Food Chemistry 448 (2024) 139048

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Review

Phytochemical and bioactive potentials of African Annonaceae species

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A R T I C L E I N F O

Keywords:
Annonaceae
Traditional medicine
Africa
Nutritional value
Biochemical composition

A B S T R A C T

This review aims to gather available information on the medicinal, nutritional, and bioactive profiles of Annonaceae species in the African continent, sponsoring their use worldwide and mainly in African communities, where access to food and medicines for basic health care is scarce. >60 medicinal taxa were compiled, belonging to 22 genera, namely *Annickia*, *Annona*, *Anonidium*, *Artabotrys*, *Cleistochlamys*, *Cleistopholis*, *Dennettia*, *Duguetia*, *Greenwayodendron*, *Hexalobus*, *Isolona*, *Lettowianthus*, *Monanthotaxis*, *Monodora*, *Neostenanthera*, *Polyceratocarpus*, *Sphaerocoryne*, *Uvaria*, *Uvariastrum*, *Uvariodendron*, *Uvariopsis* and *Xylopia*; the most diverse and economically important genera were the genera *Annona*, *Uvaria* and *Xylopia* with 7 species each. Annonaceae species hold a valuable nutritional profile, rich in proteins, fibers, and minerals, being also good sources of a wide range of bioactive compounds of high biological relevance. These compounds are especially important in developing countries, where most of these species are available for direct use as food and/or medicines by the most deprived populations.

1. Introduction

The world's human population is increasing, and it is estimated that there will be about 10 billion people on the planet in 2050. Because of this exponential growth, greater food production is required to fulfil human needs (Goncharova & Merzlyakova, 2022). However, there is little room for cropland expansion, while water scarcity is threatening future agricultural production potential (Ehara et al., 2018).

Identifying wild plants, locally used for food and in traditional medicine, can contribute to improve the quality of life, food security, and basic health care, particularly in tropical dry regions (Sapit & Padulosi, 2012). Most of these plants can be grown on underutilized lands, and are tolerant to arid and adverse environmental conditions, but are only of local or regional significance, being known as underutilized, neglected, under-exploited, under-valued, or orphan species (Okigbo & Anyaegbu, 2021). These species are important for the preservation of plant genetic resources, and their *ex-situ* and *in-situ* conservation is crucial to ensure their maintenance (Rocha et al., 2021). Despite the growing research interest in this field, and the fact that this type of species are important components of agrobiodiversity with the potential to adapt to climate change, they remain underutilized in conventional agriculture (Mabhaudhi et al., 2017).

Plant-based foods represent the main source of macro- and micronutrients, and essential minerals for human nutrition, holding bioactive properties that may contribute to the discovery of new medicines (Tekuri et al., 2019). This topic has been a major focus of attention

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https://doi.org/10.1016/j.foodchem.2024.139048
Received 19 October 2023; Received in revised form 7 March 2024; Accepted 14 March 2024
Available online 21 March 2024

worldwide, but the information available for several plant families, with distribution restricted to tropical regions, has widely been seen as modest in Africa (Catarino et al., 2021). Particularly, neglected, and underutilized species play a crucial role to fight against hunger and are a key resource for agriculture and rural development, with a high potential to contribute to global food security.

The plant family Annonaceae (the Soursop family) occurs in tropical to subtropical regions of all continents and comprises 122 genera and *ca.* 2440 species. Erkens et al. (2023) studied the distribution of this family and showed that it is present in four of the six main terrestrial biomes, distributed across about 109 countries, occurring mainly in the tropical region, in arboreal and other associated biomes; this means that their distribution is centred in the equatorial zone.

This family encompasses a wide variety of edible and non-edible plant species, extremely relevant at the medicinal and nutritional levels, providing edible fruits and allowing the extraction of oils from the seeds, leaves, and fruits of different species, able to be used as medicines, cosmetics, perfumes, and several other products (Handayani & Yuzammi., 2021).

Within this family, it outstands the genus *Annona* that has some species with horticultural and economic importance as fruit crops (Martin et al., 2019). It is known that Annonaceae species are valuable sources of bioactive compounds used mainly in traditional medicine by local communities to treat various diseases (Coria-Téllez et al., 2018).

Many of these species are odorous, due to the presence of essential oils which are mainly composed of mono- and sesquiterpene compounds (Fournier et al., 1999), and are used as biopesticides in the management of several insect pests (Maia et al., 2020) However, species widely used for food and medicines face greater extinction risk in their natural habitat, through combined over-exploitation, habitat loss and other factors (Pimenta et al., 2013).

Although the diversity of species with nutritional and pharmacological importance is recognized, there are still many knowledge gaps concerning this family, especially in African countries, where available information about the local flora is often scarce (Couvreur et al., 2006).

Approximately 40 genera and c. 500 species occur in Africa (Mols et al., 2004), where they are mainly found in tropical forests, but some have adapted to more arid climatic conditions and grow in savannahs (Couvreur, 2008). In this continent, and in addition to food and medicine, several Annonaceae species are used by local communities as timber to manufacture several materials and household and agricultural tools, to build houses and boats, to produce charcoal, and as firewood for cooking (Handayani, 2018).

In this study, we make a first attempt to review the available data on the African Annonaceae, namely their traditional medicinal uses, bioactive compounds, as well as nutritional and chemical composition, including mineral and vitamin contents, to promote their use across the world, and particularly by African communities, whose needs for food and medicines for basic health care need urgent solution.

1.1. Methods

We conducted a comprehensive review of the existing literature, following the typical guidelines of a review article. The aim of the review was to gather relevant and available information on African Annonaceae species, including their uses in traditional medicine, bioactive compounds, as well as their nutritional and chemical composition. To ensure a complete search, we used two electronic sources of scientific literature, namely Web of Science (webofknowledge.com) and Scopus (www.scopus.com), from September 2022 to March 2023. Our search encompassed original articles, commentaries, books, letters, and reports related to the Annonaceae species most used in Africa.

We specifically focused on studies published between 1984 and 2023. The initial keywords used for the search were Annonaceae, Africa, main uses, nutritional and biochemical composition. These keywords were selected to identify literature that examines various aspects of the family Annonaceae in general sense. We sought additional information from subject matter experts to refine our search strategy and locate additional relevant literature. With this, we were able to compile a final collection of 192 scientific studies for the analysis and synthesis of this review.

2. Traditional medicinal uses of Annonaceae species

In sub-Saharan African region, our investigation identified 65 Annonaceae species documented for their utilization in traditional medicine. Among these species, 63 are native, while two, namely *Annona muricata* and *Annona squamosa*, are naturalized. Introduced from America, these species are currently successfully established, capable of reproducing, and can disseminate spontaneously. **Table S1** details the main ailments addressed, traditional preparation methods, modes of administration and the specific plant parts employed, such as leaves, fruits, seeds, and bark.

