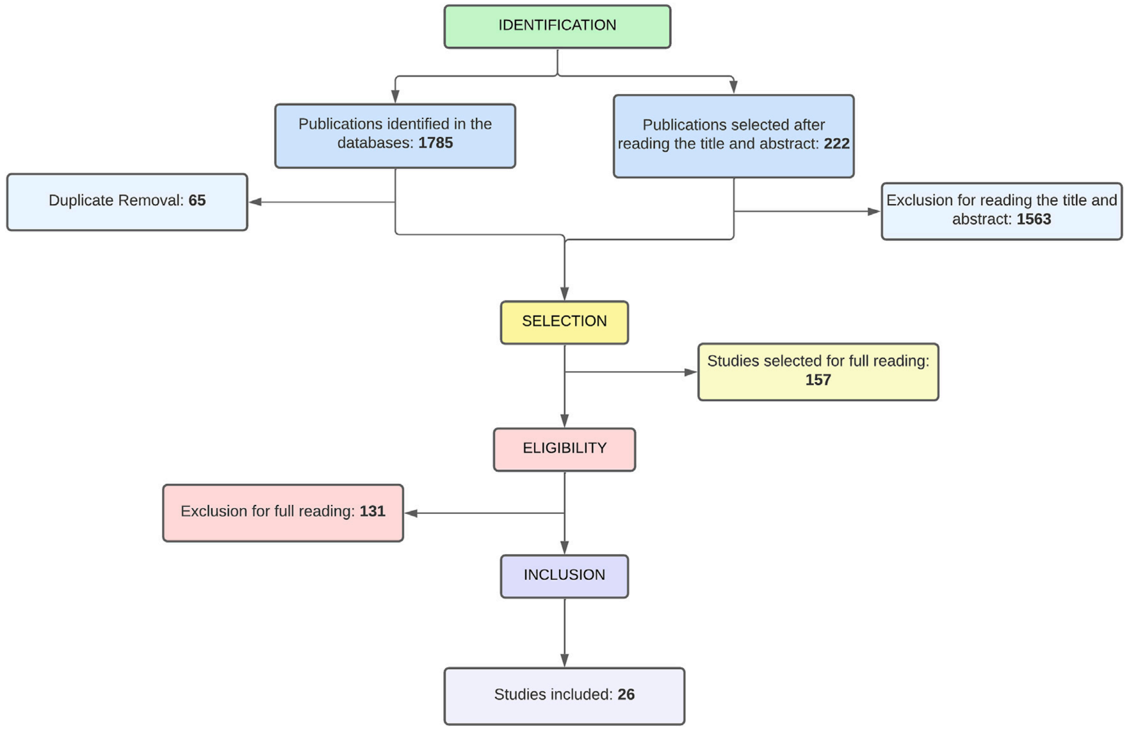


FIGURE 8 | Flowchart of the selection of studies by stages. Source: Authors (2022).

flowers and contribute to imparting sensory characteristics such as color and astringency (Guedes et al., 2017; Silva et al., 2019; Rodrigues D. B. et al., 2021). Even in small amounts, these compounds have physiological effects through their antioxidant action, playing an essential role in the processes of inhibiting the risk of cardiovascular diseases and several chronic-degenerative diseases, such as diabetes, cancer, and inflammatory processes (Guedes et al., 2017; Migues et al., 2018; Silva P. R. D. et al., 2021). **Table 3** shows the main flavonoids described in the literature for *Eugenia*.

According to **Table 2**, it appears that quercetin was the main flavonoid identified in *Eugenia* fruits, mentioned in 92.3% (24) of the studies retrieved. Moreira et al. (2017) demonstrated that cagaita leaf extract could be used in cosmetic/pharmaceutical products. This statement is due to the presence of antioxidant phytochemicals, such as quercetin, which is associated with regenerative effects of cells against damage induced by UVA exposure and considerable inhibitory activity of skin enzymes related to dermatological or aesthetic disorders. Other interesting compounds were also found in *Eugenia* fruits, such as catechin, epicatechin, rutin, myricetin, and kaempferol (**Table 2**). The main method used was HPLC, but the number and type of flavonoids identified varied according to the methodology used.

