Bioactivity of the specie Annona coriacea: A systematic review

Bioatividade da espécie Annona coriacea: Uma revisão sistemática

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Samara Raquel de Sousa
Postgraduate Program in Biotechnology - RENORBIO, Focal Point - Federal University of Piauí – UFPI
Address: Av. Nossa Senhora de Fátima s/n, 64049-550, Teresina, PI, Brazil
E-mail: sambio2015@gmail.com

Francisco Cardoso Figueiredo
Technical College of Teresina - CTT, Federal University of Piauí - UFPI
Address: Av. Nossa Senhora de Fátima s/n, 64049-550, Teresina, PI, Brazil

José Ribeiro dos Santos Júnior
Postgraduate Program in Biotechnology - RENORBIO, Focal Point - Federal University of Piauí – UFPI
Address: Av. Nossa Senhora de Fátima s/n, 64049-550, Teresina, PI, Brazil

Antônio Alberto Jorge Farias Castro
Department of Biology, Federal University of Piauí - CCN / UFPI
Address: Av. Nossa Senhora de Fátima s/n, 64049-550, Teresina, PI, Brazil

Ruth Raquel Soares de Farias
Department of Biology, Federal University of Piauí - CCN / UFPI
Address: Av. Nossa Senhora de Fátima s/n, 64049-550, Teresina, PI, Brazil

Raimundo Nonato Lopes
3Department of Biology, Federal University of Piauí - CCN / UFPI
Address: Av. Nossa Senhora de Fátima s/n, 64049-550, Teresina, PI, Brazil

Daniela Reis Joaquim de Freitas
Parasitology and Microbiology Department, Federal University of Piauí - CCS / UFPI
Address: Av. Nossa Senhora de Fátima s/n, 64049-550, Teresina, PI, Brazil

Lívio César Cunha Nunes
Postgraduate Program in Biotechnology - RENORBIO, Focal Point - Federal University of Piauí – UFPI
Address: Av. Nossa Senhora de Fátima s/n, 64049-550, Teresina, PI, Brazil
E-mail: liviocesar@hotmail.com
ABSTRACT

The araticum (Annona coriacea Mart.) is a tree of the Annonaceae family with great distribution in the northern Cerrados of the State of Piauí. Several species of this family have medicinal use and demonstrate some biological activities that have already been experimentally proven such as antihelmintic, antimalarial, antimicrobial, antinociceptive, antiprotozoal, insecticidal, parasiticidal and antioxidant activities due to the presence of acetogenins. The objective of this study was to carry out a scientific and technological prospection of the Annona coriacea plant related to tickcidal activity. The scientific bases used were; PubMed, ScienceDirect and Web of Science and the technological databases include; EPO, WIPO, USPTO, DII, LATIPAT and INPI, with the following keywords: Annona coriacea, Annona coriacea and tickcidal, Annona coriacea and acaricide and Annona coriacea and biocide, all articles published in the last decade and without temporal cut for patent registration being counted. We found 156 articles and 17 patents, most of them dealing with medicinal use and chemical composition of the plant. The study showed that there is interest in the plant studied, but there is a wide field to carry out studies on technological innovation and development of new products, as in the area of tickcidal products.

Keywords: Annonaceae, tick, phytochemistry, phytotherapy, natural product.

RESUMO

O araticum (Annona coriacea Mart.) é uma planta arbórea da família Annonaceae com grande distribuição nos Cerrados Setentrionais do Estado do Piauí. Diversas espécies desta família têm uso medicinal e algumas atividades biológicas já foram comprovadas experimentalmente como as atividades antihelmíntica, antimalárica, antimicrobiana, antinociceptiva, antiprotozoária, inseticidas, parasiticidas e antioxidante devido às acetogeninas. O objetivo deste estudo foi realizar uma prospecção científica e tecnológica da planta Annona coriacea relacionada com a atividade carrapaticida. As bases científicas foram PubMed, ScienceDirect e Web of Science e as tecnológicas EPO, WIPO, USPTO, DII, LATIPAT e INPI, com as palavras-chave: Annona coriacea, Annona coriacea e carrapaticida, Annona coriacea e acaricida e Annona coriacea e biocida, sendo computados todos os artigos publicados na última década e sem recorte temporal para o registro de patentes. Foram encontrados 156 artigos e 17 patentes, a maioria abordando uso medicinal e composição química da planta. O estudo mostrou que existe interesse pela planta estudada, contudo há um campo vasto para execução de estudos de inovação tecnológica e desenvolvimento de novos produtos, como na área de carrapaticidas.

Palavras-chave: Annonaceae, carrapato, fitoquímica, fitoterápico, produto natural.

1 INTRODUÇÃO

Annona coriacea Mart., popularly known as araticum, is an arbooreal species with great distribution in the Northern Cerrados of the State of Piauí (Sousa et al. 2013). It is a fruit of the Annonaceae family, as well as the pinecone (A. squamosa) and the graviola (A. muricata) (Ribeiro et al. 2000).

Regarding the biodiversity composition of chemical substances, this family is characterized by the presence of terpenoids (mainly diterpenes), alkaloids derived from isoquinolines, phenolic acids, tannins, flavonoids, steroids, aromatic and benzene substances, catechins, proanthocyanidins,
carbohydrates, lipids, proteins, lactones, vitamins, carotenes, saponins, besides essential oils, whose composition is predominantly of monoterpenes and sesquiterpenes (Luna 2006, Lima 2007, Silva et al. 2009, Reis 2011).

