Food Research 9 (6) : 6 - 15 (December 2025)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

MINI REVIEW

Physicochemical, nutritional and functional properties of *Annona muricata* L: a review

[1,*]Obregón-La Rosa, A.J., [2]Alfaro-Cruz, S.C. and [3]Rojas-Naccha, J.C.

[1]*Facultad de Ciencias de la Salud, Universidad Tecnológica del Perú, Lima, Perú*
[2]*Escuela de Ingeniería Industrias Alimentarias, Universidad Nacional José Faustino Sánchez Carrión, Huacho, Lima, Perú*
[3]*Departamento de Ciencias Agroindustriales, Universidad Nacional de Trujillo, Trujillo, Perú*

Article history:
Received: 8 January 2025
Received in revised form: 18 February 2025
Accepted: 6 March 2025
Available Online: 11 November 2025

Keywords:
Annona muricata,
Cactaceae,
Phytochemicals,
Nutritional properties,
Proximate composition

DOI:
https://doi.org/10.26656/fr.2017.9(6).001

Abstract

Annona muricata L., a tropical fruit-bearing plant, is widely recognized for its distinctive flavor and aroma, as well as its potential pharmacological and therapeutic properties. This review provides an updated overview of the nutritional, physicochemical, and bioactive properties of *A. muricata*, while also exploring its potential applications in health and human nutrition. A systematic search was conducted in databases such as Scopus and PubMed, utilizing predefined keywords and controlled vocabulary, in accordance with the PRISMA methodology. This search yielded 1248 articles, from which 25 relevant studies were selected, focusing on the nutritional, physicochemical, pharmacological, and bioactive properties of *A. muricata*. This species holds considerable commercial and economic value worldwide. Its composition includes a diverse array of phytochemicals that contribute to its medicinal properties, supporting its use in the management of various conditions, including diabetes, cancer, ulcers, oxidative stress, hypertension, bleeding disorders, and hyperlipidemia. Given its valuable nutritional profile and therapeutic potential, *Annona muricata* offers promising opportunities for the development of functional ingredients and pharmaceuticals aimed at enhancing public health.

1. Introduction

Annona muricata L. is a plant native to various tropical regions worldwide, particularly in Peru and Ecuador, within the Andean highlands. Its cultivation dates back to the time of the ancient Inca Empire in Peru. Anthropological evidence indicates that *A. muricata* was part of the diet of the ancient Inca civilization (Bonavia *et al*., 2004). Commonly known as soursop, graviola, guanabana, paw-paw, and sirsak, this fruit belongs to the Annonaceae family, which comprises approximately 130 genera and 2,300 species (Moghadamtousi *et al*., 2015; Coria-Téllez *et al*., 2018; Osei *et al*., 2023).

The cultivation of this fruit is of significant international importance due to its nutritional and medicinal properties. While *A. muricata* is primarily consumed fresh, a wide variety of products derived from the fruit are commercially available, including ice creams, juices, nectars, yogurt, purees, alcoholic beverages, desserts, and extracts containing bioactive compounds with medicinal properties (Hernández Fuentes *et al*., 2022).

Over the past few decades, research has highlighted that *A. muricata* contains a diverse array of phytochemicals, such as acetogenins, alkaloids, fatty acids, cyclic peptides, and flavonoids (Anaya-Esparza and Montalvo-González, 2020; Solís-Fuentes *et al*., 2020; Olas, 2023; Osei *et al*., 2023). Furthermore, it has a wide range of medicinal applications due to its pharmaceutical, nutraceutical, and metabolomic properties (Zubaidi *et al*., 2023; Nambooze *et al*., 2024).

The objective of this review is to provide updated information on the nutritional, physicochemical, and functional properties of *A. muricata*, and to explore its potential applications in the development of foods and functional ingredients for health-related purposes in human nutrition.

2. Material and methods

For an adequate information search, the recommendations of the PRISMA statement were followed (Moher *et al*., 2009; Page *et al*., 2021). The following MeSH terms were identified as keywords in

*Corresponding author.
Email: *c23320@utp.edu.pe*

eISSN: 2550-2166 /
Published by Rynnye Lyan Resources

English: "*Annona muricata*," guanabana, graviola, soursop, Annonaceae, "bioactive compounds," "nutritional compounds," "chemical composition," antioxidants, phytochemicals, "functional foods," "pharmaceutical properties," and polyphenols.

The search was conducted from January to February 2024 in the following databases: Scopus and PubMed, preferably focusing on publications from the last 10 years.

Likewise, the search terms that produced the most effective results in both search engines were: (TITLE-ABS-KEY ("annona muricata" OR graviola OR soursop OR annonacea) AND TITLE-ABS-KEY ("Bioactive compounds" OR "nutritional compounds" OR "chemical composition" OR antioxidants OR phytochemicals OR "functional foods" OR "pharmaceutical properties" OR poliphenols)) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "ch")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish")). A total of 1248 articles were retrieved, with 908 originating from the Scopus database and 340 from PubMed, for detailed analysis. From these, 25 studies focusing on the nutritional, physicochemical, pharmacological, and bioactive properties of *A. muricata* were selected.

3. Results and discussion

3.1 Botanical characteristics

The fruit of *Annona muricata* has several common names depending on the region of origin: soursop, guanabana, graviola, sirsak, among others (Coria-Téllez *et al*., 2018). This plant belongs to the Annonaceae family, in the genus Annona, within the division Angiosperms and the class Magnoliophyta (Wilkins, 2007; Gavamukulya *et al*., 2017; Santos *et al*., 2023). The genus Annona encompasses over 70 species, of which *A. muricata* is the most cultivated and one of the most valued varieties worldwide (Santos *et al*., 2023). Table 1 shows the taxonomy of this plant, as well as its availability, common names, and the uses of the various parts of the plant.

The Annonaceae, which are part of the order Magnoliales, are the most extensive and varied family within this group, characterized by their high species richness, low extinction rates, and diverse habitats. This family is one of the most primitive among seed plants (also known as angiosperms) and is often referred to as Annoniflorae due to the frequency with which they exhibit an indefinite number of free floral parts and spirally arranged stamens (Paull and Duarte, 2010; Leal and Paull, 2023).