Annona senegalensis (Fig. 1) and *Xylopia aethiopica* stand out as the most reported species across distinct African countries, exhibiting diverse therapeutic applications. For example, in Cameroon, a decoction of *Annona senegalensis* bark is used for fever, respiratory infections, convulsions and snake bites (Tsabang et al., 2012). In the Democratic Republic of Congo (DRC), a decoction of the bark, leaves, and roots of the same species is employed for diabetes (Kasali et al., 2021), while in Guinea-Bissau, it is utilized for alleviating pains, addressing pregnancy complications, intestinal disorders, and skin inflammations (Catarino et al., 2016). *Xylopia aethiopica* seeds are applied for chest pains, coughs, and intestinal parasites in Angola (Costa & Pedro, 2013), while mashed fruits serve post-partum care in Cote d'Ivoire (Malan et al., 2015), and a decoction of dried fruits is used for aches and fever in Cameroon (Tsabang et al., 2012).

Annona muricata, *Duguetia staudtii*, and *Monodora myristica* (Fig. 1) are each documented in five countries. *Annona muricata* (Fig. 1) is predominantly utilized for its leaves and is documented for treating malaria in Angola, Cameroon, and Togo (Costa & Pedro, 2013; Koudouvo et al., 2011; Tsabang et al., 2012). In Guinea-Bissau and Nigeria, it is employed for addressing intestinal problems (Aiyeloja & Bello, 2006; Catarino et al., 2016). *Duguetia staudtii*, primarily used for its bark, is reported for malaria treatment in Cameroon and respiratory problems in Congo, Ghana, Cote d'Ivoire, and Nigeria (Sarpong et al., 2016; Tolu-Odugbemi., 2008; Tsabang et al., 2012). *Monodora myristica* is extensively used for its seeds, addressing diabetes in the DRC, pregnancy problems in Guinea-Bissau, and haemorrhoids in Cote d'Ivoire (Catarino et al., 2016; Malan et al., 2015).

Among the African countries, Cameroon leads with 34 reported Annonaceae medicinal species, followed by Nigeria (17) and Tanzania (9) (**Fig. S1**). Bark seems to be the most frequently used plant part (documented 51 times), followed by roots (39), leaves (31), and fruits (10). Decoction remains the preferred method of preparation, reported for 46 species.

Africa encompasses a rich diversity of cultures and indigenous knowledge systems that have long relied on plants for medicinal purposes, often utilizing the same plant species for various therapeutic applications across different regions (Table S1). Documenting these traditional uses of medicinal plants is critical for the preservation of valuable indigenous knowledge that may otherwise be lost in the near future (Romeiras et al., 2023). Moreover, understanding the diverse medicinal uses of Annonaceae species in Africa's developing countries, where the access to conventional medical services is limited, can inform healthcare practices, and contribute to improved public health outcomes.

In addition, the documentation of traditional uses of medicinal plants also enhances the potential for drug discovery, given that many modern pharmaceuticals are derived from natural compounds found in plants (Kayser, 2018). Therefore, investigating traditional medicinal applications not only offers guidance but also underscores opportunities

Fig. 1. Representative leaves, fruits, and seeds from different species. A - *Annona senegalensis* leaves; B – *A. senegalensis* fruits; C - *Monodora myristica* seeds; D – *A. muricata* fruits; E – *A. squamosa* fruits. (Photos by the author Josefa Rangel).

for pharmacological research.

3. Bioactive compounds in Annonaceae species

Plants are the main sources of bioactive compounds for the research of new drugs, producing substances of different chemical classes (Perrone et al., 2022). Over the last few years, several studies have revealed the medicinal and phytochemical properties of Annonaceae species in Africa, Asia, and America; a wide range of bioactive compounds has been found, isolated, and characterized from different parts of the plants. Some of these compounds and their biological relevance for human health and well-being are presented in Table 1.

Phytochemical studies have revealed different classes of secondary metabolites, such as monoterpenes, diterpenes, triterpenes, flavonoids, phenylpropanoids, acetogenins, and, especially, isoquinoline derivatives. Some of these secondary metabolites isolated from Annonaceae species show important biological assets such as anti-inflammatory, trypanocide, leishmanicidal, antimalarial, antimicrobial, antioxidant, and antirheumatic activities, being also cytotoxic to human tumor cells. Liaw et al. (2010) identified acetogenins as the main class of compounds found in the Annonaceae family, these being exclusive to species native from tropical regions. The unique structure of this class of compounds (Parmena et al., 2012), makes acetogenins important natural compounds due to their antitumoral activity as well as for being potent antimalarial, immunosuppressive and pesticide agents (Keinan & Sinha, 2002).

Despite the effort to investigate the phytochemical and pharmacological properties of Annonaceae species in recent years, the number of studied species is still very low compared with their great biodiversity. According to Costa et al. (2021), only 15% of the Annonaceae species were subject to phytochemical and pharmacological investigation. Most of the studies focused on the genera *Annona*, *Asimina* and *Cananga*, and some species of the genera *Duguetia, Guatteria* and *Xylopia,* mainly due to their great economic relevance. In a study performed by Nyandoro et al. (2019), the crude ethanolic extract of the root bark of *Cleistochlamys kirkii* was able to inhibit 72% of the malaria parasite *Plasmodium falciparum*, this effect being attributed to the presence of cleistonol. Also, alkaloids and flavonoids isolated from the leaves of *Annona cherimola* present antimicrobial, antiviral, and cytotoxic effects against the human prostate tumor cell line (PC-3), these biological activities being mainly due to cherimolacyclopeptide E, annomolin, and annocherimolin (Biba et al., 2014).

Anti-depressive effects have likewise been reported for the alkaloids annonaine, sinomenine, codeine, codeinone and hernagine in fruits of *Annona muricata* (Gavamukulya et al., 2017; Lee et al., 2021). In this species, toxicity against PC-3 prostate cancer cells was also reported, which is presumably due to the acetogenins annomuricin A, muricin J, muricin K, and muricin L present in its leaves, fruits, and pericarp (Sun et al., 2014). Acetogenins also seem responsible for the anticancer activity reported in *Uvaria acuminata* (Qian et al., 2015). Antioxidant, antidiabetic, hypolipidemic, hepatoprotective, antimicrobial, antiulcer, snake venom neutralizing and antiplasmodic activities have been reported in the leaves, roots, and fruits of *Uvaria chamae* (Ita, 2017; Monon et al., 2015).

In *Xylopia longipetala*, antimicrobial and antioxidant activities were also reported and associated with the occurrence of diterpenes β-pinene, α-pinene, trans-pinocarveol, and myrtenol in the roots (Woguem et al., 2014). Biological and therapeutic effects such as anti-inflammatory, antispasmodic, diuretic, antihypertensive, cholesterol-lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial, and antifungal, have been assigned to the occurrence of the monoterpenoids α-phellandrene, p-cymene, α-pinene, cis-sabinol, geraniol, eugenol camphene, myrcene, thujene, and limonene in *Monodora myristica* seeds (Agiriga & Siwela, 2017). Altogether, the available information shows not only the richness in bioactive compounds from different classes that can be found in several species of Annonaceae, but also their enormous biological and therapeutic relevance in traditional medicine and for the development of new drugs.