Pharmacological and phytochemical studies using species of annonaceae have largely intensified due to the discovery of acetogenins, extremely bioactive secondary metabolites, exclusive to this family, which have been considered as important alternatives for the development of antitumor drugs (Leite 2009, Rupprecht et al. 1990).

Regarding the biological activities of A. coriacea, it has been used in traditional medicine due to its analgesic, anti-inflammatory, antiprotozoan, antioxidant, antiproliferative, anticholinergic, antinociceptive and antifungal properties (Sousa et al. 2007, Toledo et al. 2011, Siqueira et al. 2011, Benites et al. 2015, Formagio et al. 2015, Sousa et al. 2011, Sousa et al. 2012, Silva et al. 2012).

In China, some annonaceae are widely cultivated and used as insecticides and parasiticides (Chen et al. 2004). There are proven anthelmintic, antimalarial, antimicrobial, antinociceptive, antiprotozoal, pesticide and antioxidant activities due to acetogenins (Alali et al. 1999, Gripp et al., 2020, Julian-Loaeza et al. 2011). Thus, considering the reports in the literature and emphasizing its parasiticide potential, the species in question is known to be an antiparasitic agent, which is still unsatisfactory. In this sense, due to its wide use in folk medicine and some of its scientifically verified actions, the phytochemical study of araticum extract on ticks is relevant, since they cause damage to bovine performance due to their spoiling, mechanical and toxic actions (Fraga et al. 2003).

The Rhipicephalus (Boophilus) microplus is an ectoparasite of great economic impact in cattle raising in Brazil because it can cause losses such as: reduction of the productive and reproductive performance of dairy cattle herd, reduction of the production yield, reduction of the quality of animal hide, and loss of animal weight and milk production (Gomes et al. 2011, Santos and Vogel 2012), which leads to economic losses to producers, by reducing the income related to the animal and increased expenses with products for the control of this parasite.

Currently, the chemical control of ticks is characterized by the progressive increase in the number of strains resistant to the main acaricides used and, consequently, by the increase in the frequency of application (Furlong et al. 2007), which causes two major problems: the accelerated development of resistance to the active ingredient and the residues in products of animal origin, which has caused great concern to society and government agencies (Leal et al. 2003).

In this perspective, plants are important sources of substances having different chemical structures with different activities against arthropods (Sousa et al. 2008), which drive the development of research on new control practices such as the use of medicines based on plant extracts.
In view of the above, it is believed that with regard to scientific and technological prospection, research that shows the properties already described for *Annona coriacea*, with special focus on its antiparasitic activity, represent a valuable tool, because they constitute systematic means of scientific information that are fundamental in guiding the development of new technologies (Machado et al. 2014).

In this context, the objective of the present study was to carry out a scientific and technological prospection of plant *A. coriacea* related to tickcidal activity, in order to analyze the number of patent applications filled in each country, through national and international innovation and technology data bases, as well as to describe the profile of scientific production of this species.

2 MATERIALS AND METHODS

The prospective study was carried out in November 2019 based on the search of patent applications and scientific articles on the species *Annona coriacea*, as well as its relation with tickcidal activity. The following keywords were used: *Annona coriacea*, *A. coriacea* and tickcidal, *A. coriacea* and acaricide and *A. coriacea* and biocide. The scientific bases used were PubMed, ScienceDirect and Web of Science. In this stage, only research articles published in the last 10 years that displayed these descriptors in their titles and/or abstracts were selected. Duplicate articles found in the same database and/or in more than one of the databases used, were excluded.

The European Patent Office (EPO), World Intellectual Property Organization (WIPO), United States Patent and Trademark Office (USPTO), Derwent Innovations Index® (DII), Latin American Patent database (LATIPAT) and database of the Brazilian National Institute of Industrial Property (INPI) were used for the technological databases. Prospection was carried out through search, collection and treatment of data in patent documents between the years 1963 and 2019.

The program Microsoft Excel version Windows 10® was used for data analysis.

3 RESULTS AND DISCUSSION

3.1 SCIENTIFIC PROSPECTION

Concerning *Annona coriacea* species, the initial search with this descriptor in PubMed gave rise to (58) associated results, 64 in Science Direct and 31 related articles in Web of Science. However, with regard to tickcidal activity, 1 article was found in the PubMed database and 2 articles in the Web of Science database using the following descriptors: *Annona coriacea* and acaricide and *Annona coriacea* and biocide (Table I).
TABLE I: Number of scientific articles published in PubMed, ScienceDirect and Web of Science databases, by keywords.

| Keywords                        | PubMed | ScienceDirect | Web of Science |
|---------------------------------|--------|---------------|----------------|
| Annona coriacea                 | 58     | 64            | 31             |
| Annona coriacea and tickcide    | 0      | 0             | 0              |
| Annona coriacea and acaricide   | 1      | 0             | 1              |
| Annona coriacea and biocide     | 0      | 0             | 1              |

Through the scientific bases used in this study, a total of 156 articles were computed for the species studied. The search strategy and selection of the researched articles were described through the PRISMA flowchart (Figure 1). Of the total number of articles identified in the databases, after reading the title and abstract and, when necessary, the text itself, some were excluded by duplication, because it is a book chapter or because the species itself was not cited in the text. As well as those who approached the species in a botanical, ecological, genetic, morphological and chemical context, besides those who reported other biological activities, other than the tickcidal activity. Those in which the species was cited only in the references and those in which the authors mentioned the species only in their discussion, but not related to the tickcidal activity, were also removed resulting in the eligibility of only 4 articles for discussion, all found in the Web of Science database (Table II).
Figure 1. PRISMA flow diagram.