The studies addressed in the present work focused mainly on the pulp of *Eugenia* fruits, in such a way that only five studies studied the seed, leaves, or peel (**Table 2**). It is observed that for the same fruit, the flavonoid profile can vary according to the part studied, as in work by Gasca et al. (2017) and Silva et al. (2019), who verified, respectively, quercetin in cagaita leaves and vitexin in the pulp. The variation of compounds found can occur even when using the same methodology and part of the fruit, as in Ferreira-Nunes et al. (2017) and Guedes et al. (2017) studies that evaluate the pulp of cagaita and prove this fact. The first study found catechin through HPLC, while the second discovered epicatechin, quercetin, and rutin using the same methodology.

Products from cagaita were also addressed. Silva M. et al. (2021) studied cagaita ice cream, while Rodrigues D. B. et al. (2021) investigated cagaita jelly so that both detected the presence of flavonoids in these food matrices. Rodrigues and his collaborators also evaluated the alteration of the bioactive compounds in the fresh fruit. In the end, they noticed that 78% of the fruit compounds remained in the ice cream after processing. Flavones were also identified in the pulp by Alves et al. (2017) and in the fruit of cagaita by Silva P. R. D. et al. (2021) and his collaborators. The latter evaluated three progenies of the fruit in different areas of a microregion and concluded that two of them were more promising for future genetic improvements in the species. In this way, it is possible to infer that this class of compounds remains present even through technological processes to develop new products.

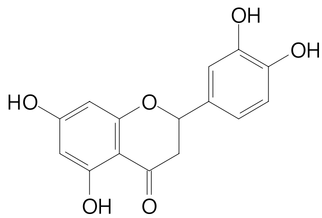
Souto (2017) found that the flavonoid profile does not change with the development of pitanga fruits. However, a reduction in its content was observed in the red and yellow varieties, compared to the purple one. On the other hand, Borges and Bezerra (2016) characterized the red and purple pitanga pulp and found that most of the bioactive compounds were flavonoids in both colors. In this study, cherry pitanga had a higher concentration of quercetin, and in turn, only myricetin was found in red pitanga.

TABLE 2 | Summary of selected works.

