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SOURSOP BOTANY, CHEMICAL COMPOSITION AND MEDICINAL PROSPECTS: A CONCISE REVIEW

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ABSTRACT

Soursop (*Annona muricata* L.) belongs to the family Annonaceae and is reported to have the largest fruit in the genus, *Annona*. It is best known as "sawasop" in Nigerian vernacular. It is a fruit tree that was in almost every home garden in time past. The need for space, urbanization, inadequate knowledge about the fruit tree potentials, economic relevance and/or preference, has led to its fast eroding out of the urban and semi-urban areas, with relatively fewer stands, compared to decades ago.Soursop has been reported to originate from the American tropics but has been successfully introduced and domesticated around the world. Several past and current researches have been aimed at revealing the medicinal potential and other properties of soursop. Hitherto, the reported ethnomedicinal properties of soursop include but not restricted to analgesic, antibacterial, anticancer, antifungal, antioxidant, antitumor, antiulcer, antiviral, anti-arthritic, anti-diabetic, anti-hypertensive, anti-inflammatory, anti-insomnia, anti-rheumatic, anti-stress, immune enhancing, as well as wound healing capacity. This review highlights a brief description of the botany, chemical composition and the burgeoning need for the utilization of soursop based on its inherent medicinal properties.

Keywords: Acetogenin, *annona*, anticancer, ethnomedicine, phytochemical, soursop

Introduction

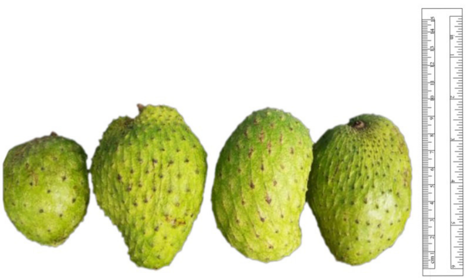
Annona is a genus of tropical fruit trees belonging to the family Annonaceae. The number of genera and species in the family Annonaceae has been a long term debate among researchers (Pinto *et al*., 2005). Annonaceae family is one of the earliest angiosperms. Most *Annona* species have South America and the Antilles as their origin, with Mexico as its center of origin (Hernández Fuentes, 2022). The term *Annona* etymologically is derived from the Latin word *Annona* which means 'yearly produced' (Bourke, 1976). In the genus *Annona,* edible fruits are produced by *Annona cherimola*, *Annona muricata*, *Annona reticulata*, *Annona squamosa*, *Annona atemoya* (a natural hybrid of *Annona cherimola* and *Annona squamosa*), and *Annona diversifolia* (Anuragi *et al*., 2016). The *Annona* genus is usually composite fruits made up of scaly sections that grow together in fir-cone fashion (Samson, 1986).

Annona muricata is the most tropical semi-deciduous tree with the largest fruits of the *Annona* genus. It is widespread in the tropic area of Asia, Central and South America, including the Amazon basin. It is known as "guanabana" in Spanish, "graviola" in Portuguese, "soursop" in English and "ebo" in Yoruba (Samson, 1986). Soursop is commonly found in the southern part of Nigeria; it is mostly eaten as fresh fruits and cultivated mainly in-home gardens (Fasakin *et al*., 2008).

Botanical description

Wild soursop (*Annona muricata* L.) is believed to have originated from Africa (Pinto *et al*., 2005). Soursop has a dichogamous protogynous flower behavior. There are several floral stages of soursop during the whole year. The production of the flowers is not uniform but constant (Escobar & Sanchez, 1993). Soursop grows upright forming a canopy with green leaves, although it could also be low branched and varies in height from not less than about 4 meters to above 10 meters.

The leaf has an aromatic smell like the leaves of *Citrus*. The inflorescence appears around the branches. The fruits of the tree are edible, and the shape of the fruit goes from non-uniform between the length, breadth and width to almost always heart-shaped or ovoid. The pericarp of the fruit has spines and is generally dark green. The endocarp which is the succulent white fleshy part has seeds that are somewhat brownish or black in color. The number of seeds varies in number depending on fruit size, with small fruits having as low as 10 seeds and larger fruits over 100 seeds (Figure 1).



(a)

(b)

(c)

Fig. 1: Soursop; (a) Fruit (b) Flower (c) Seeds

Soursop fruit has 2.9% fleshy receptacle, 85.5% pulp, 3.3% seeds and 8.9% skin (Paull *et al*., 1983). The seed make up about 4% of the whole fruit (Fasakin *et al*., 2008), and can be stored for several months before used for planting (Badrie & Schauss, 2009). Seeds will germinate three (3) weeks after planting in optimal condition, and takes 2-3 months to germinate in suboptimal conditions (Badrie & Schauss, 2009).