4. Nutritional and chemical composition of Annonaceae species

Several countries in tropical Africa have a wide variety of food sources that play a key role in human nutrition and well-being. Still, millions of people suffer from malnutrition, and most of the population depends on indigenous edible resources to meet their vitamin and mineral needs, which is why it is essential to sustainably exploit

Table 1
Bioactive compounds and their biological relevance in African Annonaceae species.

Scientific name	Used parts	Bioactivities	Type of study	Phenolic compounds or other isolated compounds	Therapeutic doses	Class of compounds	References
Annickia chlorantha (Oliv.) Setten & Maas	Stem barks	Antimalarial	*In vivo* (infected mice)	-	400 mg/kg (100% parasite clearance)	Alkaloids, saponins, phenolics, flavonoids and glycosides	(Adesokan & Akanji, 2010)
Annona cherimola Mill.	Leaves	Antioxidant Antiproliferative	*In vitro* HeLa and HepG2 cell lines	Anonaine, asimilobine, catechin, liriodenine, stepharine, lanuginosine, pronuciferine, and quercetin, kaempherol, luteolin, and apigenin derivatives	GI_{50}–8.92 μg dw/mL cell medium (HeLa) GI_{50}–10.22 μg dw/mL cell medium (HepG2)	Flavonoids Alkaloids	(Mannino et al., 2020)
Annona glabra L.	Fruits	Anti-inflammatory (inhibition of cyclooxygenase-2)	*In vitro* (Raw 264.7 mouse leukemic monocyte–macrophages)	Isodesacetyluvaricin	5 μM (barely detectable levels of COX-2 mRNA)	Acetogenins	(Wu et al., 2012)
Annona muricata L.	Leaves Fruits (pulp) Seeds	Cytotoxic Antioxidant Antioxidant Antioxidant	*In vitro:* human breast carcinoma (MDA-MB-435S), human immortalized keratinocyte (HaCaT), and normal human hepatic cells (WRL-68) - *In vitro*	Quercetin, robinetin, gallic acid, apigenin, luteolin, vitexin Cinnamic acid derivatives, coumaric acid, caffeoylquinic acid, and cafeic acid derivatives Gallic acid, catechin, chlorogenic acid, caffeic acid, vanillin, coumaric acid, ferulic acid, quercetin, cinnamic acid, rutin	Normal cells -IC_{50} = 52.4 μg; Cancerous cells - IC_{50} = 29.2 μg (MDA-MB-435S) and 30.1 μg (HaCaT) - 100 mg/mL (77.34% antioxidant activity)	Flavonols Polyphenols Flavones	(George et al., 2012; Jiménez et al., 2014; Menezes et al., 2019)
Annona reticulata L.	Barks	Analgesic and anti-inflammatory	*In vitro*	Kaur-16-en-19-oic acid	10 and 20 mg/kg	Ent-kaurane diterpenoid	(Aggarwal et al., 2018; Shahriar et al., 2016)
	Leaves	Thrombolytic activity	*In vitro:* human erythrocytes	-	Methanol, ethanol and chloroform extract showed 68.81%, 72.06% and 78.17% inhibition of RBC hemolysis	Alkaloids, steroids, polyphenols	
	Fruits	Antioxidant, antibacterial, antifungal, antitumor, antidiabetic, hypo-cholesterolemic, antiatherosclerotic, insecticidal and larvicidal	*In vitro*	*n*-hexadecanoic, octadecadienoic, pimaric, and carboxylic acids, napthalenemethanol, decahydro-5-(5-hydroxy-3-methyl-3-pentenyl)-1,4a-dimethyl- 6 -methylene- and spathulenol.	-	Polyohenols	
Annona senegalensis Pers.	Seeds	Anti-inflammatory	*In vivo*: LPS stimulated J774.2 mouse macrophages	Tryptamide alkaloid N-cerotoyltryptamine, acetogenin asimicin, kauranoic acid methylester, lacceroic acid, and stigmasterol glycoside	Plant extract - IC_{50} = 8.7 ± 10.2 mg/mL N-cerotoyltryptamine (isolated from the plant) - IC_{50} = (2.7 ± 0.1 mg/mL)	Alkaloid, acetogenin	(Tamfu et al., 2021)
Annona squamosa L.	Leaves	Antiproliferative and citotoxic	*In vivo*: rats with breast cancer cell lines (MCF-7 and MDA-MB-231)	Germacrene-D, humulene, phytol	100 μg/mL	Polyphenols Flavonoids	(Adesanwo et al., 2020; Al-Nemari et al., 2022)
	Seeds Fruits	Antimicrobial Antioxidant	*In vitro*	Octadec-9-enoic acid, 9,10-dehydroisolongifo-lene and androsterone	Methanol extract – MIC = 0.39 mg/mL n-hexane fraction MIC = 1.56 mg/mL Antioxidant activity IC_{50} = 1.33	Polyphenols	

(continued on next page)

Table 1 (*continued*)