Identification
- Records identified by searching the database after previously described criteria (n = 156)
- Additional records identified by other sources (n = 0)

Screening
- Records duplicates removed (n = 9)

Eligibility
- Selected records (n = 147)
- Deleted records (n = 2)

Included
- Full text articles evaluated for eligibility (n = 145)
- Full text articles deleted with reasons (n = 141)

Inclusion
- Studies included in qualitative synthesis (n = 4)
| Author/Year | Title                                                                 | Arthropod | Objective                                                                 | Periodical                                      | Principal Results                                                                                                                                                                                                 |
|------------|----------------------------------------------------------------------|-----------|---------------------------------------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Alves et al. 2015 | Acaricidal activity of Annonaceae fractions against Tetranychus tumidus and Tetranychus urticae (Acari: Tetranychidae) and the metabolite profile of Dugetia lanceolata (Annonaceae) using GC-MS | Mite      | Select soluble fractions in dichloromethane with acaricide activity, coming from methanolic extracts of annonaceous species. | Semina: Ciências Agrárias                        | Among the soluble fractions in dichloromethane, only that coming from the bark of the stem of D. lanceolata caused a reduction in the survival of females of T. tumidus, but without ovicidal activity. Activity regarding T. urticae was also found. The analysis of the metabolite profile of the D. lanceolata stem bark fraction by means of GC-MS suggested that the major constituents are 2,4,5-trimethoxystyrene and trans-asarone. |
| Carneiro et al. 2013 | Biocide activity of Annona coriacea seeds extract on Rhodnius neglectus (Hemiptera: Reduviidae) | Insect    | To evaluate the biocidal activity of the ethanolic extract of Annona coriacea seeds in nymphs and adults of Rhodnius neglectus (Chagas disease vector). | Revista de Biologia Tropical                    | A. coriacea extract was able to disrupt the development of nymphs and adults of R. neglectus, with a mortality rate higher than 90%, 36% and 100%, in the highest concentrations, respectively. There was also inhibition of moultling in nymphs, lower reproductive capacity in females, food deterrence, and morphological changes in nymphs and adults. |
| Freitas et al. 2014 | Effects of Methanolic Extracts of Annona Species on the Development and Reproduction of Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) | Insect    | Report the effect of methanol leaf extracts from Annona dioica, Annona cacans and Annona coriacea on the development and reproduction of Spodoptera frugiperda. | Neotropical Entomology                          | A. coriacea leaf extract decreased larval survival, interrupted pupal development and affected weight gain of S. frugiperda. A. dioica also affected the survival of larvae, but its effects were more pronounced at the adult stage, as fecundity, fertility, egg hatching and embryonic development were severely affected. Extracts of A. cacans leaves had no effect on S. frugiperda. Extracts of leaves of A. dioica and A. coriacea showed higher content of flavonoids and phenols, respectively. Our results indicated that both A. dioica and A. coriacea have the potential for development of botanical insecticides. |
| Costa et al. 2012 | Morphological Changes in the Midgut of Aedes aegypti L. (Diptera: Culicidae) Larvae Following Exposure to an Annona coriacea (Magnoliales: Annonaceae) Extract | Insect    | Describe the morphological changes that occur in the middle intestine of the third instar Aedes aegypti L. (Diptera: Culicidae) after treatment with a methanolic extract of Annona coriacea (Magnoliales: Annonaceae). | Neotropical Entomology                          | Insects exposed to the extract demonstrated intense and destructive cytoplasmic vacuolization in columnar and regenerative intestinal cells. The apical surfaces of columnar cells exhibited cytoplasmic protrusions oriented toward the lumen, suggesting that these cells could be involved in apocrine secretory processes and/or apoptosis. |
Figure 2 (a, b, c) shows the evolution of publications in the scientific databases related to the term *Annona coriacea*, being possible to observe an increase in publications in the last 10 years, with emphasis on the year 2016, which has 13.79% of articles. This trend is related to the versatility of araticum’s applications in different areas of research, such as medicine, pharmacology, chemistry, botany, entomology and agriculture. November 2019 already has a significant portion of articles (12.41%), and this result is superior to that of the year 2018, which shows the growing interest of the research groups for the species object of this study.

Figure 2. Results obtained for the scientific search for the term “*Annona coriacea*” in PubMed, ScienceDirect and Web of Science (a) and Annual evolution of publications referring to the term “*Annona coriacea*” in the aforementioned scientific bases, general (b) and individual (c).

The development of scientific research on the species studied, point out American and Asian countries as the authors of number of publications, especially Brazil (South America), which stands out in 1st place, with a total of 92 publications reported between 2009 and 2019, followed by the
United States (North America), with 8 papers and China (East Asia) and India (South Asia), with 7 studies, each, occupying the second, third and fourth place in this order (Figure 3 a, b).

The profile of the studies varied widely, with the highest number of publications referring to medicinal potential (Table III). Among the pharmacological activities described are cytoprotective (Júnior et al. 2016), antiproliferative and anticholinesterase (Formagio et al. 2015), antidiarrheal (Araújo et al. 2014, Lozano et al. 2014), anticoagulant (Ribeiro et al. 2017), antimicrobial (Toledo et al. 2011), antiophidic (Ribeiro et al. 2014, Saraiva et al. 2015), anti-inflammatory (Sousa et al. 2014, Sousa et al. 2012, Sousa et al. 2011), antioxidant (Novaes et al. 2019, Benites et al. 2015), diuretic (Magalhães et al. 2019), phytotoxic (Novaes et al. 2016), hepatotoxic (Nascimento et al. 2012), antinociceptive (Sousa et al. 2012, Sousa et al. 2011) and antiprotozoal (Siqueira et al. 2011). These studies promote the emergence of new drugs as an alternative to pharmacotherapy.