3.2 Proximal composition

The main component of the proximal composition present in *A. muricata* corresponds to carbohydrates, with fiber content being the most significant representative (0.74 to 5.76 g/100 g) (Table 2). The variations found in the different levels of fiber reported by various authors are due to different factors, such as climatic conditions, cultivation methods, origin and analysis methods.

Dietary fiber refers to the parts of plant-based foods that are not digested by enzymes. It is categorized into two types: soluble and fermentable fiber, which can be processed in the colon, and insoluble fiber, which provides bulk but can also undergo extensive fermentation in the colon (Snauwaert *et al*., 2023). It is important to note that most prebiotics are indigestible carbohydrates that ferment in the colon. Inulins and fructooligosaccharides act selectively to stimulate the growth of bifidobacteria, which are considered beneficial

Table 1. General information about *Annona muricata* L.

Taxonomy	Availability	Common names	Plant parts in use	Reference(s)
Kingdom: Plantae Division: Angiosperms (Magnoliophyta) Class: Magnolids Order: Magnoliales Family: Annonaceae Genus: Annona Species: *Annona muricata*	Tropical regions of Central and South America, Western Africa and Southeast Asia.	English: soursop Indonesian: sirsak, nangka belanda Malay: durian belanda Portugese: graviola Latin American Spanish: guanabana Other Indigenous names: annone, anona, araticum grande, araticum-manso, graviola, guanábana, guanábano, prickly custard apple	Leaf, bark, root, seed, fruit, flower, stem, pulp	Wilkins (2007), Moghadamtousi *et al*. (2015), Coria-Téllez *et al*. (2018), Wahab *et al*. (2018)

Table 2. Proximal composition of the edible part of *Annona muricata* L. fruits.

Moisture (g)	Protein (g)	Lipids (g)	Carbohydrates (g)	Fiber (g)	Country of origin	Reference(s)
67.45	3.59	0.80	-------	2.36	Nigeria	Afzaal *et al.* (2022)
80.48-83.2	0.69 – 1.10	0.20-0.97	12.50-18.23	4.83-5.76	Mexico	Hernández Fuentes *et al.* (2022)
81.20	1.00	0.30	16.80	3.30	USA	Gómez-Maqueo *et al.* (2020)
84.00	0.90	0.20	14.30	3.30	Peru	Reyes *et al.* (2017)
79.34±0.34 - 81.14±0.33	1.02± 0.02- 1.10± 0.02	0.01± 0.01	11.91±0.32 - 14.70±1.57	3.72±0.22 - 5.69±0.08	Brazil	Siqueira *et al.* (2015)
78.46-80.93	0.94 - 1.24	0.51-0.79	13.80 – 18.60	0.74-0.86	Venezuela	Ojeda *et al.* (2007)
65.14±2.31	5.35±0.24	0.74±0.06	15.62±3.14	2.26±0.10	Nigeria	Ndife *et al.* (2014)

for human health (Ioniță-Mîndrican *et al*., 2022). The American Dietetic Association recommends a consumption of 14 g of dietary fiber for every 1,000 kcal, additionally recommending 25 g for adult women and 38 g for adult men. Thus, 100 g of *A. muricata* could provide between 3% and 23% of the recommended daily intake for women and between 2.3% and 15.2% for men.

3.3 Physicochemical characteristics

Table 3 presents the reported results on the physicochemical characteristics of different *A. muricata* genotypes. Regarding its soluble solids content, the values are relatively variable, ranging from 5.28 to 15.50 °Brix. It can be observed that the highest reported values of soluble solids corresponded to genotypes from Venezuela, with a range of 13.80 to 15.50 °Brix, which is one of the countries with the highest production of this crop.

The flavor of *A. muricata* fruit results from a combination of organic acids and sugars, with the most important being citric and malic acids (Hernández Fuentes *et al*., 2022). Organic acids play an important role in terms of flavor and texture, which are fundamental for consumer acceptance (Guevara *et al*., 2019).

The pulp of *A. muricata* is slightly acidic, with pH values ranging from 3.52 to 4.1 across different genotypes. *A. muricata* exhibits high acidity (0.36-1.52 g citric acid/100 g fresh fruit). This value is similar when compared with orange (0.6-1.3%) (Shaaban *et al*., 2006), but lower when compared with lemon (5.84-6.52%) (Al-Jaleel *et al*., 2005).

3.4 Mineral content

The mineral content of *A. muricata* is shown in Tables 4 and 5. Potassium is the most abundant macromineral, followed in order by phosphorus and calcium.

Gómez-Maqueo *et al*. (2020) reported that the predominant mineral in fruits from the Mesoamerican region is potassium, with values ranging from 125 to 660 mg/100 g, placing *A. muricata* within this range. It should be noted that this study reported potassium values in the range of 278-320 mg/100 g of edible fruit (Table 4).

On the other hand, Gómez-Maqueo *et al*. (2020) and Rhodes *et al*. (2023) reported that the most relevant microelements in *A. muricata* are iron (6 mg/kg), zinc (1 mg/kg) and copper (0.9 mg/kg), values that are comparable with those reported by Reyes *et al*. (2017) for iron (7-10 mg/kg) and zinc (1 mg/kg) (Table 5).

Minerals are important for human nutrition. Enzymatic activities, as well as the electrolyte balance of blood fluid, are related to adequate levels of Na, K, Mg, and Zn. Potassium is essential for maintaining blood fluid volume and osmotic balance. Rickets and calcification of bones can be caused by a deficiency of these micronutrients (Akomolafe and Ajayi, 2015).

The presence and quantity of different minerals in plants are attributed to soil composition, selectivity, and the ability of plants to absorb and accumulate these

Table 3. Physicochemical characteristics of the edible part of *Annona muricata* fruits.

Total acidity (g/100 g citric acid)	pH	Soluble solids (°Brix)	Country of origin	Reference(s)
1.02	3.70	11.00	Peru	Fernández and Ramos (2021)
0.70	3.60	10.90	Mexico	Jiménez-Zurita *et al.* (2017)
1.50±0.05	3.52±0.35	5.28±0.12	Nigeria	Ndife *et al.* (2014)
1.02± 0.43	3.70±0.06	11.00±0.40	Malaysia	Umme *et al.* (1997), Badrie and Schauss (2010)
0.36-0.48	3.8-4.1	13.80-15.50	Venezuela	Ojeda *et al.* (2007)

https://doi.org/10.26656/fr.2017.9(6).001

Table 4. Mineral macroelements content of *Annona muricata* (mg/100 g).

