

Review

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Review

Characterization of Phenolic Compounds in the Fruit *Eugenia Stipitata* Mac Vaugh (Arazá)— A Systematic Review

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Abstract: (1) Background: In *Eugenia Stipitata* Mac Vaugh (Arazá), there is an abundance of flavonoids, carotenoids, and phenolic acids, which are bioactive compounds with antioxidant, anticarcinogenic, antimicrobial, anti-inflammatory, antispasmodic, antiulcer, and cardiovascular disease prevention benefits. Therefore, the aim of this review is to compile the compounds that have been identified in the fruit and gather information about secondary metabolites to establish their potential preventive and therapeutic effects; (2) Methods: a literature search was conducted in repositories and databases such as Science Direct, Scopus, PubMed, Web of Science, Agriculture Collection Gale, SAGE, OXFORD University, DOAJ, among others. Articles identifying and quantifying bioactive compounds present in Arazá were included; (3) Results: Five studies meeting the inclusion criteria were incorporated, resulting in the compilation of 82 compounds, of which 24 were identified and quantified, while 58 were solely identified. This review was able to identify and report the concentration, and in some cases, the quantity, of phenolic compounds with antioxidant and anti-inflammatory capabilities present in Arazá; (4) Conclusions: With this scope, it was possible to obtain a more comprehensive understanding of the fruit's potential to potentially enhance health aspects, thereby providing greater prominence and added value to this product, allowing for more frequent inclusion in the diets of consumers, and even enabling exportation.

Keywords: characterization; Arazá; phenolic compounds

1. Introduction

The origin of the Arazá is attributed to the Peruvian Amazon region, more precisely in Loreto (Peru) near the source of the Amazon River where the greatest genetic diversity is reported for its two subspecies (sororia and stipitata). The stipitata variety spread between countries that share Amazonia such as Peru and Brazil [1].

In the Colombian region its origin comes from the sexual seeds brought from Manaus-Brazil and Iquitos-Peru. This plant is characterized by having a globose and somewhat depressed berry fruit. Climatic factors affect its production and cultivation, such that it requires large amounts of rainwater (annual rainfall of 2900 mm), little sunlight (sunshine of 1650 hours per year), an average temperature of 26 °C and a relative humidity of 84%. Since 1989, the domestication of this fruit began in Colombia, starting in the departments of Amazonas and its proximity to Peru and Brazil. It later expanded to the departments of Caquetá, Guaviare, Meta, Cundinamarca, Caldas, Antioquia, and Putumayo [2].

The compounds that abound in the fruit and that have been registered through research include flavonoids, carotenoids, and phenolic acids. These are bioactive compounds with great health benefits for people, who can obtain from them antioxidant, anticarcinogenic, antimicrobial, anti-inflammatory, antispasmodic, anti-ulcer, and cardiovascular disease prevention properties [3].

Given the excellent and diverse climatic characteristics, Colombia has a great potential in a variety of promising native fruits for their exploitation and transformation into different types of

products. The consumption of this type of fruit is not exclusively for taste. Currently there is a growing concern for improving health conditions, and there is an interest not only in the nutritional value but also in its ability to prevent or assist in the treatment of various diseases. This is the case of the *Eugenia Stipitata* fruit, which has been found to have anti-inflammatory and antipyretic properties without showing toxicity in mice [4,5].

The objective of this review is to make a compilation of the compounds of the Amazonian fruit that have already been fully identified and to obtain information on the secondary metabolites found to establish their possible preventive and therapeutic effects on human health.

2. Materials and Methods

2.1. Literature search

For this study a search was carried out in repositories of Colombian universities, in the Network of Latin American Repositories, LA REFERENCIA (network of open access repositories), SINCHI (Amazonian Institute of Scientific Research), Alexander von Humboldt (Institutional Repository of Scientific Documentation), in databases to which the University of Caldas has access: Science Direct, Scopus, PubMed (MedLine), Web of Science, Agriculture Collection Gale, SAGE, OXFORD University, DOAJ, as well as open access resources (SciELO and Redalyc).

In addition, ResearchGate and Google Scholar databases were examined. These searches were conducted between May 17 and September 30, 2021. The keywords used were, *Eugenia stipitata*, bioactive compounds, polyphenols, flavonoids. The search strategies were “*Eugenia stipitata*, AND compounds bioactive, OR polyphenols, OR flavonoids”. “Repository:”, symbol “+”, “*Eugenia Stipitata*”, “Arazá”, “*Eugenia Stipitata* AND Bioactive”, “Flavonoids AND *Eugenia Stipitata*”, “*Eugenia Stipitata* AND polyphenols”.