Sample	Technique	Results	References
Cerrado pear pulp	Paper spray ambient ionization mass spectrometry (PS-MS)	Gallocatechin, delphinidin-3-caffeoyl glycoside, peonidin-3-*O*-glycoside, petunidin, quercetin arabinoside, myricetin-3-glycoside, apigenin neohesperidoside I, quercetin-3-O-(6′-hydroxy-3-methyl) glutaroyl -â-galactoside	Xavier Mariano et al. (2020)
Uvaia peel and seed extract	UHPLC-QTOF-MS/MS	Dihydrokaempferol, epicatechin, taxifolin, rutin, myricetin, quercetin, isoquercitin, quercetin-3-*O*-pentoside, quercitrin, kaempferol 3-*O*-alpha-*L*-rhamnoside	Rodrigues L. M. et al. (2021)
Uvaia seed	ESI-LTQ-MS/MS.	Apigenin hexoside, hexosyl acetylhexosyl hexosyl kaempferol, luteolin hexoside	Farias et al. (2020)
Cagaita leaves	HPLC-DAD	Quercetin and Catechin	Gasca et al. (2017)
Cagaita leaf extract	HPLC	Quercetin	Moreira et al. (2017)
Cagaita pulp	Paper spray ambient ionization mass spectrometry (PS-MS)	Vitexin	Silva et al. (2019)
Cagaita pulp	HPLC	Epicatechin, quercetin and rutin	Guedes et al. (2017)
Cagaita pulp	Paper spray ambient ionization mass spectrometry (PS-MS)	Delphinidin-3-glycoside, kaempferol-3-*O*-malonylglucoside, quercetin acetylhexoside, quercetin-3-*O*-glucuronide, quercetin acetylhexoside	Silva P. R. D. et al. (2021)
Cagaita pulp	PS-MS	Cryoseriol, vitexin, delphinidin 3-*O*-arabinoside; delphinidin 3-*O*-glucoside	Silva M. et al. (2021)
Cagaita peel and pulp	Ionization Mass Spectrometry (LC-ESI-MS/MS	Quercetin, delphinidin rutinoside, cyanidin 3-glycoside	Alves et al. (2017)
Cagaita jelly and pulp	PS-MS paper spray mass spectrometry	Myrtilin, kaempferol-3-*O*-malonylglucoside, quercetin acetyl hexoside, quercetin-3-*O*-glucuronide, quercetin acetyl hexoside, vitexin, cyanidin-3-*O*-rutinoside	Rodrigues D. B. et al. (2021)
Cagaita pulp	HPLC	Catechin	Ferreira-Nunes et al. (2017)
Grumixama pulp	HPLC-DAD e LC-ESI-MS/MS	Quercetin aglycone; quercetin 3-glucoside; myricetin aglycone	Teixeira et al. (2019)
Grumixama pulp	Paper spray PS/MS	Cyanidin-3-galactoside; catechin; diosmetin; kaempferolrhamnoside; myricetinrhamnoside; quercetin-monoglucuronide; myricetin glucoside	Ramos et al. (2020)
Grumixama pulp	HPLC-DAD e LC-ESI-MS/MS	Isoquercetin, quercetin and rutin	Nascimento et al. (2017)
Grumixama pulp	HPLC-ESI-MS/MS	Myricetin; quercetin; rutin	Nehring, (2016)
Grumixama pulp	LC–MS/MS (Z-electrospray (ESI))	Epicatechin, quercetin and hexoside	Lazarini et al. (2018)
Pitanga pulp	HPLC-DAD-MS	Quercetin and myricetin	Tambara et al. (2018)
Pitanga pulp	UPLC-QToF-MS	Quercetin; quercetin hexoside; rhamnoside quercetin and kaempferol	Stafussa et al. (2021)
Pitanga pulp	HPLC-DAD-ESI-MS	Epigallocatechin gallate; myricetin glucoside; myricetin arabinopyranoside; quercetin glucoside; kaempferol glucoside; quercetin pentoside; quercetin rhamnose; quercetin deoxyglycoside; myricetin-galloyl-deoxyhexose; myricetin; quercetin	Silva C. et al. (2021)
Pitanga pulp	HPLC-DAD	Myricetin and quercetin	Borges and Bezerra, (2016)
Pitanga pulp	LC-MS	Myricetin-*O*-a-*L*-rhamnopyranoside; myricetin; myricetin-*O*-(*O*-galoyl)-deohexyhexose; catechin/epitechin; isorhamnetin glycoside; quercetin; quercetin-*O*-(*O*-galoyl)-hexoside	Sobral - Souza et al. (2020)
Pitanga pulp	LC-ESI-MS/MS-DAD	Quercetin hexoside; quercetin-3-*O*-glucoside; quercetin raminoside; myricetin dimer; quercetin dimer; kaempferol	Souto (2017)
Pitanga pulp	HPLC-DAD-ESI/MS e RP-HPLC-DAD	Myricetin-galloylhexoside; myricetin-hexoside; myricetin-hexoside; myricetin-pentoside, quercetin galloyl hexoside; myricetin-pentoside 2; myricetin-rhamnoside; quercetin hexoside; quercetin pentoside; quercetin rhamnoside	Migues et al. (2018)
Pitanga pulp	HPLC-DAD-LC-ESI-QTOF-MS/MS	Quercetin; myricetin pentoside; quercetin galactoside; quercetin 3-*O*-glucoside; quercetin pentoside; quercetin rhamnoside, quercetin hexoside þ pentoside; quercetin glucosyl rhamnoside	Rodrigues et al. (2020)
Pitanga pulp	HPLC-ESI-MS/MS	Quercetin and isoquercitrin	Siebert et al. (2019)

Source: Authors (2022).

TABLE 3 | Main flavonoids described in the literature for *Eugenias*.