Scientific name	Used parts	Bioactivities	Type of study	Phenolic compounds or other isolated compounds	Therapeutic doses	Class of compounds	References
Artabotrys modestus Diels	Bark	Antiviral	*In ovo*	Quebrachitol, cyclohexane-1,2,4,5-tetrol	360 μg/m	Alicyclic polyhydroxy compounds	(Nyandoro, 2017)
Cleistochlamys kirkii (Benth.) Oliv.	Bark	Antibacterial	*In vitro*	Dichamanetin, chamanetin, isochamanetin, α,β-unsaturated lactone (−)-cleistenolide	Dichamanetin – MIC = 1–7.5 μg/mL	Flavanones	(Nyandoro et al., 2019; Pereira et al., 2016)
	Bark, stem	Antimalarial and anticancer	*In vitro* - MDA-MB-231, triple-negative, aggressive breast cancer cell line	Dichamanetin, (*E*)-acetylmelodorinol, and cleistenolide	Antimalarial 0.01 μg/mL - 72% inhibition of *P. falciparum* Anticancer IC_{50} = 42.0 μg/mL (crude extract) and 9.6–30.7 μM (isolated compounds)	Sesquiterpene	
Cleistopholis patens (Benth.) Engl. & Diels	Barks	Antibacterial, antioxidant	*In vitro*	–	100 mg/mL – 40% reducing ability 100 mg/mL against *Proteus vulgaris* and *Yersinia;* 18 mg/ml against *Klebsiella aerogenes*	Aminoacids, amides, amines, carboxylic acid, carbonyl compounds, organic hydrocarbons, halogens, alcohols, phenols, sulfonamides	(Daniels & Ibiyemi, 2021)
Duguetia staudtii (Engl. & Diels) Chatrou	Barks	Anti-inflammatory, urease activity	*In vitro*	Pachypolignan, pachypophyllin, pachypodol, kumatakenin, etramethoxyflavone, benzopyran, corypalmine, polycarpol	Anti-inflammatory IC_{50} = 3.89 to 14.13 μg/mL Urease activity IC_{50} = 10.9 to 20.2 μg/mL	Bisnorlignan, flavonoids, alkaloid, triterpenoid	
Greenwayodendron suaveolens (Engl. & Diels) Verdc.	Fruits, Leaves, Bark, Stem	Antiprotozoal	*In vitro*	Polycarpol and, dihydropolycarpol; polyalthenol and *N*-acetylpolyveoline	Root bark extract - IC_{50} 0.26 μg/mL; stem bark alkaloid fraction = IC_{50} 0.27 μg/mL; root bark alkaloid fraction - IC_{50} < 1 μg/mL; methanol fractions - 0.36 μg/mL to 0.69 μg/mL	Triterpenes, Alkaloids	(Muganza et al., 2016)
Isolona hexaloba (Pierre) Engl. & Diels	Leaves, root barks, stems barks	Antiprotozoal	*In vitro*	–	Crude methanol extracts of root bark - IC_{50} = 1.97 μg/ml and leaves - IC_{50} = 2.65 μg/ml	Saponins, alkaloids, flavonoids, anthraquinones, steroids, tepernoids, coumarins	(Muganza et al., 2016)
Monanthotaxis caffra (Sond.) Verdc.	Leaves	Antihepatotoxic	*In vivo* (rats)	Crotepoxide, 5,6-diace-toxi1-benzoiloximetil-1, 3-ciclohexadieno	100 mg/kg	Terpenes	(Makhuvele et al., 2022)
Monanthotaxis discolor (Diels) Verdc.	Root barks	Antimicrobial	*In vitro*	α-cadinol, (−)-alloaromadendrene, aristolone, γ-cadinene, δ-cadinene, cubenene	Dichloromethane extract - LC_{50} 41.794 μg/ml Methanol extract - LC_{50} 13.560 μg/ml	Sesquiterpenes	(Parmena et al., 2012)
Monodora myristica (Gaertn.) Dunal	Seeds	Anti-nephrolithiasis Antioxidant	*In vitro*	Gallic, chlorogenic, caffeic, *p*-coumaric, ellagic acids, catechin, rutin, quercetin and luteolin	Inhibitory activity against xanthine oxidase and urease - IC_{50} 0.56 ± 1.72 and 17.86 ± 1.13 μg/mL, respectively; DPPH and Fe2+ chelation -IC_{50} 9.39 ± 0.39 and 14.91 ± 0.82 μg/mL, respectively	Phenolic compounds	(Irondi et al., 2023)
Uvaria acuminata Oliv.	All plant parts	Antimicrobial	*In vitro*	Diuvaretin, triuvaretin, angoluvarin	-	Dihydrochalcones	(Munissi, 2019)

(*continued on next page*)

Table 1 (*continued*)

Scientific name	Used parts	Bioactivities	Type of study	Phenolic compounds or other isolated compounds	Therapeutic doses	Class of compounds	References
Uvaria afzelii Scott Elliot	Roots	Hepatoprotective effect	*In vivo* (rats)	Syncarpic acid, dimethoxymatteucinol, emorydone, uvafzelic acid, syncarpurea, afzeliindanone	125, 250 and 500 mg/kg conjugated with CCl_4	–	(Ofeimun et al., 2013)
Uvaria angolensis Welw. ex Oliv.	Leaves, twigs and stem bark	Antiplasmodial	*In vivo* (albino mice) *In vitro*	–	400 mg/kg throughout 4 days	Acetogenins, alkaloids, phenols, lactones	(Mfopa et al., 2017)
Uvaria chamae P. Beauv.	Roots Seeds	Antioxidant Antibacterial Anti-inflammatory	*In vitro*	- Joolanin, squamocin, desacetyluvaricin, chamuvarinin	Ethanolic extract – MIC = 2 Aqueous extract – MIC = 16 DPPH – IC_{50} = 3.52 to 14.35 μg/mL	Tannins, flavonoids, and phenols Acetogenins	(Monon et al., 2015) (Fall et al., 2006; Jalil et al., 2020)
Uvaria lucida Bojer ex Benth.	Root bark	Antimalarial	–	Lucidene, uvaretin, diuvaretin, chamuvaretin	–	Sesquiterpene, dihydrochalcones	(Weenen et al., 1990)
Uvaria pandensis Verdc.	Leaves	Antibacterial, cytotoxic (human breast cancer)	*In vitro*	(−) -Pipoxide, (+) -Pandoxide, pandensenol D - F	Antibacterial (8'α,9'β-dihydroxy)-3-farnesylindole - EC_{50} = 9.8 μM against *B. subtilis* Cytotoxicity EC_{50} > 100 μM	Cyclohexene derivatives, flavonoids	(Maeda et al., 2022)
Uvaria tanzaniae Verdc.	Stem and root bark	Antimalarial	–	Tanzanene	-	Sesquiterpene	(Weenen et al., 1991)
Uvaria versicolor Pierre ex Engl. & Diels	Stems	Acaricidal	*In vitro*	Benzyl benzoate, versuvanone, oxoaporphine, liriodenine	Methanol and hexane extracts with EC_{50} values of 0.095 g/m2 and 0.12 g/m2, respectively	Flavanone	(Akendengue et al., 2003)
Uvariodendron angustifolium (Engl. & Diels) R. E.Fr.	Stem, stem bark, leaves, and root	Cytotoxic activity on MCF-7 human breast cancer cells	*In vitro*	Neral, geranial, methyl eugenol,	IC_{50} values of the leaf (220 μg/mL), stem (270 μg/mL), stem-bark (320 μg/mL) and root (460 μg/mL) volatile extracts μg/mL	Monoterpenes	(Noudogbessi et al., 2014)
Xylopia hypolampra Mildbr.	Bark, stem	Antimicrobial	*In vitro*	Verbenone, borneol, eucalyptol, nopinone, *trans*-pinocarveol, α-terpineol, *para*-cymen-8-ol, terpinen-4-ol, cyperotundone, myrtenal	MIC >500 μg/mL	Terpenes, monoterpenes, sesquiterpenes	(Pedrali et al., 2019)
Xylopia longipetala De Wild. & T. Durand	Fruits Bark, roots	Chemopreventive, anti-inflammatory, antimicrobial Analgesic and antiplasmodic	*In vitro* -	β-pinene, α- pinene, trans-pinocarveol, myrtenol Xylopinidine, dehydrocoreximine, *N*, *N*-dimethylanomurine, methylphoebine	IC_{50} = 6.56 μg/ml (MDA-MB 231); 7.47 μg/ml (A375); 6.63 μg/ml (HCT116) -	Monoterpene hydrocarbons Alkaloids	(Nishiyama et al., 2004; Woguem et al., 2014)
Xylopia staudtii Engl. & Diels	Bark	Antimicrobial	*In vivo* (immunodepressed mice)	Kaurenoic acid	Bacterial load in faeces reduced 100% with 400 mg/kg	Diterpenes	(Nguiam et al., 2021)

available local resources. Particularly, in rural areas, malnutrition can be overcome through the consumption of local unknown products which might be rich sources of proteins, carbohydrates, and essential vitamins (Atasie et al., 2009). An example of this are some wild plants, whose fresh leaves, seeds, fruits, among other parts, can serve as the basis for a more balanced diet, especially among the poorest communities (Ruffo et al., 2002) and at times of seasonal food shortages (Umaru et al., 2007).