Google Scholar included words such as: “*Eugenia stipitata* +”bioactive compounds “+”polyphenols”; repository: “*eugenia stipitata* +”bioactive “+”polyphenols”; repository: “*eugenia stipitata*”. Studies in Portuguese, English and Spanish were included.

2.2. Inclusion and Exclusion Criteria

Articles identifying and quantifying bioactive compounds present in *Eugenia Stipitata* Mc Vaughn were included. We did not include articles that presented logical inconsistencies related to the instruments and analytical methods for obtaining bioactive compounds, nor those that studied species other than *Eugenia Stipitata* Mc Vaughn.

2.3. Inclusion and Exclusion Criteria

The articles that met the inclusion criteria were recorded in an Excel sheet along with the identification and quantification data of the compounds according to the different parts of the fruit (pulp, peel, seed). In addition, moisture, number of samples treated, type of compound, chemical formula and a confidence code of the references were included. The data were validated by two of the study investigators.

3. Results

Figure 1 shows the PRISMA diagram with the different phases of the literature review. Following the identification, screening, and eligibility phases, 5 studies that met the inclusion criteria were included. In this study, 82 compounds were found, of which 24 were identified and quantified and 58 were only identified (Tables 1–5). Based on these results, it was possible to obtain an important compendium of bioactive compounds whose totality had not been reported in previous studies [6].

The samples treated for fruit moisture calculation by [7] for both pulp and peel are 6. The compounds reported by [8] are part of the combination of pulp and peel. The quercetin and kaempferol values contributed by [9,10] were reported as the average of both authors. The values

selected by [11] were taken from the ripe fruit. The compounds identified by [12] are part of the pulp and peel mixture.

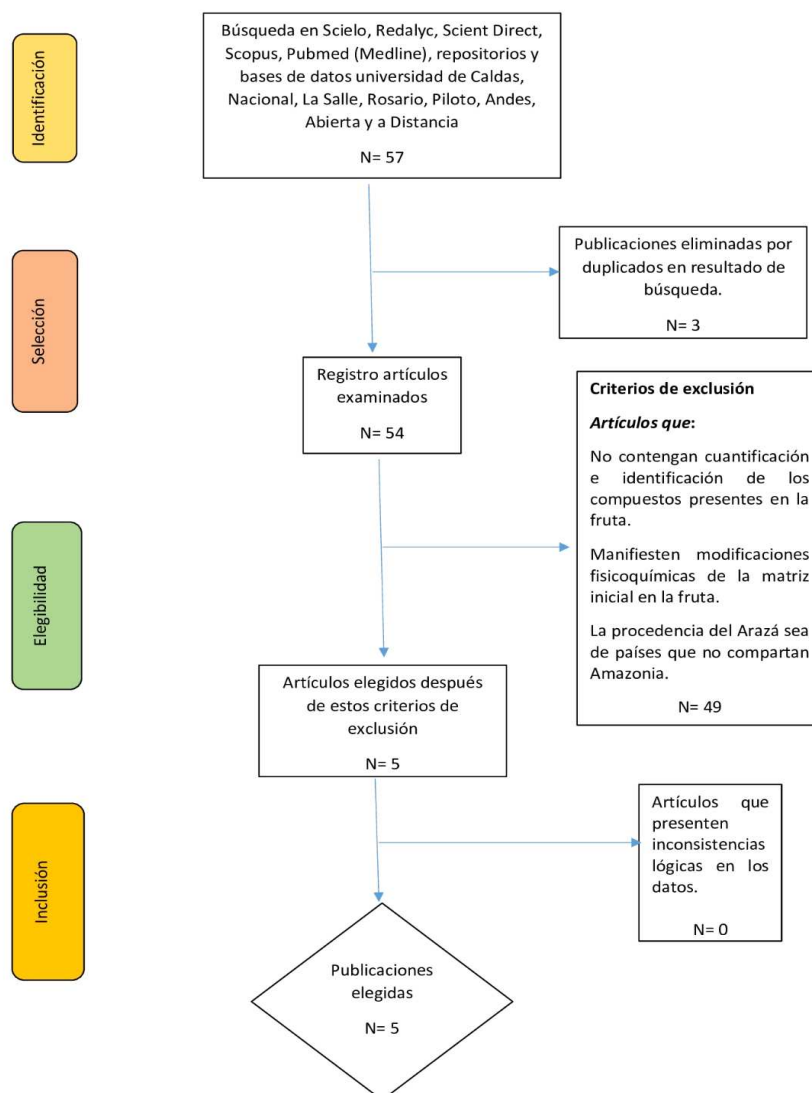


Figure 1. Prism diagram of the different phases of the bibliographic review.