Calcium	Phosphorus	Potassium	Magnesium	Country of origin	Reference(s)
14	27	278	21	USA	Gómez-Maqueo *et al*. (2020),
38	43	----------	----------	Peru	Reyes *et al*. (2017)
10.3	27.7	-----------	-----------	Cuba	Badrie and Schauss (2010)
9-10.3	27.7-29	320	22	Mexico	Hernández Fuentes *et al*.

Table 5. Mineral microelements content of *Annona muricata* (mg/kg).

Iron	Zinc	Copper	Country of origin	Reference
6.0	1.0	0.9	USA	Gómez-Maqueo *et al*. (2020), Rhodes *et al*. (2023)
7.0 – 10.0	1.0	---------	Peru	Reyes *et al*. (2017)
2-6	-------	---------	n.d	Pareek *et al*. (2011)
0.500±0.01	0.25±0.03	0.100±0.01	Solomon Islands	Maeaba *et al*. (2025)

n.d.: not determined

micronutrients. The presence and variations in concentration are attributed to the type of plant and its environment (Ugochi *et al*., 2019).

Copper acts as a vital catalyst for many reactions involved in iron absorption, and its deficiency can lead to osteoporosis and anemia. Zinc is a key component of many enzymes and plays a vital role in the actions of various enzymes, such as alcohol dehydrogenase, ribonucleic acid polymerases, alkaline phosphatase, and carbonic anhydrase. Zinc deficiency during pregnancy can lead to developmental disorders in offspring and may also contribute to coronary diseases (Karpiuk *et al*., 2016; Ugochi *et al*., 2019).

3.5 Bioactive compounds

More than 200 bioactive compounds have been found in *A. muricata*, in its various parts: leaves, seeds, and fruits. The main components found are acetogenins, alkaloids, and phenolic compounds, among others (Coria -Téllez *et al*., 2018; Patil *et al*., 2023). Table 6 presents the content of the main bioactive compounds present in the edible part of *A. muricata* from different countries. These findings underscore the variability in the levels of bioactive compounds in *A. muricata* according to the geographic region of cultivation, which is crucial for understanding its nutritional potential and health benefits.

The values of vitamin C varied in a range from 15.98 to 106 mg of ascorbic acid/100 g of fresh weight (Table 6). According to the classification reported by Ramful *et al*. (2011), in terms of vitamin C content, *A. muricata* would be classified as a fruit with medium to high vitamin C content (between 30 to more than 50 mg of vitamin C/100 g of fresh weight). According to Bendich (2001), the recommended daily intake (RDI) of vitamin C for adults over 19 years old is 90 mg for men and 75 mg for women. Therefore, *A. muricata* could provide 18% to 100% of the daily vitamin C requirement.

Regarding the total phenolic content, it varied from 42 to 485.85 mg GAE/100 g of fresh weight (Table 6). *Annona muricata* would represent a fruit with low (< 100 GAE/100 g of fresh weight) to medium (100-500 mg GAE/100 g of fresh weight) total phenolic content (Vasco *et al*., 2008).

The main phenolic compounds present in *A. muricata* are: Rutin, Kaempferol, and Quercetin (Patil *et al*., 2023). These compounds exhibit antioxidant, anticancer, and antiplatelet activities (Rady *et al*., 2018; Son *et al*., 2021; Olas, 2023).

Regarding flavonoid content, these vary from 1.9220 to 28.4 mg QE/g of sample (Table 4). It has been reported that the main flavonoids found in *A. muricata* include: Luteolin, the most abundant flavonoid, followed

Table 6. Bioactive compounds from the edible part of *Annona muricata.*

Vitamin C (mg/100 g)	Total polyphenols (mg GAE/100 g)	Total flavonoids (mg QE/g)	Country of origin	Reference
30.0±1.2	86.1±0.9	28.4±0.5	Sri Lanka	Abeysuriya *et al*. (2020)
---------	-----------	2.16±0.12-34.41±2.20	Dominican	Orak *et al*. (2019)
106±8.50	485.85±36.38	2.15±0.18	Ecuador	Guevara *et al*. (2019)
15.98	236	---------	Singapore	Isabelle *et al*. (2010)
---------	42.0	nd	Fiji	Lako *et al*. (2007)
26.64±1.01	398.79±14.91	1.9220±8.50	Ecuador	Párraga *et al*. (2024)

nd: not detected, GAE: Gallic acid equivalent, QE: Quercetin equivalent

https://doi.org/10.26656/fr.2017.9(6).001

by Myricetin and Apigenin (Párraga *et al*., 2024).

3.6 Antioxidant capacity

To determine the antioxidant capacity of *A. muricata*, a variety of methods have been used, most of which utilize chromogenic compounds that stimulate the reduction of reactive oxygen species. The most commonly used assays are 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2′-azinobis-(3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS), ferric reducing/antioxidant power (FRAP), and Oxygen Radical Absorbance Capacity (ORAC) (Ihejieto *et al*., 2023) (Table 7).

The antioxidant capacity values shown in Table 7 demonstrate variability in results within each type of assay and when compared to one another. This variability is due to a number of factors, such as the extraction techniques used, the reagents employed, the origin of the fruit, its maturity stage and its composition.

In evaluating the antioxidant capacity of foods, the combined effect of various antioxidants present is analyzed, which possess different mechanisms of action and may interact synergistically. For this reason, it is essential to employ multiple methods to determine the in vitro antioxidant capacity of foods (Pérez-Jiménez *et al*., 2008; Almeida *et al*., 2011; Yamauchi *et al*., 2024).

Abeysuriya *et al*. (2020) reported an EC_{50} value of 67.4±0.3 mg/mL for *A. muricata*. According to their classification, fruits with a low EC_{50} value (20-100 mg/mL) exhibit high antioxidant activity to scavenge free radicals; therefore, *A. muricata* would be classified by these authors as a fruit with high antioxidant activity.

Regarding the antioxidant content assessed using the ABTS method, the results exhibit considerable variability, which is influenced by both the country of origin and the method of expression employed (Table 7). As noted by various studies, one of the most common methods to evaluate the effectiveness of an antioxidant in capturing free radicals is the ABTS•+ radical. This method is characterized by its high sensitivity, practicality, speed, and stability (Kuskoski *et al*., 2005). However, the measured antioxidant activity may vary depending on the selected evaluation time. In the ABTS method, absorbance is measured at 1 and 7 min. However, research has indicated that the reaction with the ABTS•+ radical is not complete in less than 1 minute, and according to Re *et al*. (1999), the most appropriate time is 4 min.