Propagation

Soursop is propagated by seeds, but the variation among individual tree is often great. Germination of seeds causes no major problems and takes from 15-30 days if humidity is low (approximately 60%) and temperatures above 12 ˚C are maintained. Pretreatment of seeds with fungicides are required and 90% of viability is expected after five (5) months (Escobar & Sanchez, 1993).

Successful nursery production of good quality seed is largely dependent on the growth media composition (Osaigbovo & Orhue, 2012); this could be a great resource in addressing the conservation issues related to soursop. To produce quality fruit tree seedlings, an appropriate potting media is necessary because vigorous growth is required to face the seasonal hazards encountered on the field (Khan *et al*., 2006). There is a dearth of information about the nursery growth media suitable for propagation of soursop seedlings. Soursop grows well in acid, sandy soils, porous, oolitic and preferentially limestone soils. Desirable growth is achieved in semi-dry deep soils (1.20 m), rich in minerals and well drained. Good aeration and drainage are required in any case. Soursop can tolerate lack of water. The soils with pH from 5.5-6.5 appear to be most suitable (Morton, 1987). Maintaining and increasing the economic potential of soursop must include steps that must be taken in order to develop high quality soursop that are adaptable to different conditions (biotic and abiotic), meet the market demands for the fruit and generate good return for growers (Garcia *et al*., 2012).

Tissue culture is the *in vitro* aseptic culture of cells, organs, tissues, or whole plant under controlled nutritional and environmental conditions (Thorpe, 2007). *In vitro* multiplication through tissue culture has been successful in soursop (Andrade *et al*., 2014; Inwanna *et al*., 2014). Future application of tissue culture in *Annonaceaes* will focus on the mass micropropagation of selected accessions and development of regeneration methodologies for agronomic improvement of these species through plant breeding, manipulation of ploidy and genetic transformation (Encina *et al*., 2014).

Results by Garcia *et al*. (2012) who carried out a study on genetic transformation of Soursop via *Agrobacterium tumefaciens*, stated that genetic transformation could be a potential alternative for genetic improvement and rapid mass propagation of soursop.

Mineral composition, phytochemical and proximate studies of soursop

Mineral composition, phytochemical and proximate studies of soursop extract revealed the presence of various compounds including alkaloids, ascorbic acid, beta-carotene, calcium, carbohydrate, essential oils, fibre, flavonoids, iron, lipid, magnesium, oxalate, phenol, phytate, potassium, protein, tannin, polyphenols, reducing sugar, saponin, etc. (Fasakin *et al*., 2008; Anuragi *et al*., 2016; Agu & Okolie, 2017; Hernández Fuentes, 2022).

The presence of various major minerals such as calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg) and sodium (Na) suggest that the composition of the soursop fruit can help contribute essential elements and nutrient to the human body (Gyamfi *et al*., 2011). Soursop fruits are low in toxicants (tannins, phytate and cyanide) and rich in protein and oil, therefore could be incorporated in animal and human nutrition (Fasakin *et al*., 2008). Soursop is rich in seed oil content and can be exploited in oil industries (Anuragi *et al*., 2016).