The fruits of some Annonaceae species are mainly consumed *in natura* but can also be processed into different food products such as ice cream, juices, flakes, jellies, nectars, purees, yoghurts, syrups, alcoholic beverages, and extracts with medicinal properties (Fuentes et al., 2022). Table 2 presents the available data on the nutritional and energetic composition, particularly of fruits of Annonaceae species native to

Table 2
Nutritional composition (g/100 g dw) and energetic value (g/100 kcal dw) of African Annonaceae species.

Scientific name	Plant Parts	Moisture (% fw)	Ash (g/100 g dw)	Crude protein (g/100 g dw)	Crude Fiber (g/100 g dw)	Fat (g/100 g dw)	Carbohydrate (g/100 g dw)	Energy (kcal/100 g dw)	References
Annickia chlorantha (Oliv.) Setten & Maas	Stem bark	3.85 ± 0.35	2.5 ± 0.1	10.8 ± 0.2	72.3 ± 0.4	3.8 ± 0.2	6.3 ± 0.2	–	(Dawodu et al., 2014)
Annona cherimola Mill.	Pulp	–	0.9 ± 0.17	1.5 ± 0.2	–	–	–	–	(Cordeiro et al., 2013)
Annona muricata L.	Pulp Leaves Fruit	0.018 ± 0.001 4.95 82.8	0.006 ± 0.001 7.5 60	1.38 ± 0.01 11.4 1.0	3.02 ± 0.01 5.4 0.8	9.75 ± 0.01 0.2 0.97	67.14 ± 0.09 75.7 14.6	364.5 35.0 53.1–61.3	(Akomolafe & Ajayi, 2015; Coria-Téllez et al., 2018; Badrie & Schauss, 2010)
Annona senegalensis Pers.	Seeds	12.2	12.1	8.80	17.6	24.0	25.3	–	(Yisa et al., 2010)
Annona squamosa L.	Pulp and Fruits Seeds	78.54 ± 0.14 6.65 ± 0.05	2.8 ± 0.2 5.24 ± 0.04	1.13 ± 0.01 18.34 ± 0.03	5.90 ± 0.05 17.6 ± 0.1	0.79 ± 0.03 17.6 ± 0.1	10.80 ± 0.06 21.8 ± 0.1	51.8 ± 0.3 434.5 ± 0.2	(Abdualrahman et al., 2019)
Cleistopholis glauca Pierre ex Engl. & Diels	Fruits	–	1.2	5.0	29.7	–	9.7	57.3	(Lamperti et al., 2014)
Duguetia staudtii (Engl. & Diels) Chatrou	Fruits	–	1.8	5.4	53.8	–	19.8	–	(Lamperti et al., 2014)
Greenwayodendron suaveolens (Engl. & Diels) Verdc.	Young leaves	9.98 ± 0.29	6.14 ± 0.01	01.34 ± 0.01	05.6 ± 0.1	14.8 ± 0.1	72.3 ± 0.02	–	(Oshomoh et al., 2022)
Monodora myristica (Gaertn.) Dunal	Seeds	14.6 ± 0.4	2.4 ± 0.2	14.0 ± 0.8	21.0 ± 1.1	31.0 ± 0.5	16.9	402.8	(Borquaye et al., 2017)
Monodora tenuifolia Benth.	Seeds	19.0 ± 0.1	4.9 ± 0.6	8.3 ± 1.0	26.2 ± 1.2	34.9 ± 1.9	6.6 ± 0.7	–	(Chukwuma & Uzoma, 2013)
Xylopia aethiopica (Dunal) A.Rich.	Pulp Whole fruit Seeds	12.3 ± 0.2 11.3 ± 0.1 9.70 ± 0.05	5.1 ± 0.5 10.68 ± 0.02 6.60 ± 0.04	7.7 ± 0.9	18.3 ± 0.9 18.4 ± 0.4 4.61 ± 0.04	6.5 ± 0.8 32.7 ± 0.1 28.60 ± 0.05	50.1 ± 0.5 30.4 ± 0.4 54.52 ± 0.02	289.6 - -	(Borquaye et al., 2017; Fategbe et al., 2021)
Xylopia longipetala De Wild. & T.Durand	Seeds	8.95 ± 1.13	6.3 ± 0.4	8.3 ± 0.2	8.3 ± 0.6	6.1 ± 0.5	62.5 ± 0.8	80.8 ± 0.3	(Yanda-Shaba, 2017)
Xylopia rubescens Oliv.	Fruits	–	2.2	4.9	52.4	–	3.9	–	(Lamperti et al., 2014)
Xylopia staudtii Engl. & Diels	Fruits	–	1.6	8.6	43.7	21.4	6.5	–	(Lamperti et al., 2014)

Africa. Low-fat concentrations were found in the fruits of some of them, with *Annona muricata* leaves (0.2 g/100 g dw) and *Annona squamosa* fruits (0.79 g/100 g dw, Fig. 1) exhibiting the lowest values (López-Martínez et al., 2022). On the other hand, highest fat concentrations were found on seeds from *A. senegalensis* Pers (24.0 g/100 g dw) (Yisa et al., 2010), *A. squamosa* L. (17.6 g/100 g dw) (Abdualrahman et al., 2019), *M. myristica* (31.0 g/100 g dw) (Abdualrahman et al., 2019), *M. tenuifolia* Benth (34.9 g/100 g dw) (Chukwuma & Uzoma, 2013), and *X. aethiopica* (28.6 g/100 g dw) (Borquaye et al., 2017; Fategbe et al., 2021), as well as in the fruits of *X. staudtii* and *X. aethiopica* (21.4 and 32.7 g/100 g dw, respectively) (Lamperti et al., 2014), and young leaves of *G. suaveolens* (14.8 g/100 g dw) (Oshomoh et al., 2022), these parameter being highly influenced not only by the species, but also by the different parts of the plant used, along with other genetic and edaphoclimatic factors.