On the other hand, regarding the determination of antioxidant content using the Oxygen Radical Absorbance Capacity (ORAC) method, (Isabelle *et al*., 2010) indicated that it is better to report antioxidant capacity values per serving size, which varies depending on the type of fruit, as each fruit is consumed in different amounts. *A. muricata* reported a value of 2003 µM TE/serving size, higher than other traditional fruits such as banana (*Musa paradisiaca* L.; 1173 µM TE/serving size), red pitaya (*Hylocereus polyrhizus*; 1239 µM TE/serving size), grape (*Vitis vinifera* L.; 1358-1478 µM TE/serving size), mango (*Mangifera indica* L.; 1535 µM TE/serving size), cantaloupe melon (*Cucumis melo* L. var. *Reticulatus*; 162 µM TE/serving size), apple (*Malus domestica* Borkh; 135-198 µM TE/serving size), pineapple (*Ananas comosus* L. Merril; 1006 µM TE/serving size), papaya (*Carica papaya* L.; 381 µM TE/serving size), among others (Isabelle *et al*., 2010).

3.7 Other compounds

A component of great relevance for public health found in Annonaceae, such as *A. muricata*, is annonaceous acetogenins. These secondary metabolites,

Table 7. Antioxidant capacity of *Annona muricata* according to method of analysis

EC_{50} DPPH	ABTS	FRAP	Country of origin	Reference(s)
67.4±0.3 (mg/mL)	---------------	20.8±0.4 (µmol $FeSO_4$/g FW)	Sri Lanka	Abeysuriya *et al*. (2020)
0.22± 0.11 (mg/mL)	0.87±0.04 (mg/mL)	76.7±0.80 (µmol Fe^{2+}/g)	Dominican Island/ South Korea	Nam *et al*. (2017); Orak *et al*. (2019)
92.96±9.46 (µmol TE/g FW)	-------	422.11±57.72 (µmol TE/g FW)	Ecuador	Guevara *et al*. (2019)
102.86±0.215 (µg/mL)	20.00±0.22 (mmol TE/µg)	----------	Nigeria	Oboh *et al*. (2015)
1.36±0.01(µmol/g)	6.09±0.13 (µmol/g)	---------	Brazil	Almeida *et al*. (2011)
---------	----------------	503±11 (µmol/L/g)	Fiji	Correa Gordillo *et al*. (2012)
2.88±0.2 (µmol TE/g)	4.3±0.4 (µmol TE/g)	---------	Brazil	Kuskoski *et al*. (2005)
0.85±0.15 (mg/mL)	0.84±0.06 (mg/mL)	0.89±0.09 (µmol Fe^{2+}/g)	Mexico	León-Fernández *et al*. (2017)

TE: Trolox Equivalent, DPPH: diphenyl-1-picrylhydrazy, ABTS: 2:2-Azinobis 3-ethylbenzthiazoline-6-sulfonic acid radical scavenging assay, FRAP: ferric ion reducing antioxidant parameter, EC_{50}: concentration required to obtain an antioxidant effect of 50%.

https://doi.org/10.26656/fr.2017.9(6).001

derived from fatty acids, are found in different parts of the plant, including leaves, seeds, pulp, and peel of the fruit. Acetogenins are characterized by long aliphatic chains comprising 35 to 37 carbon atoms, a terminal ring of γ-lactone methyl-alpha beta-unsaturated, as well as tetrahydrofuran (THF) and tetrahydropyran (THP) rings, although the latter are present less frequently (Lima *et al.*, 2022; Aguilar-Hernández *et al.*, 2024). More than 120 acetogenins have been found in the leaves, stems, bark, seeds, pulp, and peel of *A. muricata*, with the leaves containing around 46 acetogenins (Wahab *et al.*, 2018; Zubaidi *et al.*, 2023).

Various studies have confirmed that acetogenins from *A. muricata* have effects in reducing several types of cancer, including colon, breast, skin, prostate cancer, and leukemia (Rady *et al.,* 2018; Anaya-Esparza and Montalvo-González, 2020; Delgado *et al.*, 2021). Acetogenins exhibit antiproliferative, cytotoxic, and anticancer properties. They show inhibitory activity against mitochondrial complex I NADPH, which is an essential part of the electron transport chain and vital for producing large amounts of ATP in cancer cells (Deep *et al.*, 2016; Qazi *et al.*, 2018). Moreover, these compounds have been shown to affect various metabolic pathways by inhibiting the Na^+/K^+ ATPase pump, as well as the hypoxic and glycolytic pathways, resulting in the induction of apoptosis and cell death (Yap *et al.*, 2017; Yiallouris *et al.*, 2018; Delgado *et al.*, 2021).

3.8 Potential therapeutic uses of Annona muricata

Various components of the *A. muricata* tree and other species within the Annona genus are utilized in traditional medicine for the treatment of numerous human health issues, including cancer and parasitic infections. The fruit of this plant is commonly employed in natural remedies to alleviate pain from conditions such as arthritis, neuralgia, diarrhea, dysentery, fever, malaria, parasitic infections, rheumatism, skin rashes, and worms. In contrast, the leaves are used to address conditions like cystitis, diabetes, headaches, and insomnia. (Moghadamtousi *et al*., 2015; Ilango *et al*., 2022; Mutakin *et al*., 2022). Likewise, the seeds of *A. muricata* are used in the treatment of helminthiasis and parasitosis, while its leaves, bark and roots have been used for their anti-inflammatory, antihypertensive, sedative, antidiabetic, smooth muscle relaxant and antispasmodic properties (Moghadamtousi *et al*., 2015; Mutakin *et al*., 2022).

Various studies have examined different parts of *A. muricata*, revealing a wide range of phytochemicals. These include alkaloids, megastigmanes, flavonol triglycosides, phenolic compounds, essential oils, and acetogenins. In addition, the presence of essential minerals such as potassium, calcium, sodium, copper, iron and magnesium has been identified (Moghadamtousi *et al*., 2015).