Figure 3. Distribution of scientific articles by world region (a) and country of origin (b), referring to the term “Annona coriacea” in PubMed, ScienceDirect and Web of Science databases.
In public health, arboviruses have been a cause of great concern all over the world, most of them transmitted by hematophagous arthropods, where mosquitoes of the *Culex* and *Aedes* genera represent are the most dangerous to human health, however, other arboviruses are transmitted by sand flies and ticks (Weaver and Reisen 2010). In this scenario, insecticide applications with relevance to health were addressed, such as the use of extracts to induce morphological changes in the middle intestine of *Aedes aegypti* larvae (Costa et al. 2012), as well as the ethanolic extract of seeds, which was able to disturb the development of nymphs and adults of *Rhodnius neglectus* (Hemiptera: Reduviidae), host of *Trypanosoma cruzi* (Carneiro et al. 2013), besides the leaf extract that decreased the survival of the larvae, interrupted the development of the pupae and affected the weight gain of *Spodoptera frugiperda*, which indicates that this species can be used in development of botanical insecticides (Freitas et al. 2014). However, few studies reported the tickcidal effects of the *Annona coriacea* plant.
TABLE III: Evaluation of studies that presented some biological activity found in PubMed, ScienceDirect and Web of Science, 2009-2019.

| Author/ Year | Title | Parte da Planta | Indicação Terapêutica | Principais Resultados |
|--------------|-------|-----------------|-----------------------|-----------------------|
| Júnior et al. 2016 | Chemical Characterization and Cytoprotective Effect of the Hydroethanol Extract from Annona coriacea Mart. (Araticum) | leaves | cytoprotective | The results obtained in this study show that HEAC presents cytoprotective activity on the strains tested in vitro and may also exert an antagonistic effect when associated with aminoglycosides, reinforcing the need for caution in the combination of natural and pharmaceutical products. |
| Formagio et al. 2015 | In vitro biological screening of the anticholinesterase and antiproliferative activities of medicinal plants belonging to Annonaceae | leaves, floral chapters and seeds | antiproliferative and anticholinesterase | In general, the results indicated that Annona crassiflora and A. coriacea extracts have antiproliferative and anticholinesterase properties, which opens new possibilities for alternative pharmacotherapeutic drugs. |
| Araújo et al. 2014 | Evaluation of the anti-mycobacterium tuberculosis activity and in vivo acute toxicity of Annona sylvatica | leaves | antidiarrhea | Tea from Annona coriacea leaves is used to control diarrhea. |
| Lozano et al. 2014 | The apparency hypothesis applied to a local pharmacopoeia in the Brazilian northeast | leaves | antidiarrhea | Tea from Annona coriacea leaves is used to control diarrhea. |
| Ribeiro et al. 2017 | Ethnobotanical study of medicinal plants used by Ribeirinhos in the North Araguaia microregion, Mato Grosso, Brazil | stem bark | anticoagulant | The bark of the stem of Annona coriacea is macerated and used against thrombosis. |
| Toledo et al. 2011 | Antimicrobial and cytotoxic activities of medicinal plants of the Brazilian cerrado, using Brazilian cachaça as extractor liquid | leaves | antimicrobial | Antimicrobial activity was demonstrated for Annona coriacea specie, where the CE obtained from it showed better activity against the promastigote form of Leishmania amazonensis (IC50 = 175 g/ml). None of the extracts showed toxicity against human erythrocytes. |
| Ribeiro et al. 2014 | Promising medicinal plants for bioprospection in a Cerrado area of Chapada do Araripe, Northeastern Brazil | leaves and stem bark | antiophidic | The leaves or bark of the stem of Annona coriacea are used against snake bite, applied on the affected part of the body. |
| Saraiva et al. 2015 | Plant species as a therapeutic resource in areas of the savanna in the state of Pernambuco, Northeast Brazil | root | antiophidic | Annona coriacea root is used against snake bite by ingestion or poultice. |
| Souza et al. 2014 | Ethnopharmacology of medicinal plants of carrasso, northeastern Brazil | leaves | anti-inflammatory | Tea from the leaves of Annona coriacea is indicated against depurative dermatitis. |
| Novaes et al. 2019 | Comparing antioxidant activities of flavonols from Annona coriacea by four approaches | leaves | antioxidant | Of the eleven flavonols isolated from the leaves, two response patterns of glycosylated flavonols in antioxidant assays were observed: (i) quercetin and its derivatives were the most active antioxidant compounds in PPHD and FRAP assays; and (ii) derivatives of isormarnetin had higher or similar antioxidant activities than derivatives of quercetin in ABTS + and ORAC assays. |
Medicinal plants of the Caatinga, northeastern Brazil: Ethnopharmacopeia (1980–1990) of the late professor Francisco José de Abreu Matos

- **Annona coriacea**
  - Leaves
  - Diuretic
  - Annona coriacea leaf tea is used as a diuretic to combat nervousness and urinary infection. The study demonstrated a new approach in ethnopharmacology, mapping the therapeutic potential of Caatinga species.

- **Biological activities of Annonaceae species extracts from Cerrado**
  - Leaves and stems
  - Phytotoxic
  - The strongest phytotoxic activities were detected for extracts of Annona coriacea and Xylopia aromatic. These extracts also inhibited the growth of Urochloa decumbens (Stapf) R. D. Webster. The extracts of A. coriacea were also very toxic to the shrimp nauplii. Among the four species, X. aromatic and A. coriacea exhibited strong biological activities and the results may be useful in agricultural fields in Brazil. These extracts have also been promising for the isolation and identification of valuable commercial metabolites.