Annonaceae species are also characterized by low protein concentrations, the highest values being found in *Annona squamosa* seeds (18.34 g/100 g dw) (Abdualrahman et al., 2019). The highest moisture contents were identified in *Annona* genus, with the highest levels being identified in *Annona muricata* (82.8%) (Akomolafe & Ajayi, 2015) and in *Annona squamosa* (78.5%) fruits (Abdualrahman et al., 2019). The ash content, representing the mineral amounts present in each part of the plant (Imo et al., 2018), seems to vary between species, with *Annona senegalensis* presenting the highest concentration (12.1 g/100 g dw) and *Annona muricata* (0.006 g/100 g dw) the lowest (Akomolafe & Ajayi, 2015).

In general, despite their interesting nutritional profile, the proximate composition of Annonaceae fruits may considerably vary depending on species, soil characteristics, harvesting time, genetics, environmental conditions (*i.e.*, temperature and precipitation), among other factors. Also, the recorded variation could be attributed to the use of different methodologies to quantify the nutritional parameters.

Plants are one of the main sources of vitamins and minerals necessary for the proper functioning of living organisms, playing, among others, a key role in resistance against pathogens (Yanda-Shaba, 2017). However, many of such plants are often unknown, underutilized, and seasonal (Ayessou et al., 2009), factors that may restrict their everyday use. Some of these micronutrients are essential minerals, such as potassium (K), iron (Fe), magnesium (Mg), zinc (Zn), important for both human nutrition and prevention of various chronic and acute diseases that may be associated with imbalances of one or more of these minerals (El-Ramady et al., 2022).

The necessary concentration of minerals to conduct certain biological functions is variable, and some may be present in smaller amounts and act concomitantly with others. For example, lower levels of zinc can support calcium functions, as zinc helps calcium absorption into bones and, in turn, during some metabolic processes, certain enzymes depend on zinc to perform their vital functions (Imo et al., 2018).

In Table 3, the mineral profiles of some species of the Annonaceae family are presented. *Annona muricata,* for example, presents high levels of calcium in its fruit pulp (857.2 mg/100 g), and elevated levels of phosphorus (146.3 mg/100 g) have been reported in its seeds (Chimbevo & Essuman, 2019). High potassium levels were reported for the fruits of *Monodora myristica* (869.64 mg/100 g dw) (Raphael et al., 2010), *Annona cherimola* (406.8 mg/100 g dw) (Cordeiro et al., 2013), and *Xylopia aethiopica* (288.7 mg/100 g), the latter also with interesting amounts of magnesium (175.3 mg/100 g) (Fategbe et al., 2021). High amounts of calcium were found in *Annona muricata* pulp (857.2 mg/100 g) and in the seeds of *Annona squamosa* (648.5 mg/100 g) (Chimbevo & Essuman, 2019).

Table 3
Mineral composition (mg/100 g dw) of African Annonaceae species.

Scientific name	Plant Part	Calcium	Sodium	Potassium	Phosphorus	Zinc	Iron	Magnesium	Copper	References
Annickia chlorantha (Oliv.) Setten & Maas	Fruits	0.36	0.06	–	0.13	17.8	104	0.28	27.2	(Lamperti et al., 2014)
Annona cherimola Mill.	Fruit	11.3	15.9	406.8	17.9	0.13	0.12	177.0	0.06	(Cordeiro et al., 2013)
Annona muricata L.	Pulp	857.2 ± 6.4	843.4 ± 16.3	322.3 ± 13.1	32.5 ± 0.9	0.40 ± 0.03	1.05 ± 0.06	24.0 ± 0.8	1.00 ± 0.03	(Chimbevo & Essuman, 2019)
	Seeds	158.4 ± 2.9	21.0 ± 1.4	354.6 ± 2.2	146.3 ± 4.0	0.46 ± 0.04	3.6 ± 0.1	13.7 ± 0.3	0.04 ± 0.01	
Annona senegalensis Pers.	Seeds	135	–	47	–	48	180	24	29	(Yisa et al., 2010)
Annona squamosa L.	Pulp	455.0 ± 2.9	10.4 ± 0.4	48.0 ± 0.6	28.7 ± 1.0	0.32 ± 0.02	1.65 ± 0.04	395.5 ± 4.6	0.10 ± 0.01	(Chimbevo & Essuman, 2019)
	Seeds	648.5 ± 2.5	31.4 ± 0.6	23.3 ± 0.7	22.2 ± 0.8	0.31 ± 0.02	2.07 ± 0.02	52.0 ± 1.0	0.03 ± 0.01	
Cleistopholis glauca Pierre ex Engl. & Diels	Fruits	140	40	–	80	11.7	118	80	8.5	(Lamperti et al., 2014)
Cleistopholis patens (Benth.) Engl. & Diels	Fruits	340	40	–	90	16.9	50.5	17	7.7	(Lamperti et al., 2014)
Duguetia staudtii (Engl. & Diels) Chatrou	Fruits	170	20	–	80	8.6	40.5	70	7.9	(Lamperti et al., 2014)
Monodora myristica (Gaertn.) Dunal	Seeds	416.0 ± 1.4	17.7 ± 0.3	869.6 ± 4.0	112.0 ± 4.6	1.5 ± 0.1	21.7 ± 0.5	87.0 ± 4.0	0.19 ± 0.02	(Raphael et al., 2010)
Uvaria chamae P.Beauv.	Stem bark	34.5 ± 0.9	2.7 ± 0.6	4.2 ± 0.2	1.8 ± 1.0	0.8 ± 0.4	3.4 ± 0.7	1.3 ± 0.5	–	(Ojokuku et al., 2011)
Xylopia aethiopica (Dunal) A.Rich.	Whole fruit	236.4 ± 2.0	15.77 ± 0.08	288.7 ± 0.1	62.75 ± 0.05	4.14 ± 0.04	32.5 ± 0.5	175.3 ± 1.2	1.55 ± 0.02	(Fategbe et al., 2021)
	Seeds	212.2 ± 1.2	13.60 ± 0.04	246.9 ± 0.6	59.0 ± 1.1	2.8 ± 0.6	29.0 ± 0.4	168.2 ± 0.7	1.32 ± 0.02	
Xylopia rubescens Oliv.	Fruits	120	10	–	50	47.4	111	50	22.5	(Lamperti et al., 2014)

In addition to their mineral contents, Annonaceae species are rich in vitamins, such as vitamins C, E, thiamin, riboflavin, niacin, among others (Fuentes et al., 2022), which may provide several health benefits for living organisms (Scrimshaw, 2007). According to Floegel et al. (2011), some of these nutraceuticals act as antioxidants to prevent various acute and chronic diseases. Likewise, vitamins A, B, and C are non-enzymatic antioxidants and dietary supplements needed for human health, these being able to prevent and/or stop the development of some diseases, such as cancer, cardiovascular, and inflammatory diseases, among other health conditions (Didier et al., 2023).