Several researchers have studied and demonstrated the pharmacological properties of *A. muricata* extracts, such as anticancer, cytotoxic, anti-inflammatory, antiulcer, antidiabetic, antibacterial and antiviral, among others (Oyebamiji *et al*., 2022; Nambozee *et al*., 2024).

4. Conclusion

Annona muricata contains a variety of bioactive compounds, including acetogenins, flavonoids, phenolic acids, alkaloids, and vitamin C. It is particularly notable for its high fiber content and its abundance of both macronutrients and micronutrients, such as potassium, calcium, magnesium, copper, iron, and zinc. This review examines the therapeutic uses and applications of *A. muricata*, as well as its chemical composition and pharmacological effects. Further research is needed to explore the biochemical and physiological functions of the bioactive compounds in *A. muricata*, along with the underlying mechanisms responsible for these activities. Future studies and clinical trials should also investigate the potential toxicity of specific compounds, as well as determine their optimal dosages and effects on human health.

Conflict of interest

The authors declare no conflict of interest.

References

Abeysuriya, H.I., Bulugahapitiya, V.P. and Loku, P.J. (2020). Total vitamin C, ascorbic acid, dehydroascorbic acid, antioxidant properties, and iron content of underutilized and commonly consumed fruits in Sri Lanka. *International Journal of Food Science*, 2020, 4783029. https://doi.org/10.1155/2020/4783029

Afzaal, M., Saeed, F., Asghar, A., Shah, Y.A., Ikram, A., Ateeq, H., Hussain, M., Ofoedu, C.E. and Chacha, J.S. (2022). Nutritional and Therapeutic Potential of Soursop. *Journal of Food Quality*, 2022, 8828358. https://doi.org/10.1155/2022/8828358

Aguilar-Hernández, G., López-Romero, B.A., Huerta-Castellanos, I., Tellez-Isaias, G. and Montalvo-González, E. (2024). Acetogenins from *Annona muricata* as Antimicrobial Agents. In Tellez-Isaias, G., Graham G. and El-Ashram, S. (Eds.). Enterococcus - Unveiling the Emergence of a Potent Pathogen, p. 1-19. Intechopen E-Book. https://doi.org/10.5772/intechopen.115064

Akomolafe, S.F. and Ajayi, O.B. (2015). A comparative study on antioxidant properties, proximate and mineral compositions of the peel and pulp of ripe *Annona muricata* (L.) fruit. *International Food Research Journal,* 22(6), 2381–2388.

Al-Jaleel, A., Zekri, M. and Hammam, Y. (2005). Yield, fruit quality, and tree health of "Allen Eureka" lemon on seven rootstocks in Saudi Arabia. *Scientia Horticulturae*, 105(4), 457-465. https://doi.org/10.1016/j.scienta.2005.02.008

Almeida, M.M.B., de Sousa, P.H.M., Arriaga, Â.M.C., do Prado, G.M., Magalhães, C.E. de Carvalho, C.E., Maia, G.A. and de Lemos, T.L.G. (2011). Bioactive compounds and antioxidant activity of fresh exotic fruits from northeastern Brazil. *Food Research International*, 44(7), 2155–2159. https://doi.org/10.1016/j.foodres.2011.03.051

Anaya-Esparza, L.M. and Montalvo-González, E. (2020). Bioactive Compounds of Soursop (Annona muricata L.) Fruit. In Murthy, H., Bapat, V. (Eds.). Bioactive Compounds in Underutilized Fruits and Nuts. Reference Series in Phytochemistry, p. 175-189. Cham, Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-030-30182-8_8

Badrie, N. and Schauss, A.G. (2010). Soursop (*Annona muricata* L.): Composition, nutritional value, medicinal uses, and toxicology. In Ross, W.R. and Preedy, R.V. (Eds.). Bioactive Foods in Promoting Health, p. 621–643. London, UK: Academic Press. https://doi.org/10.1016/B978-0-12-374628-3.00039-6

Bendich, A. (2001). Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Institute of medicine, Washington, DC, USA: National Academy Press. https://doi.org/10.1016/s0899-9007(00)00596-7

Bonavia, D., Ochoa, C.M., Tovar, Ó.S. and Palomino, R.C. (2004). Archaeological Evidence of Cherimoya (*Annona cherimolia* Mill.) and Guanabana (*Annona muricata* L.) in Ancient Peru. *Economic Botany*, 58(4), 509–522. https://doi.org/10.1663/0013-0001(2004)058[0509:aeocac]2.0.co;2

Coria-Téllez, A.V., Montalvo-Gónzalez, E., Yahia, E.M. and Obledo-Vázquez, E.N. (2018). Annona muricata: A comprehensive review on its traditional medicinal uses, phytochemicals, pharmacological activities, mechanisms of action and toxicity. *Arabian Journal of Chemistry*, 11(5), 662–691. https://doi.org/10.1016/j.arabjc.2016.01.004

Correa Gordillo, J., Ortiz, D., Larrahondo, J.E., Sánchez Mejía, M. and Pachón, H. (2012). Actividad antioxidante en guanábana (*Annona muricata* L.). *Boletín Latinoamericano y Del Caribe de Plantas Medicinales y Aromaticas*, 11(2), 111–126.

Deep, G., Kumar, R., Jain, A.K., Dhar, D., Panigrahi, G.K., Hussain, A., Agarwal, C., El-Elimat, T., Sica, V.P., Oberlies, N.H. and Agarwal, R. (2016). Graviola inhibits hypoxia-induced NADPH oxidase activity in prostate cancer cells reducing their proliferation and clonogenicity. *Scientific Reports*, 6, 23135. https://doi.org/10.1038/srep23135

Delgado, Y., Cassé, C., Ferrer-Acosta, Y., Suárez-Arroyo, I.J., Rodríguez-Zayas, J., Torres, A., Torres-Martínez, Z., Pérez, D., González, M.J., Velázquez-Aponte, R.A., Andino, J., Correa-Rodríguez, C., Franco, J.C., Milán, W., Rosario, G., Velázquez, E., Vega, J., Colón, J. and Batista, C. (2021). Biomedical effects of the phytonutrients turmeric, garlic, cinnamon, graviola, and oregano: A comprehensive review. *Applied Sciences*, 11(18), 847. https://doi.org/10.3390/app11188477

Fernández, R. and Ramos, F. (2021). Efecto de la ingesta de frutas nativas como guanábana, sachatomate, aguaymanto y tumbo serrano sobre la glicemia a través del índice glicémico. *Revista Españoña de Nutrición Comunitaria*, 27(2), 131–137. https://doi.org/10.14642/RENC.2021.27.2.5366 [In Spanish].