3.1. Carotenoids

3.1.1. Identified and quantified

This group has the highest number of compounds reported with identification and quantification. [7] found 14 compounds in both pulp and peel. In relation to the total concentration, it was possible to identify that the carotenoids in peel are approximately 3 times more than the content found in the pulp. Due to the high concentration of carotenoids in the peel, a higher antioxidant power is attributed to this part of the fruit.

Another study [8] found 4 new compounds (violaxanthin, 15-cis- β -carotene, 13-cis- β -carotene, 9-cis- β -carotene) from the homogenization of pulp and peel. High percentages (45%) of bioaccessibility were also recorded for zeaxanthin, 15-cis- β -carotene, and α -carotene compounds, i.e., those components that are released from the food matrix in greater proportion during digestion and become available for absorption.

The most abundant carotenoids are lutein (18.1%–18.2%), β -cryptoxanthin (5.56%–27.6%), β -carotene (5.21%–23.8%) and violaxanthin (11.8%).

3.1.2. Identified and unquantified

According to [7] the study reported only one unquantified compound called anhydro zeaxanthin found in pulp and peel. In turn, the study describes the presence of an unknown compound possibly rubixanthin-palmitate. This would indicate the possible existence of other carotenoids that have not been reported.

Table 1. Compounds Identified and Quantified (carotenoids pulp).

N°	Average humidity	Class	Type	Chemical Formula	Result	SD	Quantity		†
							Min	Max	
3	93,6 ± 1,0	Xanthophyll	Lutein	C40H56O2	0,15	0,11	0,05	0,26	[7]
3	93,4	Xanthophyll	Lutein	C40H56O2	0,16	NA	-	-	[8]
3	93,6 ± 1,0	Xanthophyll	Lutein myristate palmitate	C70H112O4	0,10	0,017	0,082	0,12	
3	93,6 ± 1,0	Xanthophyll	β -Cryptoxanthin palmitate	C56H86O2	0,092	0,038	0,054	0,13	
3	93,6 ± 1,0	Xanthophyll	Lutein dipalmitate	C72H116O4	0,091	0,018	0,073	0,11	[7]
3	93,6 ± 1,0	Xanthophyll	Anhydroluteina	C40H54O	0,063	0,024	0,039	0,087	
3	93,6 ± 1,0	Xanthophyll	Zeinoxanthin Palmitate	C56H86O3	0,054	0,022	0,032	0,076	
3	93,6 ± 1,0	Xanthophyll	β -Cryptoxanthin	C40H56O	0,047	0,027	0,020	0,074	
3	93,4	Xanthophyll	β -Cryptoxanthin	C40H56O	0,24	NA	-	-	[8]
3	93,6 ± 1,0	Xanthophyll	Lutein Dimyristate	C68H108O4	0,047	0,0090	0,038	0,056	[7]
3	93,6 ± 1,0	Carotene	β -Carotene	C40H56	0,044	0,016	0,028	0,060	
3	93,4	Carotene	Todo-trans- β -Caroteno	C40H56	0,21	NA	-	-	[8]
3	93,6 ± 1,0	Xanthophyll	β -Cryptoxanthin myristate	C54H82O2	0,043	0,022	0,021	0,065	
3	93,6 ± 1,0	Xanthophyll	Zeinoxanthin myristate	C54H82O2	0,038	0,016	0,022	0,054	[7]
3	93,6 ± 1,0	Carotene	α -Carotene	C40H56	0,031	0,014	0,017	0,045	
3	93,4	Carotene	Todo-trans- α -Carotene	C40H56	0,065	NA	-	-	[8]
3	93,6 ± 1,0	Xanthophyll	Zeaxanthin	C40H56O	0,025	0,020	0,0050	0,045	[7]
3	93,6 ± 1,0	Xanthophyll	Zeaxanthin	C40H56O2	0,017	0,0090	0,0080	0,026	
3	93,4	Xanthophyll	Zeaxanthin	C40H56O2	0,055	NA	-	-	
3	93,4	Xanthophyll	Violaxanthin	C40H56O4	0,10	NA	-	-	
3	93,4	Carotene	15-cis- β Carotene	C40H56	0,011	NA	-	-	[8]
3	93,4	Carotene	13-cis- β Carotene	C40H56	0,016	NA	-	-	
3	93,4	Carotene	9-cis- β Carotene	C40H56	0,018	NA	-	-	
3	89,0 ± 2,4	Xanthophyll	Anhydroluteina	C40H54O	0,14	0,025	0,11	0,16	