	Flavanone	
	 Taxifolin	
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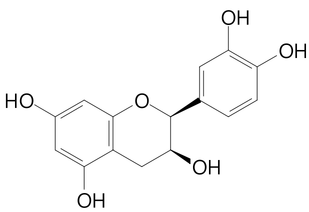
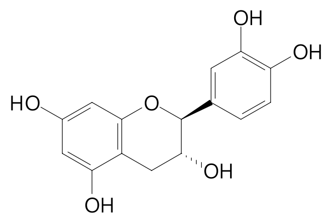
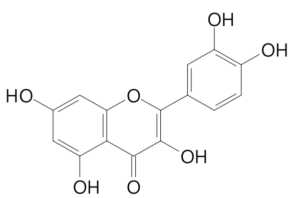
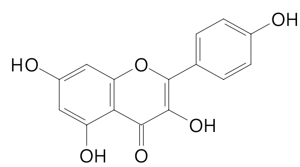
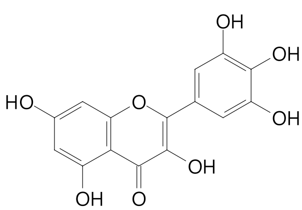
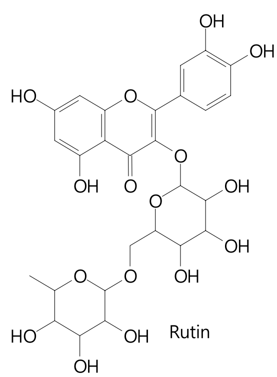
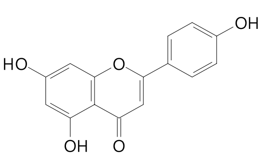
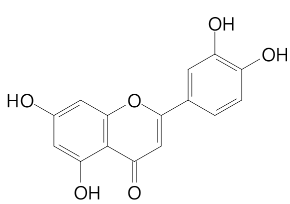
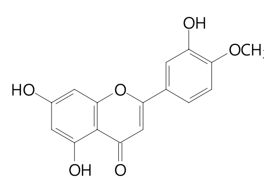
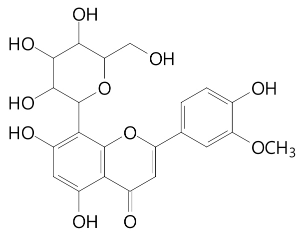
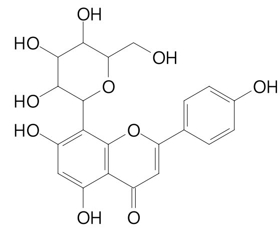
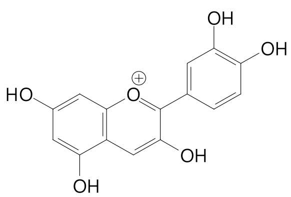
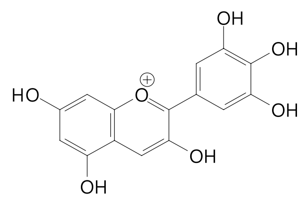
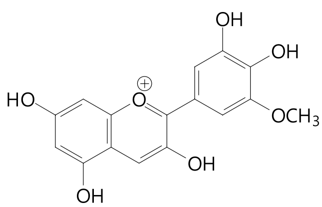
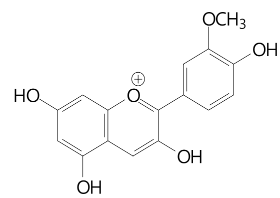
 Epicatechin		 Catechin
	Flavonol	
 Quercetin		 Kaempferol
 Myricetin		 Rutin
	Flavone	
 Apigenin	 Luteolin	 Diosmetin

(Continued on following page)

TABLE 3 | (*Continued*) Main flavonoids described in the literature for *Eugenias*.

 Escoparin	 Vitexin
Anthocyanidine	
 Cyanidin	 Delphinidin
 Petunidin	 Peonidin

Source: Authors (2022).

Siebert et al. (2019) studied the inhibitory activity of cherry juice on target enzymes in Alzheimer's and diabetes mellitus treatment and they discovered that, at least in part, the enzyme activity values (52.67% and 69.47%, respectively) are related to the presence of flavonoids. Sobral-Souza et al. (2020) concluded that natural compounds from *Eugenia uniflora* are promising sources of natural products with antioxidant and chelating activity. Rodrigues et al. (2020) found that the combination of furanone with pitanga extract could inhibit the growth of *S. liquefaciens*, a degrading microorganism of relevance in the dairy industry. Tambara et al. (2018) also evaluated the antioxidant effect of cherry pulp on *C. elegans* and found that this fruit could protect against oxidative stress genes. Finally, Stafussa et al. (2021) report that the presence of flavonoids in cherry pulp supports preserving its antioxidant and antimicrobial properties during *in vitro* digestion.

Eugenia klotzschiana Berg is popularly known as the Cerrado pear. Xavier Mariano et al. (2020), when working with the pulp of this fruit, reported that the paper spray ambient ionization with mass spectrometry technique (PS-MS) is efficient in identifying bioactive compounds present in the pulp, with flavonoids corresponding to 70% of the identified compounds. Although only one work retrieved in this research addressed this fruit, the results of these authors showed that the Cerrado pear has the potential to be exploited. Due to its diversity in chemical composition encompassing bioactive compounds, it can provide an important benefit to human food.