Gavamukulya, Y., Wamunyokoli, F. and El-Shemy, H.A. (2017). *Annona muricata*: Is the natural therapy to most disease conditions including cancer growing in our backyard? A systematic review of its research history and future prospects. *Asian Pacific Journal of Tropical Medicine*, 10(9), 835–848. https://doi.org/10.1016/j.apjtm.2017.08.009

Gómez-Maqueo, A., Escobedo-Avellaneda, Z. and Welti-Chanes, J. (2020). Phenolic compounds in mesoamerican fruits—Characterization, health potential and processing with innovative technologies. *International Journal of Molecular Sciences*, 21(1), 8357. https://doi.org/10.3390/ijms21218357

Guevara, M., Tejera, E., Granda-Albuja, M.G., Iturralde, G., Chisaguano-Tonato, M., Granda-Albuja, S., Jaramillo-Vivanco, T., Giampieri, F., Battino, M. and Alvarez-Suarez, J.M. (2019). Chemical composition and antioxidant activity of the main fruits consumed in the western coastal region of Ecuador as a source of health-promoting compounds. *Antioxidants*, 8(9), 8090387. https://doi.org/10.3390/antiox8090387

Hernández Fuentes, L.M., González, E.M., Magaña, M. de L.G., Esparza, L.M.A., González, Y.N., Villagrán, Z., Torres, S.G., Monreal, J.J.V. and Flores, D.A.M. (2022). Current situation and perspectives of fruit annonaceae in Mexico: Biological and agronomic importance and bioactive properties. *Plants*, 11(1), 10007. https://doi.org/10.3390/plants11010007

Ihejieto, H.A., Ibegbulem, C.O., Ujowundu, C.O. and Ukairo, D.I. (2023). Antioxidative Potentials of *Annona muricata* Pulp and *Allium cepa* Bulb Juices. *International Journal of Biochemistry Research and Review*, 32(8), 8832. https://doi.org/10.9734/ijbcrr/2023/v32i8832

Ilango, S., Sahoo, D.K., Paital, B., Kathirvel, K., Gabriel, J.I., Subramaniam, K., Jayachandran, P., Dash, R.K., Hati, A.K., Behera, T.R., Mishra, P. and Nirmaladevi, R. (2022). A Review on *Annona muricata* and Its Anticancer Activity. *Cancers*, 14 (18), 4539. https://doi.org/10.3390/cancers14184539

Ioniță-Mîndrican, C.B., Ziani, K., Mititelu, M., Oprea, E., Neacşu, S.M., Moroşan, E., Dumitrescu, D.E., Roşca, A.C., Drăgănescu, D. and Negrei, C. (2022). Therapeutic Benefits and Dietary Restrictions of Fiber Intake: A State-of-the-Art Review. *Nutrients*, 14(13), 2641. https://doi.org/10.3390/nu14132641

Isabelle, M., Lee, B.L., Lim, M.T., Koh, W.P., Huang, D. and Ong, C.N. (2010). Antioxidant activity and profiles of common fruits in Singapore. *Food Chemistry*, 123(1), 77-84. https://doi.org/10.1016/j.foodchem.2010.04.002

Jiménez-Zurita, J.O., Balois-Morales, R., Alia-Tejacal, I., Porfirio Juárez-López, P., Sumaya-Martínez, M.T. and Bello-Lara, J.E. (2017). Caracterización de frutos de guanabana (*Annona muricata* L.) en Tepic, Nayarit, México. *Revista Mexicana de Ciencias Agrícolas*, 7(6), 1261–1270. https://doi.org/10.29312/remexca.v7i6.175

Karpiuk, U.V., Al Azzam, K.M., Mahmoud Abudayeh, Z.H., Kislichenko, V., Naddaf, A., Cholak, I. and Yemelianova, O. (2016). Qualitative and quantitative content determination of macro-minor elements in *Bryonia alba* L. roots using flame atomic absorption spectroscopy technique. *Advanced Pharmaceutical Bulletin*, 6(2), 285-291. https://doi.org/10.15171/apb.2016.040

Kuskoski, E.M., Asuero, A.G., Troncoso, A.M., Mancini-Filho, J. and Fett, R. (2005). Aplicación de diversos métodos químicos para determinar actividad antioxidante en pulpa de frutos. *Ciência e Tecnologia de Alimentos*, 25(4), 400016. https://doi.org/10.1590/s0101-20612005000400016

Lako, J., Trenerry, V.C., Wahlqvist, M., Wattanapenpaiboon, N., Sotheeswaran, S. and Premier, R. (2007). Phytochemical flavonols, carotenoids and the antioxidant properties of a wide selection of Fijian fruit, vegetables and other readily available foods. *Food Chemistry*, 101(4), 1727–1741. https://doi.org/10.1016/j.foodchem.2006.01.031

Leal, F. and Paull, R.E. (2023). The genus Annona: Botanical characteristics, horticultural requirements and uses. *Crop Science*, 63(3), 1030-1049. https://doi.org/10.1002/csc2.20833

León-Fernández, A.E., Obledo-Vazquez, E.N., Vivar-Vera, M.D.L.A., Sáyago-Ayerdi, S.G. and Montalvo - Gonzalez, E. (2017). Evaluation of emerging methods on the polyphenol content, antioxidant capacity and qualitative presence of acetogenins in soursop pulp (*Annona muricata* L.). *Revista Brasileira de Fruticultura*, 39, 1–8. https://doi.org/10.1590/0100-29452017358

Lima, N.N.C., Faustino, D.C., Allahdadi, K.J., França, L.S. de A. and Pinto, L.C. (2022). Acetogenins from Annonaceae plants: potent antitumor and neurotoxic compounds. *PharmaNutrition*, 20, 100295. https://doi.org/10.1016/j.phanu.2022.100295

Maeaba, W., Singh, P. and Prasad, S. (2025). Determination of Microelements Profile in Fruits from the Solomon Islands. *Journal of Food Composition and Analysis*, 2025, 107284. https://doi.org/10.1016/j.jfca.2025.107284