Abbreviations: SD, Standard Deviation; Min, Minimum; Max, Maximum; NA, Not Available; †, Source. Average humidity data are presented as degree (°) and standard deviation (\pm). Sample Number (N°): number of samples evaluated for statistical analysis. Class: identification assigned corresponding to the functional group it contains, whether flavonoid, carotenoid, phenolic acid, or tannin. Type: specific compound found in the analysis. Result (mg/100 g): amount in milligrams per 100 grams of the compound present in pulp or fresh peel. Quantity (mg/100 g): present range of the compound in pulp or peel recorded in milligrams per 100 grams.

Table 2. Compounds Identified and Quantified (carotenoids peel).

N°	Average humidity	Class	Type	Chemical Formula	Result	SD	Quantity		†
							Min	Max	
3	89,0 ± 2,4	Xanthophyll	Lutein	C40H56O2	0,76	0,12	0,64	0,87	
3	89,0 ± 2,4	Xanthophyll	Lutein dipalmitate	C72H116O4	0,26	0,046	0,21	0,30	
3	89,0 ± 2,4	Xanthophyll	Lutein myristate palmitate	C70H112O4	0,24	0,032	0,20	0,27	
3	89,0 ± 2,4	Xanthophyll	Zeinoxanthin palmitate	C56H86O3	0,19	0,024	0,16	0,21	
3	89,0 ± 2,4	Xanthophyll	β -Criptoxantina palmitato	C56H86O2	0,15	0,032	0,12	0,19	
3	89,0 ± 2,4	Carotene	β -Carotene	C40H56	0,14	0,025	0,12	0,17	[7]
3	89,0 ± 2,4	Xanthophyll	β -Criptoxantina	C40H56O	0,14	0,045	0,10	0,19	
3	89,0 ± 2,4	Xanthophyll	Anhydroluteina	C40H54O	0,14	0,025	0,11	0,16	
3	89,0 ± 2,4	Xanthophyll	Zeinoxanthin	C40H56O2	0,11	0,049	0,065	0,16	
3	89,0 ± 2,4	Xanthophyll	Zeinoxanthin myristate	C54H82O2	0,10	0,006	0,10	0,11	
3	89,0 ± 2,4	Xanthophyll	Lutein Dimyristate	C68H108O4	0,10	0,014	0,087	0,12	
3	89,0 ± 2,4	Carotene	α -Carotene	C40H56	0,096	0,020	0,076	0,12	

3	89,0 ± 2,4	Xanthophyll	Zeinoxanthin	C40H56O	0,081	0,023	0,058	0,10
3	89,0 ± 2,5	Xanthophyll	β-Cryptoxanthin myristate	C54H82O2	0,077	0,010	0,067	0,09

Abbreviations: DE, Deviation Standard; Min, Minimum; Max, Maximum; NA, Not Available; †, Source. Average humidity data are presented as degree (°) and standard deviation (±). Sample Number (N°): number of samples evaluated for statistical analysis. Class: identification assigned corresponding to the functional group it contains, whether flavonoid, carotenoid, phenolic acid, or tannin. Type: specific compound found in the analysis. Result (mg/100 g): amount in milligrams per 100 grams of the compound present in pulp or fresh peel. Quantity (mg/100 g): present range of the compound in pulp or peel recorded in milligrams per 100 grams.