TABLE 1

Chemical composition of soursop

Compounds	Plant part	References
Acetogenins	Leaf, pericarp, pulp, seed, root, stem	(Jaramillo *et al*. (2000); Gleye *et al*. (2001); Li *et al*. (2001); Sun *et al*., 2014; Agu *et al*. (2017); Rady *et al*.(2018))
Alkaloids	Leaf, pericarp, pulp, root, seed, stem	(Agu & Okolie, 2017; Rady *et al*.(2018); Audu *et al*.(2019))
Arginine	Leaf, pulp, root, stem	(Agu & Okolie, 2017)
Aromatic amino acids	Leaf, pulp, root, stem	(Agu & Okolie, 2017)
Ascorbic acid (vitamin C)	Leaf, pulp, seed	(Onimawo, 2002; Anuragi *et al*., 2016 ; Abiola, 2018; Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Ash	Leaf, pulp, root, seed, stem	(Fasakin *et al*., 2008; Anuragi *et al*., 2016; Agu & Okolie, 2017; Prince-will-Ogbonna *et al*., 2019)
Balsams	Pericarp, pulp, seed	(Audu *et al*., 2019)
Beta carotene (Vitamin A)	Leaf	(Princewill-Ogbonna *et al*., 2019)
Calcium	Leaf, pericarp, pulp, seed	(Fasakin *et al*., 2008; Audu *et al*., 2019; Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Carbohydrate	Leaf, pericarp, pulp, root, seed, stem	(Onimawo, 2002; Fasakin *et al*., 2008; Anuragi *et al*., 2016; Agu & Okolie, 2017; Audu *et al*., 2019; Princewill-Og-bonna *et al*., 2019; Hernández Fuentes, 2022)
Cardiac glycosides	Leaf, root	(Agu & Okolie, 2017
Copper	Leaf, pericarp, pulp, seed	Fasakin *et al*., 2008; Abiola, 2018; Audu *et al*., 2019)
Cyanides	Seed	(Fasakin *et al*., 2008)
Cysteine	Leaf, pulp, root, stem	(Agu & Okolie, 2017
Essential oil	Leaf, pulp, root, seed, stem	(Fasakin *et al*., 2008; Anuragi *et al*., 2016; Agu & Okolie, 2017)
Ether	Leaf	(Princewill-Ogbonna *et al*., 2019)
Fat	Leaf, pulp, root, seed, stem	(Anuragi *et al*., 2016; Agu & Okolie, 2017; Hernández Fuentes, 2022)
Fiber	Leaf, pulp, root, seed, stem	(Fasakin *et al*., 2008; Anuragi *et al*., 2016; Agu & Okolie, 2017; Prince-will-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Flavonoids	Leaf, pericarp, pulp, root, seed, stem	(Agu & Okolie, 2017; Rady *et al*., 2018; Audu *et al*., 2019)
Glycosides	Pericarp, pulp	(Audu *et al*., 2019
Hydrogen cyanide	Seed	(Fasakin *et al*., 2008; Abiola, 2018)
Iron	Leaf; pericarp, pulp, seed	(Fasakin *et al*., 2008; Audu *et al*., 2019; Hernández Fuentes, 2022)

Ketoses	Leaf, pulp, root, stem	(Agu & Okolie, 2017)
Magnesium	Leaf, pericarp, pulp, seed	(Fasakin *et al*., 2008; Audu *et al*., 2019; Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Moisture	Pulp, seed	(Anuragi *et al*., 2016; Agu & Okolie, 2017; Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Monosaccharides	Leaf, pulp, root, stem	(Agu & Okolie, 2017)
Niacin (Vitamin B3)	Leaf	(Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Non-reducing sugars	Leaf, pulp, seed	(Onimawo, 2002; Anuragi *et al*., 2016)
Oxalate	Seed	(Abiola, 2018)
Pentoses	Leaf, pulp, root, stem	(Agu & Okolie, 2017)
Phenolic amino acids	Leaf, pulp, root, stem	(Agu & Okolie, 2017)
Phenols	Leaf, pericarp, pulp, root, seed, stem	(Anuragi *et al*., 2016; Agu & Okolie, 2017; Audu *et al*., 2019)
Phosphorus	Leaf, pulp	(Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Phytate	Seed	(Fasakin *et al*., 2008; Abiola, 2018)
Potassium	Leaf, pulp, seed	(Fasakin *et al*., 2008; Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Protein	Leaf, pulp, root, seed, stem	(Fasakin *et al*., 2008; Onimawo, 2002; Anuragi *et al*., 2016; Agu & Okolie, 2017; Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Reducing sugar	Leaf, pulp, root, stem	(Agu & Okolie, 2017)
Resins	Pericarp, pulp	(Audu *et al*., 2019)
Riboflavin (Vitamin B2)	Pulp, seed	(Onimawo, 2002; Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Saponins	Leaf, pericarp, pulp, root, seed, stem	(Agu & Okolie, 2017; Audu *et al*., 2019)
Sodium	Leaf, seed	(Fasakin *et al*., 2008; Princewill-Ogbonna *et al*., 2019)
Starch	Leaf, pulp, root, stem	(Agu & Okolie, 2017)
Steroids	Leaf, pericarp, pulp, root, seed, stem	(Agu & Okolie, 2017; Audu *et al*., 2019)
Tannins	Leaf, pericarp, pulp, root, stem	(Fasakin *et al*., 2008; Agu & Okolie, 2017; Abiola, 2018, Audu *et al*., 2019)
Terpenoids	Leaf, pericarp, pulp, root, seed, stem	(Agu & Okolie, 2017; Audu *et al*., 2019)
Thiamine (Vitamin B1)	Leaf, pulp, seed	(Onimawo, 2002; Princewill-Ogbonna *et al*., 2019; Hernández Fuentes, 2022)
Titratable acidity	Pulp. Seed	(Onimawo, 2002; Anuragi *et al*., 20160
Total soluble solids	Pulp, seed	9Anuragi *et al*., 2016)