Moghadamtousi, S.Z., Fadaeinasab, M., Nikzad, S., Mohan, G., Ali, H.M. and Kadir, H.A. (2015). *Annona muricata* (Annonaceae): A review of its traditional uses, isolated acetogenins and biological activities. *International Journal of Molecular Sciences*, 16(7), 15625-15658. https://doi.org/10.3390/ijms160715625

Moher, D., Liberati, A., Tetzlaff, J. and Altman, D.G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine*, 6(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Mutakin, M., Fauziati, R., Fadhilah, F.N., Zuhrotun, A., Amalia, R. and Hadisaputri, Y.E. (2022). Pharmacological Activities of Soursop (*Annona muricata* Lin.). *Molecules*, 27(4), 1201. https://doi.org/10.3390/molecules27041201

Nam, J.S., Park, S.Y., Jang, H.L. and Rhee, Y.H. (2017). Phenolic compounds in different parts of young *Annona muricata* cultivated in Korea and their antioxidant activity. *Applied Biological Chemistry*, 60, 535-543. https://doi.org/10.1007/s13765-017-0309-5

Nambooze, J., Erukainure, O.L. and Chukwuma, C.I. (2024). Anticancer Properties of Graviola: A Comprehensive Mechanistic Review. *Tropical Journal of Natural Product Research*, 8(5), 7050–

7062. https://doi.org/10.26538/tjnpr/v8i5.1

Ndife, J., Kwaya, P.J. and Bello, S. (2014). Production and Evaluation of Storage Changes in Soursop-Juice. *Asian Journal of Agriculture and Food Sciences*, 2 (5), 425-433.

Oboh, G., Ademosun, A.O., Akinleye, M., Omojokun, O.S., Boligon, A.A. and Athayde, M.L. (2015). Starch composition, glycemic indices, phenolic constituents, and antioxidative and antidiabetic properties of some common tropical fruits. *Journal of Ethnic Foods*, 2(2), 64–73. https://doi.org/10.1016/j.jef.2015.05.003

Ojeda, G., Coronado, J., Nava, R., Sulbarán, B., Araujo, D. and Cabrera, L. (2007). Caracterización fisicoquímica de la pulpa de la guanábana (*Annona muricata*) cultivada en el occidente de Venezuela. *Boletín Del Centro de Investigaciones Biológicas*, 41 (2), 151–160. https://doi.org/10.3989/gya.064309 [In Spanish].

Olas, B. (2023). The Antioxidant Potential of Graviola and Its Potential Medicinal Application. *Nutrients*, 15(2), 402. https://doi.org/10.3390/nu15020402

Orak, H.H., Bahrisefit, I.S. and Sabudak, T. (2019). Antioxidant activity of extracts of soursop (*Annona muricata* L.) leaves, fruit pulps, peels, and seeds. *Polish Journal of Food and Nutrition Sciences*, 69 (4), 359–366. https://doi.org/10.31883/pjfns/112654

Osei, P.A., Kpodo, F.M., Tettey, C.O., Dzah, C.S., Agbenorhevi, J.K., Hunkpe, G. and Nanga, S. (2023). Proximate composition, phenolic, and antioxidant properties of soursop fruit parts. *CYTA - Journal of Food*, 21(1), 475–480. https://doi.org/10.1080/19476337.2023.2227250

Oyebamiji, A.K., Akintelu, S.A., Akintayo, E.T., Akintayo, C.O., Semire, B. and Faboro, E.O. (2022). *Annona muricata* L. – A Plant with Vast Pharmaceutical Prospective: Phytochemistry and Pharmacology. *Adeleke University Journal of Science*, 1(1), 538-554.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., Mcguinnes, L.A; Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P. and Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLoS Medicine*, 18(3), e1003583. https://doi.org/10.1371/journal.pmed.1003583

Pareek, S., Yahia, E.M., Pareek, O.P. and Kaushik, R.A. (2011). Postharvest physiology and technology of Annona fruits. *Food Research International*, 44(7), 1741–1751. https://doi.org/10.1016/j.foodres.2011.02.016

Párraga, C., Rincón-Acosta, F., Barre-Zambrano, R., Vera-Cedeño, J., Vargas, P. and Mendoza Rivadeneira, F. (2024). Bioactive compounds and antioxidant activity of *Annona muricata* L. fruits located in Manabí, Ecuador. *Revista de la Facultad de Agronomía*, 41(1), e244107. https://doi.org/10.47280/RevFacAgron.v41.n1.07

Patil, H.V., Dhankani, M.A. and Dhankani, A.R. (2023). A Review on Marvel Fruit: *Annona muricata*. *Medical Sciences Forum*, 2(1), 26. https://doi.org/10.3390/ECB2023-14355

Paull, R.E. and Duarte, O. (2010). Annonas: cherimoya, atemoya and sweetsop. In Paull, R.E. and Duarte, O. (Eds.). Tropical fruits, Vol. 1, p. 123-152. Wallingford, UK: CABI. https://doi.org/10.1079/9781845936723.0123

Pérez-Jiménez, J., Arranz, S., Tabernero, M., Díaz-Rubio, M.E., Serrano, J., Goñi, I. and Saura-Calixto, F. (2008). Updated methodology to determine antioxidant capacity in plant foods, oils and beverages: Extraction, measurement and expression of results. *Food Research International*, 41(3), 274-285. https://doi.org/10.1016/j.foodres.2007.12.004

Qazi, A.K., Siddiqui, J.A., Jahan, R., Chaudhary, S., Walker, L.A., Sayed, Z., Jones, D.T., Batra, S.K. and Macha, M.A. (2018). Emerging therapeutic potential of graviola and its constituents in cancers. *Carcinogenesis*, 39(4), 522-533. https://doi.org/10.1093/carcin/bgy024

Rady, I., Bloch, M.B., Chamcheu, R.C.N., Banang Mbeumi, S., Anwar, M.R., Mohamed, H., Babatunde, A.S., Kuiate, J.R., Noubissi, F.K., El Sayed, K.A., Whitfield, G.K. and Chamcheu, J.C. (2018). Anticancer Properties of Graviola (*Annona muricata*): A Comprehensive Mechanistic Review. *Oxidative Medicine and Cellular Longevity*, 2018, 1826170. https://doi.org/10.1155/2018/1826170

Ramful, D., Tarnus, E., Aruoma, O.I., Bourdon, E. and Bahorun, T. (2011). Polyphenol composition, vitamin C content and antioxidant capacity of Mauritian citrus fruit pulps. *Food Research International*, 44(7), 2088-2099. https://doi.org/10.1016/j.foodres.2011.03.056

Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M. and Rice-Evans, C. (1999). Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Biology and Medicine*, 26(9–10), 1231-1237. https://doi.org/10.1016/S0891-5849(98)00315-3

Reyes, M., Gomez, I. and Espinoza, C. (2017). Tablas peruanas de composicion de alimentos. 9 ed. Lima, Perú: Ministerio de Salud. Instituto Nacional de Salud. [In Spanish].