3.2. Phenolic acids

3.2.1. Identified and quantified

[11] determined that the pulp and peel of ripe Arazá have a high antioxidant power thanks to this group of compounds. These authors identified and quantified chlorogenic acid, gallic acid and caffeic acid as the main phenolic acids. It has also been found that chlorogenic acid in pulp increases its concentration as fruit ripening progresses, its concentration then goes from 4.41 mg/100g (green state) to 7.56 mg/100 g (ripe state). The same happens with gallic acid in the peel, which increases from 2.32 mg/100 g (green state) to 3.91 mg/100 g (ripe state). Chlorogenic acid is found in higher concentration in the ripe state in peel (39.6 mg/100 g) and pulp (7.56 mg/100g) followed by gallic acid respectively (3.91 mg/100g and 2.94 mg/100g). Of these 3 compounds chlorogenic acid, given its high concentration, has the highest antioxidant capacity, followed by gallic acid. The presence of ellagic acid is also relevant since it has a high free radical scavenging capacity [13,14].

3.2.2. Identified and unquantified

[15] described 9 compounds present in the mixture of peel and pulp. They also reported 6 phenolic acids in the seed, describing that the phenolic content in the seed is 15 times higher than that found in the peel and pulp, which would indicate a greater antioxidant potential. This finding was confirmed by [16] who also reported for the first time the presence of p-coumaric acid and sinapic acid. On the other hand, [13] provide 4 different compounds in the pulp (Ellagic acid hexoside, Vanillic acid-O-hexoside II, Coumaric acid-O-Hexoxide I, Pinoresinol hexoside).

Table 3. Compounds Identified and Quantified (Phenolic acids pulp).

N°	Average humidity	Class	Type	Chemical Formula	Result	SD	Quantity		†
							Min	Max	
3	NA	Hydroxycinnamic acid	Chlorogenic acid	C16H18O9	7,6	NA	-	-	
3	NA	Hydroxybenzoic acid	Gallic acid	C7H6O5	2,9	NA	-	-	[11]
3	NA	Hydroxycinnamic acid	Caffeic acid	C9H8O4	0,40	NA	-	-	

Abbreviations: SD, Standard Deviation; Min, Minimum; Max, Maximum; NA, Not Available; †, Source. Average humidity data are presented as degree (°) and standard deviation (±). Sample Number (N°): number of samples evaluated for statistical analysis. Class: identification assigned corresponding to the functional group it contains, whether flavonoid, carotenoid, phenolic acid, or tannin. Type: specific compound found in the analysis. Result (mg/100 g): amount in milligrams per 100 grams of the compound present in pulp or fresh peel. Quantity (mg/100 g): present range of the compound in pulp or peel recorded in milligrams per 100 grams.

Table 4. Compounds Identified and Quantified (Phenolic acids peel).

N°	Average humidity	Class	Type	Chemical Formula	Result	SD	Quantity		†
							Min	Max	
3	NA	Hydroxycinnamic acids	Chlorogenic acid	C16H18O9	40	NA	-	-	
3	NA	Hydroxycinnamic acids	Gallic acid	C7H6O5	3,9	NA	-	-	[11]
3	NA	Hydroxycinnamic acids	Caffeic acid	C9H8O4	1,1	NA	-	-	

Abbreviations: DE, Deviation Standard; Min, Minimum; Max, Maximum; NA, Not Available; †, Source. Average humidity data are presented as degree (°) and standard deviation (±). Sample Number (N°): number of samples evaluated for statistical analysis. Class: identification assigned corresponding to the functional group it contains, whether flavonoid, carotenoid, phenolic acid, or

tannin. Type: specific compound found in the analysis. Result (mg/100 g): amount in milligrams per 100 grams of the compound present in pulp or fresh peel. Quantity (mg/100 g): present range of the compound in pulp or peel recorded in milligrams per 100 grams.

3.3. Flavonoids

3.3.1. Identified and quantified

For this group the pulp was evaluated in which myricetin, quercetin and kaempferol were found. Myricetin being the major compound with (17 mg/100 g) in pulp [9,10].

3.3.2. Identified and unquantified

[13] found 6 compounds in the pulp that had not been previously reported. On the other hand, [12] recently found 9 positive ion compounds in the pulp and peel that also had not been previously reported. These same authors evaluated the seeds of the fruit and found 11 compounds, 1 of them eugenitin as a negative ion and the remaining as positive ions (Table 6).

Table 5. Compounds Identified and Quantified (flavonoids pulp).