- **Contents of constituents and antioxidant activity of seed and pulp extracts of Annona coriacea and Annona sylvatica**
  - Fruit pulp and seeds
  - Antioxidant
  - Annona coriacea seed extracts demonstrated a moderate antioxidant effect with free radical sequestrating activity of 31.53% by the DPPH test, 51.59% by the β-carotene bleaching method and 159.50 µM trolox/g extract in the ABTS assay. The hydromethanolic extract of A. coriacea displayed a high content of total phenol (147.08 ± 4.20 mg of GAE/g extract) and flavonoid (131.18 ± 2.31 mg of QE/g extract). This indicated that the antioxidant activity of the extracts was related to the content of these constituents.

- **Investigation of the toxic potential of crude ethanol extract of Annona coriacea (araticum) seeds in acute exposed mice**
  - Seeds
  - Hepatotoxic
  - The results suggest hepatotoxic effects of the raw extract of Annona coriacea seeds, but without damage to the brain and kidneys in this experiment, showing a toxic potential for this species, as for the Annonaceae family.

- **Pharmacological effects of two polar fractions from Annona coriacea Mart in animal models**
  - Leaves
  - Antinociceptive and anti-inflammatory
  - The results show that fractions of Annona coriacea have antinociceptive and anti-inflammatory effects, supporting the use of this plant in folk medicine.

- **Pharmacological Effects of the Hexane and Dichloromethane Fractions from Annona coriacea Mart. (Annonaceae) Leaves**
  - Leaves
  - Antinociceptive and anti-inflammatory
  - The results show that Annona coriacea has antinociceptive and anti-inflammatory effects, supporting the use of this plant in folk medicine.

- **Chemical constituents of the volatile oil from leaves of Annona coriacea and in vitro antiprotozoal activity**
  - Leaves
  - Antiprotozoan
  - The volatile oil showed anti-Leishmania and trypanocidal activity against promastigotes of four species of leishmania and trypomastigotes of Trypanosoma cruzi, and was more active against Leishmania (L.) chagasi (IC50 39.93 µg/mL) (IC 95% 28.00-56.95 µg/mL).
A study on the acaricidal activity of Annonaceae fractions against *Tetranychus tumidus* and *Tetranychus urticae* (Acari: Tetranychidae) was performed with the objective of selecting soluble fractions in dichloromethane with acaricidal activity, however, in this study, species of the genus *Annona* were not active against *T. tumidus* and *T. urticae* (Alves et al. 2015), although other studies report that acetogenin, a secondary metabolite exclusive to this botanical family, exert acaricidal activity (Lümmem 1998), indicating that this result may have been different from what is reported in the literature due to the different methodologies used to obtain metabolites.

With regard to emerging diseases, a certain study reports the identification of a better antiparasitic activity of *Acoricea* extract against the promastigotes forms of *Leishmania amazonensis*, when compared to the extracts of *Curatella americana*, *Sclerolobium aureum* and *Plathymenia reticulata* (Toledo et al. 2011), as well as the essential oil of the leaves, which showed antileishmaniasis and trypanocidal activity against promastigotes of four species of *Leishmania* and trypanostigotes of *Trypanosoma cruzi*, showing more active against *Leishmania* (L.) *chagasi* (Siqueira et al. 2011).

Several current problems involving health, agribusiness, sustainability and environmental impact are caused by the use of synthetic insecticides. For problems of this nature, studies with plant products that serve as vector controllers are necessary, which is the case with the species *A. coriacea*.

### 3.2 TECHNOLOGICAL PROSPECTION

In the technological prospection, the number of patent applications filed in the following databases: EPO, DII, USPTO, WIPO, LATIPAT and INPI, was evaluated according to the terms used, and the patent registration was verified only in the DII, WIPO and INPI databases, when searching for the descriptors "*Annona coriacea*" and "*Annona coriacea and biocide*", in the title and/or abstract of patent, totaling 17 registrations (Table IV). These results serve as an alert to the national scientific community, since only five registrations were made in the national database, and only four reported on species of annonaceae, which makes new research and development of products related to this botanical family relevant.
However, of the total number of patents, only one patent was located in the WIPO base that had contained a term relating the specie of study with tickcidal activity and this patent was once again present among those found for the descriptor "Annona coriacea", in this technological base. One of the patents found in the INPI database, did not cite the Annona coriacea specie, nor any other species of the same family. After reading and evaluation, it was verified that three patents were concerned with the same innovation, but filed in different countries and a duplicate registration for the same country. Considering the exclusion of these five patents, patent registrations were reduced to 12.

Concerning this refined number of patents, four reported the species Annona coriacea, three the species A. muricata and two the species A. squamosa. A record for A. vepretorum also occurred and three patents address various species of the genus Annona spp. in their context.

Patent registrations in general are small in number when compared to scientific publications. But still, there was a growing interest in the species Annona coriacea, because in 2014, there was an increase in the number of patent registrations, which corroborates the years of higher scientific production (Table V). It is important to remember that between the date of patent filing until the date of publication, there is a period of 18 months of secrecy in Brazil, and this time may vary for other countries.

With regard to the protection of products and/or processes related to araticumby means of patents, Brazil (BR) is first, followed by the United States (US), while Korea, appears with only one patent document. Patent registration at the WIPO (WO) base surpasses Brazil, adding up to seven patent applications for registration. This usually occurs "because the same patent is filed in different offices and also in the WIPO database" via the Patent Cooperation Treaty (PCT) (Costa et al. 2014) (Figure 4).