In Table 4, the vitamin profile of some species of the Annonaceae family are presented; among them, *Annona squamosa* pulp presents the highest amount of vitamin C (25.6–58.8 mg/100 g dw) (Fuentes et al., 2022). Overall, this is the vitamin present in greatest amounts in all the analyzed species, with also interesting contents in *Annona cherimola* fruits (12.6–25.4 mg/100 g) and in *Monodora myristica* seeds (9.9 mg/100 g dw) (Nkwocha et al., 2019).

In addition to their richness in bioactive compounds, Annonaceae species are also excellent sources of other compounds (Ben-Othman et al., 2020; Bhardwaj et al., 2019), such as sugars, organic acids, essential aminoacids, and fatty acids, which can be found in leaves, seeds, roots, and stems (Nam et al., 2018). Organic acids play a fundamental role in plants, as they are responsible for their flavor and texture, thus promoting their acceptance in the market (Arena et al., 2021). There are very few studies reporting the occurrence of organic acids in Annonaceae species. In *Annona cherimola*, for example, several organic acids had been identified, namely tartaric, malic, ascorbic, succinic, lactic, acetic, citric, and oxalic acids, while in *Annona reticulata* only ascorbic and oxalic acids were reported (González-Agüero et al., 2016; Kn et al., 2016).

The composition of sugars, organic acids, and volatile compounds can affect the chemical and sensory characteristics of the plants, such as microbial stability, pH, and sweetness. Monosaccharides such as rhamnose, fucose, mannose, fructose, arabinose, galactose, xylose, glucose, among others, have been reported in *Annona squamosa* species (Dare et al., 2021), whereas in *Annona muricata* and *Annona cherimola* only sucrose, frutose, and glucose were identified (Chimbevo & Essuman, 2019; Guevara et al., 2019).

Fatty acids are important sources of energy, being also essential components of cell membranes (Ibarguren et al., 2014). Some unsaturated fatty acids, such as linoleic and alpha-linolenic acids, are considered essential because the human organism cannot produce them and must obtain them from the diet. Again, very few studies report the occurrence of these compounds in species of the Annonaceae family.

In *Annona cherimola*, *Annona muricata*, and *Annona squamosa*, for example, oleic acid, a monounsaturated fatty acid linked to lower cholesterol levels and a reduced risk of heart disease, was identified (Luzia & Jorge, 2012). Another fatty acid frequently found in

Table 4
Vitamin contents (mg/100 g dw) of African Annonaceae species.

Scientific name	Plant Parts	Vitamin C	Vitamin E	Thiamin	Riboflavin	Niacin	Cabalamin	Reference
Annona cherimola Mill.	Whole fruit	12.6–25.4	0.27	0.09–0.11	0.11–0.13	0.65–1.0	0.12	(Fuentes et al., 2022)
Annona muricata L.	Whole fruit	1.98 + 0.01	–	0.11	0.05	1.28	–	(Badrie & Schauss, 2010)
Annona squamosa L.	Fruit pulp	25.6–58.8	–	0.10	0.06	0.89	–	(Fuentes et al., 2022)
Monodora myristica (Gaertn.) Dunal	Seeds	9.9 ± 1.7	5.5 ± 1.4	–	–	–	–	(Nkwocha et al., 2019)
Xylopia aethiopica (Dunal) A.Rich.	Whole fruit	1.83 ± 0.03	0.62 ± 0.02	–	–	–	–	(Fategbe et al., 2021)

Annonaceae species is linoleic acid, a polyunsaturated fatty found in species such as *Annona muricata* and *Annona squamosa,* this being considered an important compound in cardiovascular health, in addition to being involved in the inflammatory process and immunity (Rana, 2015). Other fatty acids, such as margaric, eicosanoic, palmitic, heneicosanoic, and stearic acids, among others, were reported for *Annona muricata* and *Annona squamosa* seeds (Luzia & Jorge, 2012). In these species, (Guevara et al., 2019) were able to identify considerable levels of lactic, acetic, citric, and oxalic acids. Also, according to Elagbar et al. (2016), the main monounsaturated and saturated acids found in *Annona muricata* seeds were oleic (39.2%) and palmitic acids (19.1–19.2%), respectively, and α-linolenic acid (1.2%) as a polyunsaturated fatty acid.

Vitamin E, in turn, is a fat-soluble organic compound (Galli et al., 2022), that behaves as a natural antioxidant found in several types of foods (Yanishlieva & Marinova, 2001). They are important for human health as they help to protect human cells against oxidative damage caused by free radicals (Devasagayam et al., 2004). Recent studies have shown that some Annonaceae species, including *Annona cherimola*, *Monodora myristica,* and *Xylopia aethiopica* also contain different concentrations of Vitamin E, with *M. myristica* standing out as the one with highest concentrations (5.5 mg/100 g dw) (Nkwocha et al., 2019).

5. Identification of edible and non-edible Annonaceae species: Toxicology problems

All over the world, plants are a source of food for many living organisms, including humans, being the basis of the diet over several centuries. Moreover, it is estimated that 80% of the world's population lives in developing countries and uses herbal medicines for basic health care. Some of these species have also been used in developed countries, including in Europe (Braun et al., 2010; Ekor, 2014). But despite the nutritional and medicinal potential of such plants, many of them are poisonous or even deadly when ingested (Wertz & Wynn, 2014).

Particularly, in rural areas, it must be considered that most of these plants have not been exhaustively examined to guarantee their safe use and to prevent possible adverse side effects associated (Kristanc & Kreft, 2016). Several studies have explored the pharmacological properties of the Annonaceae family, although many toxicologic aspects have been ignored, being the incorrect identification of plants for food, the main cause of poisoning (Cornara et al., 2018; Mezzasalma et al., 2017).

Although assessing the bioactivity of plant compounds is the basis for their therapeutic use, it is also important to consider the results of toxicological tests, and to evaluate whether the potentially harmful effects of products derived from these plants override the expected benefits (Gavamukulya et al., 2017). In the past, only morphological characteristics were used, to visually identify the species. Currently, several methods that encompass DNA and other nucleic acids analyses are employed (Miller et al., 2016).

Regarding toxicity, some studies have shown a positive correlation between the consumption of *Annona muricata* fruits and the occurrence of Parkinson's disease (Shaw & Höglinger, 2008). Likewise, toxicity studies carried out by Tan et al. (2007) with an aqueous extract of the stem bark of *Annickia chlorantha* administered orally, revealed histopathological alterations in Swiss albino mice, indicating that medium- and long-term use at doses >500 mg/kg can eventually cause lung, liver, and kidney problems. Some authors have been attributed the toxicity of Annonaceae family to the presence of acetogenins, one of the major classes of bioactive compounds in some species, which possess unique structures and powerful cytotoxic properties, with potential applications as insecticides, antiparasitic, and as a highly interesting new generation of antitumor drugs (García-Aguirre et al., 2008; Hernández-Fuentes et al., 2019). Therefore, it is crucial to understand the mechanisms of action of acetogenins, not only to explore their therapeutic potential but also to assess and mitigate the risks associated with their toxicity.