N°	Average humidity	Class	Type	Chemical Formula	Result	SD	Quantity		†
							Min	Max	
3	87,9 ± 0,1	Flavonol	Myricetin	C15H10O8	17	0,50	17	18	[9]
3	87,9 ± 0,1	Flavonol	Quercetin	C15H14O6	9,8	0,42	9,4	10	[9,10]
3	87,9 ± 0,1	Flavonol	Kaempferol	C15H10O6	3,1	1,1	2,0	4,2	

Abbreviations: SD, Standard Deviation; Min, Minimum; Max, Maximum; NA, Not Available; †, Source. Average humidity data are presented as degree (°) and standard deviation (±). Sample Number (N°): number of samples evaluated for statistical analysis. Class: identification assigned corresponding to the functional group it contains, whether flavonoid, carotenoid, phenolic acid, or tannin. Type: specific compound found in the analysis. Result (mg/100 g): amount in milligrams per 100 grams of the compound present in pulp or fresh peel. Quantity (mg/100 g): present range of the compound in pulp or peel recorded in milligrams per 100 grams.

Table 6. Compounds Identified and unquantified (pulp, peel, and seed).

<i>Carotenoids (pulp)</i>				
N°	Class	Type	Chemical Formula	†
1	Xanthophyll	Anhydrozeaxanthin	C40H56O2	[7]
<i>Flavonoid (pulp)</i>				
1	Flavan-3-ol	Gallocatechin-Gallate	C22H18O11	[13]
2	Flavonol	Dihydroquercetin glycoside	C21H22O12	
3	Flavanone	Hydrated naringin	C27H34O15	
4	Flavanone	Eriodictyol-7-O-glucoside VI	C21H22O11	
5	Flavan-3-ol	Epicatechin-gallate	C22H18O10	
6	Flavan-3-ol	Epicatechin	C15H14O6	
7	Flavone	Apigenin hexoside (positive ion) [M + H - H ₂ O] +	C21H20O10	[12]
8	Flavone	Apigenin Hexoside Caffeate (positive Ion) [M + H - H ₂ O]	C36H36O17	
9	Flavone	Methylapigenin hexoside (positive ion) [M + Na] +	C22H22O9	
10	Flavan-3-ol	Catechin dihexoside (positive ion) [M + H] +	C27H34O16	
11	Flavan-3-ol	Gallocatechin (positive ion) [M + H] +	C15H14O7	
12	Flavone	Luteolin hexoside (positive ion) [M + H] +	C20H18O10	
13	Flavone	Luteolin Malonyldihexoside (positive Ion) [M + Na] +	C30H32O18	
14	Flavonol	Kaempferol hydroxypropionylhexoside (positive ion) [M + K] +	C30H34O18	
15	Flavonol	Quercetin hexopyranosyl -hexoside (positive ion) [M + Na] +	C26H28O16	
<i>Phenolic Acids (pulp)</i>				
1	Hydroxybenzoic acid	Glycolic acid (negative ion) [M-H]-	C13H16O10	[12]
2	Hydroxycinnamic acid	Caffeoylquinic Acid (positive Ion) [M + K] +	C16H18O9	
3	Hydroxycinnamic acid	Caffeoyl tartaric acid (positive Ion) [M + H] +	C13H12O9	
4	Hydroxycinnamic acid	Caffeoyl-hexose (positive Ion) [M + K] +	C15H18O9	
5	Hydroxycinnamic acid	Caffeoyl methylquinic acid (positive ion) [M + Na] +	C17H20O9	