Vitamin E	Pulp, seed	(Abiola, 2018; Hernández Fuentes, 2022)
Zinc	Seed	(Fasakin *et al*., 2008)

Medicinal properties of soursop

More than two hundred (200) phytochemicals have been reported in soursop extracts, isolated from various parts of the plant. The bioactive phytochemicals responsible for the major anticancer, antioxidant, anti-inflammatory, antimicrobial, and other health benefits of soursop include different classes of annonaceous acetogenins, alkaloids, flavonoids, sterols, phenols and others (Rady *et al*., 2018). Numerous investigators have validated the vast array of ethnomedicinal capacity of soursop, including anti-arthritic, antidiabetic, anticancer, anticonvulant, antihyperliperdemia, anti-inflammation, antimalaria, antioxidant, antimicrobial, antiparasitic and hepatoprotective activities (Adeyemi *et al*., 2008; Adewole & Ojewole, 2009). However, Mutakin *et al*. (2022) opined that further research on the toxicity of soursop and clinical trials assaying the pure compounds has become necessary to duly elucidate its pharmacological activities and guarantee the safety of soursop as a potential drug for various diseases.

The antibacterial effects of aqueous and ethanolic extracts of pods of soursop and seeds of *Moringa* were assayed against *Staphylococcus aureus*, *Vibrio cholerae*, *Escherichia coli* and *Salmonella enteritidis*. Aqueous extract of soursop showed antibacterial effect against *Staphylococcus aureus* and *Vibrio cholera* (Vieira *et al*., 2010). Phytochemical studies reveal that annonaceous acetogenins are the major constituents of soursop. Over one hundred annonaceous acetogenins have been isolated from barks, fruits, leaves, roots and seeds of soursop (Moghadamtousi *et al*., 2015). Many pharmacological studies of leaves and seeds of soursop report the isolation of acetogenins as the secondary metabolite obtained (Oberlies *et al*., 1997). Leaf extracts of soursop have been shown to inhibit tumor growth *in vivo* in animal models and cause apoptosis of various cancer cells *in vitro* (Liu *et al*., 2016).

Ethnopharmacological relevance of soursop carried out by Liu *et al*. (2016) indicated that ethanol extract of the leaves causes apoptosis of liver cells through the endoplasmic reticulum stress pathway, which supports the ethnomedicinal use of this herb as an alternative and/or complementary therapy for cancer.

Agu *et al*. (2017) isolated 15-acetylguanacone, an acetogenin from soursop; this acetogenin had not been reported in the *Annona* genus previously. The compound was furthermore subjected to molecular docking experiments which revealed that it targets and binds to Vascular Endothelial Growth Factor 2 (VEGF2) (-8.5 kcal/mole) and α1 β2 integrin (-6.8 kcal/mole). This suggests that 15-acetylguanacone prevents metastasis and invasion by cancer cells, and ultimately initiates apoptosis. This thus confirms the great availability of possible novel or unidentified acetogenins and anticancer molecules that soursop contains.

Anticancer studies on soursop were not only limited to *in vitro* and *in vivo* investigations. A case study of a sixty-six-year-old woman with a metastatic breast cancer reported that consumption of the soursop leaves boiled in water and xeloda (a chemotherapy medication) resulted in stabilization of the disease (Hansra *et al*., 2014). The substantial anticancer and antitumor activities of soursop leaves have led to tablet formation of the ethyl acetate soluble fraction of the leaves that contains annonaceous acetogenins that can be used as a cancer adjuvant therapy (Elisya *et al*, 2014). Treatments using soursop could be an alternative choice aside chemotherapy and radiotherapy, most especially for terminally ill patients (Yajid *et al*., 2018).

Oyebamiji *et al*. (2020) conducted an investigation on soursop seed as an anticancer agent through density functional theory, molecular docking study, and molecular dynamics simulation studies. The compounds studied proved to be active as an antibreast cancer agent. Three extracts of soursop (ethanol, ethylacetate and hexane) have been shown to have strong cytotoxicity against cervical HeLa cells in a research conducted by Qorina *et al*. (2020).