Rhodes, D.G., Morton, S., Myrowitz, R. and Moshfegh, A.J. (2023). Food and Nutrient Database for Dietary Studies 2019–2020: An application database for national dietary surveillance. *Journal of Food Composition and Analysis*, 123, 105547. https://doi.org/10.1016/j.jfca.2023.105547

Santos, I.L., Rodrigues, A.M. da C., Amante, E.R. and Silva, L.H.M. (2023). Soursop (*Annona muricata*) Properties and Perspectives for Integral Valorization. *Foods*, 12(7), 1448. https://doi.org/10.3390/foods12071448

Shaaban, E.A., Abd-EL-Aal, S.K.H., Zaied, N.S. and Rizkalla, A.A. (2006). Assessment of Genetic Variability on Some Orange Accessions Using RAPD-DNA Markers. *Research Journal of Agriculture and Biological Sciences*, 2(6), 564–570.

Siqueira, A. de M.O., Moreira, A.C.C., Melo, E. de A., Stamford, T.C.M. and Stamford, T.L.M. (2015). Dietary fibre content, phenolic compounds and antioxidant activity in soursops (*Annona muricata* L.). *Revista Brasileira de Fruticultura*, 37(4), 1020–1026. https://doi.org/10.1590/0100-2945-211/14

Snauwaert, E., Paglialonga, F., Vande Walle, J., Wan, M., Desloovere, A., Polderman, N., Renken-Terhaerdt, J., Shaw, V. and Shroff, R. (2023). The benefits of dietary fiber: the gastrointestinal tract and beyond. *Pediatric Nephrology*, 38(9), 2929-2938. https://doi.org/10.1007/s00467-022-05837-2

Solís-Fuentes, J.A., Hernández-Medel, M. del R. and Durán-de-Bazúa, M. del C. (2020). Soursop Seed: Soursop (*Annona muricata* L.) Seed, Therapeutic, and Possible Food Potential. In Preedy, V.R., Watson, R.R. and Patel, V.B. (Eds.) Nuts and Seeds in Health and Disease Prevention, p. 1045-1052. Amsterdam, Netherlands: Elsevier. https://doi.org/10.1016/b978-0-12-375688-6.10124-0

Son, Y., Lee, H., Son, S.Y., Lee, C.H., Kim, S.Y. and Lim, Y. (2021). Ameliorative effect of A*nnona muricata* (Graviola) extract on hyperglycemia induced hepatic damage in type 2 diabetic mice. *Antioxidants*, 10(10), 1546. https://doi.org/10.3390/antiox10101546

Ugochi, N.I., Solomon, A.I. and Oluwasanmi, L.I. (2019). Phytochemical analysis, proximate composition and mineral contents of the seed of *Annona muricata. Journal of Medical Pharmaceutical and Allied Sciences*, 8(2), 2105–2112. https://doi.org/10.22270/JMPAS.V8I2.806

Umme, A., Asbi, B.A., Sahnah, Y., Junainah, A.H. and Jamilah, B. (1997). Characteristics of soursop natural puree and determination of optimum conditions for pasteurization. *Food Chemistry*, 58(2), 119–124. https://doi.org/10.1016/s0308-8146(96)00226-9

Vasco, C., Ruales, J. and Kamal-Eldin, A. (2008). Total phenolic compounds and antioxidant capacities of major fruits from Ecuador. *Food Chemistry*, 111(4), 816–823. https://doi.org/10.1016/j.foodchem.2008.04.054

Wahab, S.M.A., Jantan, I., Haque, M.A. and Arshad, L. (2018). Exploring the leaves of *Annona muricata* L. as a source of potential anti-inflammatory and anticancer agents. *Frontiers in Pharmacology*, 9, 661. https://doi.org/10.3389/fphar.2018.00661

Wilkins, R. (2007). Fruits for the Future 5. Annona Species. In Pinto, A.C. de Q., Cordeiro, M.C.R., de Andrade, S.R.M., Ferreira, F.R., Filgueiras, H.A. de C., Alves, R.E. and Kinpara, D.I. (Eds.). Experimental Agriculture, p. 263. Cambridge, UK: Cambridge University Press. https://doi:10.1017/S0014479706324908

Yamauchi, M., Kitamura, Y., Nagano, H., Kawatsu, J. and Gotoh, H. (2024). DPPH Measurements and Structure—Activity Relationship Studies on the Antioxidant Capacity of Phenols. *Antioxidants*, 13 (3), 309. https://doi.org/10.3390/antiox13030309

Yap, C., Subramaniam, K., Khor, S. and Chung, I. (2017). Annonacin exerts antitumor activity through induction of apoptosis and extracellular signal-regulated kinase inhibition. *Pharmacognosy Research*, 9(4), 378-383. https://doi.org/10.4103/pr.pr_19_17

Yiallouris, A., Patrikios, I., Johnson, E.O., Sereti, E., Dimas, K., De Ford, C., Fedosova, N.U., Graier, W.F., Sokratous, K., Kyriakou, K. and Stephanou, A. (2018). Annonacin promotes selective cancer cell death via NKA-dependent and SERCA-dependent pathways. *Cell Death and Disease*, 9(7), 764. https://doi.org/10.1038/s41419-018-0772-x

Zubaidi, S.N., Mohd Nani, H., Ahmad Kamal, M.S., Abdul Qayyum, T., Maarof, S., Afzan, A., Mohmad Misnan, N., Hamezah, H.S., Baharum, S.N. and Mediani, A. (2023). *Annona muricata*: Comprehensive Review on the Ethnomedicinal, Phytochemistry, and Pharmacological Aspects Focusing on Antidiabetic Properties. *Life*, 13(2), 353. https://doi.org/10.3390/life13020353