6	Hydroxycinnamic acid	Coumaroyl tartaric acid (positive ion) [M + H +H ₂ O]	C13H12O8	
7	Hydroxybenzoic acid	Fertaric acid (positive ion) [M + K] +	C14H14O9	
8	Hydroxybenzoic acid	Gallic acid hexoside (positive ion) [M + K] +	C13H16O10	
9	Hydroxybenzoic acid	Vanillic Acid (positive ion) [M + K] +	C8H8O4	
10	Hydroxybenzoic acid	Ellagic acid hexoside	C20H16O13	
11	Hydroxybenzoic acid	Vanillic acid-O-hexoside II	C14H18O9	[13]
12	Hydroxycinnamic acid	Coumaric acid - O - Hexoside I	C15H18O8	
13	Hydroxycinnamic acid	Hexoside Pinoresinol	C26H30O11	
Hydrolyzable Tannins (pulp)				
1		Telimagrandin II/pterocaryanin C	C41H30O26	
2		Di-HHDP-galloyl-glucose (casuarictin/potentilin) I	C41H28O26	
3		Di-HHDP-galloyl-glucose (casuarictin/potentilin) II	C41H28O26	
4	Elagitanino	Di-HHDP-galloyl-glucose (casuarictin/potentilin) Derivative I	C41H28O26	[13]
5		Di-HHDP-galloyl-glucose (casuarictin/potentilin) Derivative II	C41H28O26	
6		Di-HHDP-galloyl-glucose (casuarictin/potentilin) Derivative III	C41H28O26	
7		Di-HHDP-galloyl-glucose (casuarictin/potentilin) Derivative IV	C41H28O26	
8		Di-HHDP-galloyl-glucose (casuarictin/potentilin) Derivative V	C41H28O26	
Flavonoid (seed)				
1	Chromone	Eugenitine (Negative Ion) [M + Cl]-	C12H12O4	
2	Flavona	Apigenin hexoside (positive Ion) [M + H - H ₂ O]	C21H20O10	
3	Flavona	Apigenin caffeate hexoside (positive Ion) [M + H - H ₂ O]	C36H36O17	
4	Flavona	Methylapigenin hexoside (positive ion) [M + Na] +	C22H22O9	
5	Flavan-3-ol	Catechin dihexoside (positive ion) [M + H] +	C27H34O16	
6	Flavan-3-ol	Catechin hexoside (positive ion) [M + H] +	C21H24O10	[12]
7	Flavonol	Kaempferol diacetyl dicoumaroylhexoside (positive ion) [M + K] +	C43H36O17	
8	Flavonol	Kaempferol dihexoside (positive Ion) [M + H - H ₂ O]	C39H50O23	
9	Flavona	Luteolin hexoside (positive ion) [M + H] +	C20H18O10	
10	Flavonol	Myricetin coumaridihexoside hexoside (positive on) [M + K] +	C42H46O23	
11	Flavonol	Quercetin hexopyranosyl-hexoside (positive ion) [M + Na] +	C26H28O16	
12	Flavonol	Isoquercitrin	C21H20O12	[16]
13	Dihydrochalcone	Floridzin	C21H24O10	
Phenolic Acids (seed)				
1	Hydroxybenzoic acid	Gallic acid (negative ion) [M-H]-	C7H6O5	
2	Hydroxycinnamic acid	Caffeoylquinic Acid (positive Ion) [M + K] +	C16H18O9	
3	Hydroxycinnamic acid	Caffeoyl methylquinic acid (positive ion) [M + Na] +	C17H20O9	
4	Hydroxycinnamic acid	Coumaroyl tartaric acid (positive Ion) [M + H - H ₂ O] +	C13H12O8	[12]
5	Hydroxybenzoic acid	Gallic acid hexoside (positive ion) [M + K] +	C13H16O10	
6	Hydroxybenzoic acid	Vanillic acid (positive ion) [M + K] +	C8H8O4	
7	Hydroxycinnamic acid	P-coumaric acid	C9H8O3	[16]
8	Hydroxycinnamic acid	Synaptic acid	C11H12O5	
Carotenoids (peel)				
1	Xanthophyll	Anhydrozeaxanthin	C40H56O2	[7]

Sample Number (N°): number of samples evaluated for statistical analysis. Class: identification assigned corresponding to the functional group it contains, whether flavonoid, carotenoid, phenolic acid, or tannin. Type: specific compound found in the analysis.

3.4. Tannins

3.4.1. Identified and quantified

[13] found 8 compounds of the hydrolyzable tannin family named as ellagitannins. This group of compounds is formed by single molecules of phenolic acids within which include gallic acid, chlorogenic acid, caffeic acid and other basic structures of phenolic acids mentioned above [17].

Thus, [9], classified *Eugenia stipitata* Mc Vaugh as a medium category fruit in terms of phenolic content. According to Tables 3 and 4 the fruit would be in the low-medium range of total phenolic content. The diversity of results has to do with environmental conditions, geographical area, and management during harvest and postharvest.

Table 7 shows the comparison of the total phenolic content reported in the literature and Table 8 describes the evaluation range of total phenolic compounds depending on the concentration by means of the analysis proposed by [18].

Table 7. Classification of Arazá according to total phenol content.

Total phenolics (mg gallic acid (GAE)/100 g wet weight in pulp)	Source
184,08 ± 8,25	[9]
144,0 ± 0,06	[19]
122,78 ± 2,52	[20]
111 ± 3,64	[21]
87 ± 2	[22]
19,3 ± 5,1	[7]

Table 8. Evaluation range of total phenolic compounds.