Figure 4. Patent applicant countries for the species Annona coriacea Mart. BR = Brazil; JP = Japan; KR = Korea; US = United States; WO = Patent Cooperation Treaty (PCT).
According to the international classification of patents, of the 12 applications for registration, some are mainly found in Section A (Human Needs), in the A61K Classification, which deals with preparations for medical, dental or hygienic purposes, as well as in the A23L Classification, which refers to food, food products or non-alcoholic beverages, not covered by subclasses A21D or A23B-A23J; their preparation or treatment, for example, cooking, modification of nutritional qualities, physical treatment; conservation of food or food products in general, followed by Section C, on Chemistry and Metallurgy, with the majority in the C12N Classification, which refers to microorganisms or enzymes; their compositions; propagation, conservation, or maintenance of microorganisms; genetic engineering or mutations and culture media; as well as in the C11D Classification, which deals with detergent compositions; use of isolated substances as detergents; soap or soap manufacturing; resin soaps and glycerol recovery, and finally, Section B, which deals with processing and transportation operations, which constitute in the B01F Classification, the understanding of mixture as the agitation of a single material (Figure 5).
TABLE V: Patents with technological applications for the species *Annona coriacea* Mart. deposited with DII, INPI and WIPO.

| Patente number | IPC | Inventor | Title | Inovação |
|---------------|-----|----------|-------|----------|
| BR201106468-A2 | A23L 001/064, A23L 001/068 | SOUZA MARTIM SILVA | Food product comprises bitter ginger extract, araca-boi, soursop, camu-camu, cupuassu and mapati | The food product comprises bitter ginger extract (*Zingiber zerumbet*), araca-boi (*Eugenia stipitata*), soursop (*Annona coriacea* Mart.), camu-camu (*Myrciaria dubia*), cupuassu (*Theobroma grandiflorum*) and mapati (*Pourowea cecropifolia*). The food product has high content of vitamin C, good rheological characteristics and preservatives characteristics by using Amazonian fruits, and improved texture and taste in mouth during consumption, and improves life quality. |
| US20160312153 A1 | C11D 3/00, C08B 31/18, C11D 3/22 (+12) | HÜFFER MARCOS DETERING | Modified polysaccharide for use in laundry detergent and for use as anti-greying agent | The present invention relates to a modified polysaccharide obtainable by a process comprising the step of treating a polysaccharide with gaseous or liquid SO₂, a laundry detergent composition comprising said modified polysaccharide, the use of said modified polysaccharide to increase whiteness of a washed fabric, the use of said modified polysaccharide as anti-greying agent in aqueous laundry processes, the use of said modified polysaccharide as a rheology modifier for homecare applications and the use of said modified polysaccharide in the manufacture of a liquid laundry composition. Further aspects of the invention are a method for preparing a laundry detergent composition comprising said modified polysaccharide. (*Annona coriacea* Mart.) |
| US20160263013 A1 | A61K 8/97, A61Q 19/08, A61K 8/49 (+4) | BROWNELL; CHU; CORNELIUSEN; HWANG; HYUN; JIA; JIAO; KIM; LEE; LEE; NAM; OH; YIMAM | Skin Care Compositions and Methods of Use Thereof | In brief, the present disclosure is directed to compounds and compositions useful for skin care, body slimming and reducing cellulite, including stereoisomers, pharmaceutically- or dermatologically acceptable salts, tautomers, and prodrugs of the disclosed compounds, and to related methods for tightening and improving firmness of sagging skin, improving skin tone, improving skin elasticity, reducing water retention for smoother and tighter skin, and reducing fat deposits in cutaneous tissues. (*Annona spp.*) |
| WO2015000064 A1 | A61K 31/085, A61K 31/015, A61K 36/00 (+2) | EVANS; EVANS | Composition for treating pain and/or inflammation comprising eugenol and beta-caryophyllene | A novel pharmaceutical composition is provided comprising beta—caryophyllene or a functionally equivalent derivative, analogue or pharmaceutically acceptable salt thereof, and eugenol or a functionally equivalent derivative, analogue or pharmaceutically acceptable salt thereof. The composition is useful to treat pain and/or inflammation. (*Annona squamosa L.*) |
Method for blocking permeable zones in oil and natural gas bearing subterranean formations by in-situ xyloglucan degalactosylation

A method for treating an oil and/or natural gas bearing subterranean formation penetrated by at least one well bore, comprising the steps of (a) providing an aqueous well treatment formulation (A) which comprises (A1) a xyloglucan having an average molecular weight (Mw) of from 200 000 to 1 500 000 Da, (A2) an enzyme preparation comprising β-galactosidase being capable of removing galactose from xyloglucan, and (A3) optionally one or more additives; (b) injecting said aqueous well treatment formulation into at least one well bore penetrating the oil and/or gas bearing subterranean formation; and (c) gelling of said aqueous well treatment formulation effected by partial degalactosylation of the said xyloglucan; thereby blocking highly permeable zones in the oil and/or natural gas bearing subterranean formation. (Annona coriacea Mart.)

Compositions and methods for increasing vitamin C uptake into cells and methods for retarding skin ageing, lightening skin and modulating hair colour.

The present invention relates to compositions comprising extracts from plants of the Combretaceae family and the use thereof in methods for increasing the uptake of vitamin C into cells. The invention also relates to methods for treating and/or retarding skin ageing, and further relates to a method for lightening skin and modulating hair colour. (Annona spp.)