Regarding *Eugenia pyriformis*, Farias et al. (2020) determined the antioxidant properties of two fractions of this fruit (edible fraction and seed). They found that the total flavonoid content was approximately 16 times higher in the seed, a fraction that is usually discarded during consumption or processing of the fruit. Rodrigues L. M. et al. (2021) used reverse osmosis to concentrate the bioactive compounds of uvaia residue (seed and peel). They obtained a concentrate 7 to 8 times greater than the control, stimulating its use as a source of antioxidants in the development of functional food formulations, nutraceuticals, or also by pharmaceutical industries. These results also allow us to infer the use of co-products helping to reduce organic waste and possible income generation.

Teixeira et al. (2019) investigated changes in urine metabolome after acute ingestion of polyphenol-rich grumixama (*Eugenia brasiliensis*) juice. HPLC-DAD and LC-ESI-MS/MS identified the main flavonoids as cyanidin 3-*O*-glucoside and quercetin aglycone, corresponding to 20% and 29% of the total phenolic content, respectively. Fifteen healthy subjects consumed a single dose of grumixama juice in this research, and urine samples were collected before and after ingestion of this juice. The results showed an increase in plasma antioxidant capacity after ingestion and suggest that acute ingestion of grumixama juice may affect amino acid metabolism and mitochondrial metabolism. However, the health-related implications should be explored in further studies.

Grumixama was chemically characterized through Ramos et al. (2020) study. By evaluating this fruit's antioxidant potential and chemical profile, it was possible to list 45 compounds using PS-MS. The presence of flavonoids, including catechin and quercetin derivatives, naturally present in grumixama, provides beneficial effects such as antioxidant activity. Nascimento et al. (2017) identified and quantified bioactive compounds, main flavonoids in peel, pulp, and the seed of *E. brasiliensis*. The peel was the wealthiest part of the fruit concerning this class of compounds. The studies highlight that grumixama has the potential to be used in the food industry, being introduced in food products, additive or natural coloring in products that can promote possible health benefits.

Nehring (2016) sought to value native species and new sources of chemical compounds with bioactive properties. It was possible to detect 19 compounds, nine flavonoids such as aromadendrin, kaempferol, catechin, epicatechin, hispidulin, quercetin, isoquercetin, taxifolin, and myricetrin. It is possible to observe that catechin and quercetin derivatives are usually detected in *E. brasiliensis*, highlighting their promising use and beneficial effects on human health, as in work developed by Lazarini et al. (2018) These researchers confirmed the presence of epicatechin and quercetin in the grumixama pulp samples, showed potential antioxidant and anti-inflammatory properties and concluded that the observed anti-inflammatory activity was due to the presence of these compounds.

Therefore, the *Myrtaceae* family presented several flavonoids in their chemical profile, especially the fruits mentioned in this study. Those that appeared in greater abundance in the selected works can be highlighted, such as epicatechin, quercetin, rutin, kaempferol, catechin, and myricetin. Thus, these studies highlight the appreciation and importance of species of the genus *Eugenia*, which promote medicinal properties and beneficial effects on health and possible applicability to the food industry.

CONCLUSION

Therefore, it was possible to observe that among the plants studied, cagaiteira (*Eugenia dysenterica*) and pitangueira (*Eugenia uniflora* L) were those that presented the highest return of works related to the identification of flavonoids. Then followed by grumixameira (*Eugenia brasiliensis*), uvaieira (*Eugenia pyriformis* Cambess) and Cerrado pear (*Eugenia klotzschiana* O. Berg). According to the selected works, it is possible to identify that quercetin is the most common flavonoid among the fruits studied. In addition, epicatechin, catechin, kaempferol, and rutin were also evidenced in most of the works discussed. These compounds, in turn, are of great importance for human health as they have biological action already evidenced associated with preventing the emergence of various chronic and degenerative diseases, such as cancer, diabetes, hypertension, Alzheimer's, and cardiovascular diseases, among others. Based on this review, it was possible to observe the importance of plants of the genus *Eugenia* in terms of the presence and concentration of flavonoids and their main chemical properties with the possibility of application in the development of new products. Therefore, considering the presence of these compounds emphasizes the value and importance of these fruits, making them promising for the food and pharmaceutical industry due to the numerous characteristics and properties they present.

AUTHOR CONTRIBUTIONS

LN, BN, and YF were responsible for the research, data curation and writing of the original draft. AR and VC were responsible for conceptualization, project management, validation, and writing-reviewing and editing. LR and AF were responsible for research and visualization. RF, IS, JM, and PS were responsible for project management and visualization. RA and JM were responsible for project administration, writing-review, editing and resources and conceptualization.

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