Total phenolics level	Amount in (mg gallic acid (GAE)/100 g wet weight in pulp)
Alto	> 500
Medio	100–500
Bajo	< 100

4. Discussion

The present study aimed to characterize the phenolic compounds present in the fruit of *Eugenia Stipitata* Mac Vaugh (Arazá). After conducting a literature review, a total of 82 compounds were identified and quantified, of which 24 were successfully identified and quantified, while 58 were identified without quantification.

The review of carotenoids provided significant insights into the antioxidant potential of the Arazá fruit. The peel exhibited notably higher concentrations of carotenoids compared to the pulp, indicating enhanced antioxidant capacity. These findings align with previous studies such as [23], who reported higher antioxidant capacity in the mature fruit peel attributed to the presence of β -carotene.

Furthermore, the identification of new compounds such as violaxanthin, 15-cis- β -carotene, 13-cis- β -carotene, and 9-cis- β -carotene in both the pulp and peel further contributes to expanding the catalog of known bioactive compounds in Arazá. Importantly, the notable bioaccessibility of certain carotenoids emphasizes their potential health benefits upon consumption [24]. This assertion is shared by various authors, who have concluded in their studies that carotenoids like lutein, cryptoxanthin, and zeaxanthin, which were found to be the most representative in the fruit, provide ocular health benefits with sun-protective properties, in addition to scavenging free radicals and preventing cellular aging of the heart and liver [25,26].

Compounds belonging to the phenolic acid family are attributed with biological properties such as antimicrobial and anticancer activity. Therefore, food industries have utilized these compounds as additives for their antibacterial activity. These benefits are linked to their antioxidant capacity, which, as explained by [25], could be attributed to the high phenolic content of the seed, which they reported to be 15 times higher than that of the peel or fruit. Additionally, they identified six phenolic acids in the seed, a finding that aligns with [16], who also noted the presence of p-coumaric acid and sinapic acid for the first time.

Similarly, flavonoid compounds such as myricetin, quercetin, and kaempferol hold nutraceutical value, aiding in glycemic control, reducing inflammation, lowering the risk of cardiovascular diseases, and exerting anticancer effects for consumers. The concentration of myricetin as a key compound, with notable levels reported by [10] contributes to the nutritional value of Arazá. Recent studies by [13] and [15] expanded the list of flavonoids found in both the pulp and peel, highlighting the fruit's complexity and the potential for additional health benefits.

The phenolic content of the fruit falls within a moderate range, with variability attributed to factors such as environmental conditions, geographical location, and post-harvest practices. These results underscore the influence of multiple factors on phenolic content and provide valuable insights for future studies and industrial applications [9].

In terms of strengths, it's important to mention that this article provides information about identified and quantified compounds related to the *Eugenia stipitata* Mac Vaughn fruit. Compounds were identified not only in the edible part of the fruit but also in the peel and seed. The literature

review revealed that some studies do not explore the entire fruit (pulp, peel, and seed), focusing on one or two parts. Since this review aimed to collect data from different parts of the fruit, the compiled information surpasses what is reported in other literature articles. This is the case with [27], who reported 11 carotenoids and 14 bioactive phenolic compounds from *Eugenia stipitata* Mac Vaughn, highlighting only the fruit's pulp. However, the results described in this study cover the peel, pulp, and seed, providing a complete profile and expanding the number of identified compounds to 82.

Another noteworthy aspect is the investigation of a fruit variety of international interest for Amazonian countries such as Brazil, Peru, Colombia, Venezuela, Ecuador, Bolivia, Suriname, and Guyana.

Regarding limitations, it's worth mentioning that some standard deviation data are not reported throughout this review, as they were not provided in the evaluated studies. Despite attempts to contact the authors, satisfactory responses for complete records were not obtained.

It's important to highlight that a strength of this work was the inclusion of polyphenol analysis of the seeds, an area that had received limited attention in previous research. This innovative approach opens avenues to explore potential industrial applications of these compounds.

5. Conclusion

This review was able to identify and report the concentration, and in some cases the amount, of phenolic compounds with antioxidant and anti-inflammatory capacity of *Eugenia stipitata* Mac Vaughn. With this scope, it was possible to have a more complete picture of the potential of the fruit to possibly improve health aspects, and to give a greater enhancement and added value to this product so that it can be integrated more frequently in the menu of the people who access it and even to be exported.

We call on researchers to try to quantify the polyphenols in future studies, for which no information was found in the literature reviewed, to give this fruit all its nutritional and therapeutic value that it presents in its compounds.

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