Elicited plant products

The present invention is directed to a method of eliciting chemical compounds in plants. The process of the present invention may be employed for commercial production of desired compounds. The commercial production of such compounds can be accomplished in an aqueous medium containing an elicitor. The elicitor can be any elicitor, including for example, chemical elicitors such as acetic acid, which has demonstrated promising activity in inducing and improving compounds having therapeutic activity. The plants or plant parts of the invention can be specifically grown or maintained for the purpose of recovering compounds therefrom. In a preferred embodiment, the plant is grown hydroponically or aeroponically. In a particularly preferred embodiment, the roots are harvested in a manner such that the plant remains alive and can grow new roots for future harvesting and recovery of additional compounds. The invention also provides a method of identifying an agent exuded from or onto a plant surface having therapeutic activity. (Annona spp.)

Process for preparing partially degalactosylated xyloglucan

A method for treating an oil and/or natural gas bearing subterranean formation penetrated by at least one well bore, comprising the steps of (a) providing an aqueous well treatment formulation (A) which comprises (A1) a xyloglucan having an average molecular weight (Mw) of from 200 000 to 1 500 000 Da, (A2) an enzyme preparation comprising β-galactosidase being capable of removing galactose from xyloglucan, and (A3) optionally one or more additives; (b) injecting said aqueous well treatment formulation into at least one well bore penetrating the oil and/or gas bearing subterranean formation; and (c) gelling of said aqueous well treatment formulation effected by partial degalactosylation of the said xyloglucan; thereby blocking highly permeable zones in the oil and/or natural gas bearing subterranean formation. (Annona coriacea Mart.)
| Patent No. | Inventors | Description | Date |
|-----------|-----------|-------------|------|
| BR 10 2012 026697 0 A2 | Wenzke; Assmann; Baldenius; Krennrich; Siggel | and its use for oilfield applications treating formulation which comprises a treating composition, comprising partially degalactosylated xyloglucan having a galactose removal ratio of at least 0.40, based on the total number of β-D-galactopyranosyl residues of xyloglucan; and (b) injecting said aqueous treating formulation into at least one well bore penetrating the oil and/or gas bearing subterranean formation; thereby blocking highly permeable zones in the oil and/or natural gas bearing subterranean formation. *(Annona coriacea Mart.)* | 2012-2018 |
| BR 10 2016 029177 1 A2 | Moraes-Filho et al. | Herbal medicine formulated from a standardized acetonic extract obtained from the leaves of Annona muricata. | 2016-2018 |
| BR 10 2017 003197 7 A2 | Matos et al. | Extraction process of soursop seed oil *(Annona muricata L.)* and the product obtained | 2017-2018 |
| BR 102018008313-9 A2 | Santana Neto et al. | Method of production of microstructures and nanocapsules of cyclodextrin containing oil from Annona vepetorum Mart. | 2018-2019 |
| BR 102018008313-9 A2 | Basílio Júnior et al. | Microencapsulated insecticide/acaricide formulation by spray dryer of Annona squamosa and Annona muricata | 2018-2019 |
Among the documents examined, the patent of Basílio Júnior et al. (2019), classified A01N 65/08, dealing with biocides, repellents or attractants to pests or plant growth regulators containing material obtained from algae, lichen, bryophyte, multicellular plants or fungi or extracts thereof and A01N 25/28, refers to biocides, pest repellents or attractants or plant growth regulators, characterized by their forms or their inactive ingredients or their methods of application, substances to reduce the harmful effect of the active ingredients on non-pest organisms, in coated particulate form, microcapsules, being reported to Arthropodicides / Acaricides (A01P 7/02) and Arthropodicides / Insecticides (A01P 7/04); discusses the development of a microencapsulated natural product by spray drying based on hexane seed extract of Annona squamosa (pine cone) and ethanolic extract of Annona muricata (soursop), formulated from biodegradable polymers, with homogeneous insecticidal / acaricidal action, continuous and grading of the active principle with lethal and sublethal action. Thus, this patent corroborates the purpose of this research, since the species used by the authors are annonaceae, as well as the target organisms being arthropods.

Thus, it is possible to infer, through the analysis of the patents developed for the species Annona coriacea that the number of patents registered is not very significant, since this species exhibit several secondary metabolites with various promising physiological effects (Almeida et al. 2015).

4 CONCLUSION

Considering the consulted databases, the importance of the Annona coriacea species is prominent and this species can be used in technological innovation studies and development of new
products, increasing the knowledge about the species and providing data that will contribute to its understanding, besides valuing biodiversity and the preservation of the species and its environment.

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AUTHOR CONTRIBUTIONS

SRS: Bibliographic review research; Elaboration, writing and revision of the manuscript. FCF, JRSJ, AAJFC, DRJF and LCCN: Contribution to concept and design of the study and critical review of the manuscript. RRSF and RNL: contribuiu pesquisando material bibliográfico e processamento de dados.
REFERENCES

ALALI FQ, LIU XX AND McLAUGHLIN JL. 1999. Annonaceous acetogenins: recent progress. J Nat Prod 62:3 504-540.

ALMEIDA JRGS, SILVA HN, DINIZ TC, TELES RBA AND RABELO SV. 2015. Prospecção científica de espécies do gênero Annona (Annonaceae) com atividade antinociceptiva e anti-inflamatória. Rev GEINTEC 5:3 2326-2334.

ALVES DS, MOREJÓN RC, MACHADO ART, CARVALHO GA, PINA O AND OLIVEIRA DF. 2015. Acaricidal activity of Annonaceae fractions against Tetranychus tumidus and Tetranychus urticae (Acari: Tetranychidae) and the metabolite profile of Duguetia lanceolata (Annonaceae) using GC-M. Sem Cienc Agrar 36:2 4119-4132.