According to a review by Gajalakshmi *et al*. (2012), an experiment on the antiviral activity of soursop extract on Herpes Simplex Virus-1 (HSV-1) and clinical isolate (obtained from the human keratitis lesion) proved that soursop could be used as a potential anti-herpetic drug.

Results from research on formulation and production of granule from soursop fruit juice as antihypertensive instant drink proved that the granule produced from the juice has acceptable physical features and is effective in decreasing high blood pressure. Therefore, the soursop granule could be produced as an antihypertensive instant fruit drink on an industrial scale, to substitute synthetic antihypertensive drugs (Djarot & Badar, 2017).

Investigation of the effects of soursop supplementation on blood pressure, serum uric acid and kidney function indicated that the supplementation (2 × 100 g soursop fruit juice) can lower blood pressure and serum uric acid levels (Alatas *et al*., 2020).

Osorio *et al*. (2007) & Mohd Abd Razak *et al*. (2014) recorded promising antimalaria effect by assaying extracts of the leaf of soursop against *Plasmodium falciparum*. This finding was confirmed by Somsak *et al*. (2016) who found that the aqueous leaf extract of soursop had a potent antimalaria effect, lack of toxic effect and prolonged survival time. Therefore, they postulated that the extract may serve as a potential source of affordable, effective and safe antimalaria drug.

Some reported medicinal potentials of soursop are presented in table 2; however, most of the research was more of animal and experimental models. Perhaps, clinical trial of the medicinal properties of soursop involving humans is still at its infancy due to the delicacy and sensitivity of such trials.

TABLE 2

Reported medicinal properties of soursop

Medicinal properties	**Plant part**	**References**
Analgesic	Fruit	Ishola *et al*., 2014
Antibacterial	Fruit	Vieira *et al*., 2010
	Leaf	Pai *et al*., 2016; Ozor & Okwute, 2023
Anticancer	Leaf	Elisya *et al*., 2014; Hansra *et al*., 2014; Liu *et al*., 2014; Pieme *et al*., 2014; Qorina *et al*., 2020
	Seed	Oyebamiji *et al*., 2020
	Fruit	Agu *et al*., 2017
	Stem/ Root	Pieme *et al*., 2014
Antidiabetic	Fruit/ Leaf/ Stem	Djarot & Badar, 2017; Agu *et al*., 2019

Antifungal	Leaf	Pai *et al*., 2016
Antihypertensive	Fruit	Alatas *et al*., 2019
Anti-inflammatory	Fruit	Ishola *et al*., 2014
Antimalaria	Leaf	Osorio *et al*., 2007; Mohd Abd Razak *et al*., 2014; Somsak *et al*., 2016
Antioxidant	Leaf	Balderrama-Carmona *et al*., 2020
Antiviral	Leaf	Balderrama-Carmona *et al*., 2020

Conclusions

Soursop tree has shown to be diverse in terms of growth patterns, tree height, flowering time, fruit size, which could be relative to the environment as well as genetic capacity. It is mainly cultivated using seeds, and it can do well even with minimal care and there is hardly any report of a serious devastating disease or pest. The fruit has a unique taste and flavor when ripe. Of all the plant parts, extracts from the leaves tends to be the most researched for medicinal prospects. In terms of food, the fruit remains the bride; meanwhile soursop tea made from the leaves is consumed in some part of the world.

The mechanism of action of the bioactive pharmaceutical constituents of soursop has been reported. Diseases like cancer, diabetes and hypertension that soursop has been reported to have pharmacological effects on, are diseases of concern in the world that has in the past and now attracted researchers and stakeholders but much more need to be done to ascertain how to carry out a more detailed clinical trial with concerted effort from scientists across the globe.

The constraints of soursop fruit production and processing hovers around relatively short shelf/storage life and uneven ripening. Poor handling during harvest, transportation and marketing also increases post-harvest problems. Juice, puree and jam have been produced from the fruit. Due to the perishable nature of the fruit, improved storage methods and processing methodologies should be encouraged in order to mitigate this occurrence. Neurotoxicity has been exhibited in some phytochemicals, such as acetogenins from the plant. Studies are therefore necessary to evaluate the extent of neurotoxicity and ways to control it.

Conservation techniques to stem the threat of extinction of soursop should be developed, which may include the best potting media, soil amendment and environment for seedling propagation. The numerous potentials and activities of soursop should place it in the same relevance category as other fruit trees such as *Citrus*; so therefore, its cultivation should be encouraged.

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