The mechanism of action of acetogenins involves several steps: i) Inhibition of Mitochondrial Complex I: Acetogenins have been found to selectively inhibit complex I of the electron transport chain in mitochondria. This inhibition disrupts the flow of electrons, leading to a decrease in ATP (adenosine triphosphate) production and ultimately resulting in cellular dysfunction and apoptosis (programmed cell death). By targeting mitochondrial function, acetogenins induce cell death specifically in cancer cells, which rely heavily on mitochondrial respiration for their energy needs (Grba et al., 2022). ii) Disruption of ATP Production: By inhibiting mitochondrial complex I, acetogenins interfere with the process of oxidative phosphorylation, which is crucial for the generation of ATP, the energy currency of the cell. Deprived of ATP, cancer cells are unable to sustain their metabolic needs and undergo apoptosis (Grba et al., 2022). iii) Induction of Apoptosis: Acetogenins trigger apoptotic pathways in cancer cells. Apoptosis is a tightly regulated process of programmed cell death essential for maintaining tissue homeostasis. Acetogenins induce apoptosis through various mechanisms, including activation of caspases (enzymes that orchestrate cell death), disruption of mitochondrial membrane integrity, and modulation of pro-apoptotic and anti-apoptotic proteins (Han et al., 2015). iv) Selective Toxicity to Cancer Cells: One of the remarkable characteristics of acetogenins is their selective toxicity towards cancer cells while sparing normal cells. This selectivity is attributed to the higher energy demands and increased susceptibility of cancer cells to mitochondrial dysfunction compared to normal cells (Jacobo-Herrera et al., 2019).

Overall, the mechanism of action of acetogenins describe above, making them promising candidates for the development of anticancer therapeutics. However, further research is needed to fully elucidate their therapeutic potential and safety profile.

6. Conclusion and future perspectives

In Africa, a large part of the population still depends on medicinal plants for basic health care due to their availability, accessibility, and effectiveness in local communities. This review gathers valuable information about species of the Annonaceae family occurring in Africa that are used as food and in traditional medicine, as well as in other sectors such as the timber industry. The presented data clearly shows that this family encompasses a wide variety of edible and non-edible plant species, many of which are extremely relevant at the medicinal and nutritional levels. The data presented in **Table S1**, show the wide range of therapeutic possibilities offered by different genera and species of the Annonaceae family through different manipulation and administration methods. This is an excellent starting point for in-depth scientific studies of poorly known plants with high therapeutic potential and social importance in communities with little access to health care. Species such as *Annona muricata, Annona cherimola*, *Annona mucosa*, and *Annona reticulata* provide edible fruits, and oils can be extracted from the seeds, leaves, and fruits of species such as *Greenwayodendron suaveolens*, *Annona senegalensis*, *Annona squamosa*, *Monodora tenuifolia*, *Uvaria chamae* and *Xylopia staudtii*. On the other hand, wood from other species, such as *Xylopia acutiflora*, *Xylopia rubescens*, *Xylopia staudtii*, *Duguetia staudtii*, *Uvariopsis dioica* and *Uvariopsis korupensis* are used by local communities in the construction of houses, huts, canoes, and tools for domestic purposes.

Phytochemical studies, in turn, have reported the isolation of different bioactive compounds from the seeds, leaves, bark, and pulp of Annonaceae species, such as acetogenins, flavonoids, and alkaloids. Other species are also important sources of essential oils with high antimicrobial and insecticidal activities, used as traditional medicines to treat malaria, diabetes, rheumatism, and fever, among several other illnesses, and as insecticides.

The different parts of some species are rich in nutrients, antioxidants, and other bioactive compounds, which makes them potential sources for the development of new bio-based drugs, extremely relevant for the pharmaceutical industry, and functional foods. Furthermore, these medicinal and nutritional characteristics are of paramount importance in developing countries, as in Africa, where access to food and medicines is limited and people must use the natural resources locally available to meet their needs. Some of the compounds isolated from these plants have shown promising properties in *in vitro* and *in vivo* assays, including anticancer, anti-malarial, anti-parasitic, anti-inflammatory, and neuroprotective activities, among several other therapeutic effects. Although many Annonaceae species have a huge potential as sources of bioactive compounds, it is important to consider that some of them may contain harmful compounds and thus be toxic if consumed in large quantities.

Among the countries of sub-Saharan Africa, Cameroon and Nigeria are the ones that have conducted the most studies on Annonaceae species, encompassing traditional uses and phytochemical properties. However, there is still a significant dearth of research on the nutritional and chemical profiles of many species. Therefore, it is necessary to conduct further studies on species within this family, considering their degree of importance in African communities and beyond. Throughout this study, we found that the most exploited species in Africa are *Annickia chlorantha*, *Annona muricata*, *Annona senegalensis*, *Annona squamosa*, *Duguetia staudtii*, *Monodora myristica*, *Uvaria chamae*, *Xylopia aethiopica*, *Xylopia longipetala* and *Xylopia staudtii*.

Therefore, future research on Annonaceae species should be focused on the development of sustainable cultivation practices, preservation of their natural habitats, identification of further safe and potentially beneficial species, and rational exploitation of their bioactive compounds for nutritional and pharmaceutical purposes. Therefore, encouraging the study of African Annonaceae species can boost the discovery of new bioactive compounds with therapeutic potential, new sources of micro- and macronutrients, and expand the range of food products and phytochemicals available to the growing and more demanding world population.

CRediT authorship contribution statement

Josefa Rangel: Writing – original draft, Investigation. **Sílvia Catarino:** Writing – review & editing, Investigation. **José Carlos Costa:** Writing – review & editing, Supervision. **Maria M. Romeiras:** Writing – review & editing, Visualization, Supervision, Conceptualization. **Ângela Fernandes:** Writing – original draft, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

Acknowledgments

The authors are grateful to the Foundation for Science and Technology (FCT, Portugal) for financial support from the FCT/MCTES (PIDDAC) national funds to CIMO (UIDB/00690/2020 (DOI: 10.54499/UIDB/00690/2020) and UIDP/00690/2020 (DOI: 10.54499/UIDP/00690/2020)), SusTEC (LA/P/0007/2020 (DOI: 10.54499/LA/P/0007/2020)), LEAF (UIDB/04129/2020 and UIDP/04129/2020) and cE3c (UIDB/00329/2020 (DOI: 10.54499/UIDB/00329/2020)) and for the national funding by FCT and P.I. in the form of the institutional scientific employment program for the contracts of Â. Fernandes (DOI: 10.54499/CEECINST/00016/2018/CP1505/CT0008), and the PhD fellowships PRT/BD/152088/2021 and 2021.04585.BD of J. Rangel and Â. Liberal, respectively. S. Catarino was funded by GenoCash Project (PTDC/ASP-AGR/0760/2020).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodchem.2024.139048.

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