ARAÚJO RC, NEVES FA, FORMAGIO AS, KASSUYA CA, STEFANELLO ME, SOUZA VV AND CRODA J. 2014. Evaluation of the anti-mycobacterium tuberculosis activity and in vivo acute toxicity of Annona sylvatica. BMC complement altern med 14:209 1-10.

BASÍLIO JÚNIOR ID, TRINDADE RCP, MACIEL AGS, LEMOS EEP, SANTANA AEG, ARAÚJO AMN, SILVA JP, FIGUEIROA LE AND MORAIS FEM. 2019. Formulação inseticida/acaricida microemcapsulada por spray dryer de Annona squamosa e Annona muricata. BR 102018008313 9.

BENITES RSR, FORMAGIO ASN, ARGANDOÑA EJS, VOLOBUFF CRF, TREVIZAN LNF, VIEIRA MC AND SILVA MS. 2015. Contents of constituents and antioxidant activity of seed and pulp extracts of Annona coriacea and Annona sylvatica. Braz J Biol 75:3 685-691.

BROWNELL LA, CHU M, CORNELIUSEN B, HONG MF, HWANG JH, HYUN EJ, JIAO P, KIM MR, LEE BS, LEE YC, NAM JB, OH MS AND YIMAM M. 2015. Skin Care Compositions and Methods of Use Thereof. US20160263013.

BROWNELL LA, CHU M, CORNELIUSEN B, HONG MF, HWANG JH, HYUN EJ, JIAO P, KIM MR, LEE BS, LEE YC, NAM JB, OH MS AND YIMAM M. 2016. Skin Care Compositions and Methods of Use Thereof. WO2015066352.

CARNEIRO ÂP, PEREIRA MJB AND GALBIATI C. 2013. Biocide activity of Annona coriacea seeds extract on Rhodnius neglectus (Hemiptera: Reduviidae). REV BIOL TROP 61:1 419-427.

CHEN CH, HSIEH TJ, LIU TZ, CHERN CL, HSIEH PY AND CHEN CY. 2004. Annoglabayin, a Novel Dimeric Kaurane Diterpenoid, and Apoptosis in Hep G2 Cells of Annomontacin from the Fruits of Annona glabra. J Nat Prod 67:11 1942-1946.

COSTA MS, PINHEIRO DO, SERRÃO JE AND PEREIRA MJB. 2012. Morphological changes in the midgut of Aedes aegypti L. (Diptera: Culicidae) larvae following exposure to an Annona coriacea (Magnoliales: Annonaceae) extract. Neotrop Entomol 41:4 311-314.

EVANS D AND EVANS S. 2015. Composition for treating pain and/or inflammation comprising eugenol and beta-caryophyllene. WO2015000064.
FORMAGIO ASN, VIEIRA MC, VOLOBUFF CRF, SILVA MS, MATOS AI, CARDOSO CAL AND CARVALHO JE. 2015. In vitro biological screening of the anticholinesterase and antiproliferative activities of medicinal plants belonging to Annonaceae. Braz J Med Biol Res 48:4 308-315.

FRAGA AB, ALENCAR MMD, FIGUEIREDO LAD, RAZOOK AG AND CYRILLO JNDSG. 2003. Análise de fatores genéticos e ambientais que afetam a infestação de fêmeas bovinas da raça Caracu por carrapatos (Boophilus microplus). Rev Bras Zootec 32:6 1578-1586.

FREITAS AF, PEREIRA FF, FORMAGIO ASN, LUCCHETTA JT, VIEIRA MDC AND MUSSURY RM. 2014. Effects of methanolic extracts of Annona species on the development and reproduction of Spodoptera frugiperda (JE Smith)(Lepidoptera: Noctuidae). Neotrop Entomol 43:5 446-452.

FURLONG J, MARTINS JR AND PRATA MCA. 2007. O carrapato dos bovinos e a resistência: temos o que comemorar? A Hora Vet 27:159 26-32.

GOMES A, KOLLER WW AND BARROS ATMD. 2011. Suscetibilidade de Rhipicephalus (Boophilus) microplus a carrapaticidas em Mato Grosso do Sul, Brasil. Cienc Rural 41:8 1447-1452.

GRIPP ELO, CARNEIRO LU, PEREIRA IDSP, VEGA MRG & MARINHO BG. (2020). Avaliação das propriedades analgésicas de Anaxagorea dolichocarpa Sprague & Sandwith LC/Evaluation of analgesic properties of Anaxagorea dolichocarpa Sprague & Sandwith LC. Braz. J. Hea. Rev., 3(1), 382-395.

HÜFFER S, MARCOS AG AND DETERING J. 2015. Modified polysaccharide for use in laundry detergent and for use as anti-greying agent. WO2015091160.

HÜFFER S, MARCOS AG AND DETERING J. 2016a. Modified polysaccharide for use in laundry detergent and for use as anti-greying agent. US20160312153.

HÜFFER S, MARCOS AG AND DETERING J. 2016b. Modified polysaccharide for use in laundry detergent and for use as anti-greying agent. KR1020160101078.

JULIÁN-LOAEZA AP, SANTOS-SÁNCHEZ NF, VALADEZ-BLANCO R, SÁNCHEZ-GUZMÁN BS AND SALAS-CORONADO R. 2011. Chemical composition, color, and antioxidant activity of three varieties of Annona diversifolia Safford fruits. Ind Crop Prod 34:2 1262-1268.

JUNIOR JG, COUTINHO HD, BORIS TC, CRISTO JS, PEREIRA NL, FIGUEIREDO FG AND MOREIRA PH. 2016. Chemical characterization and cytoprotective effect of the hydroethanol extract from Annona coriacea Mart.(Araticum). Pharmacog Res 8:4 253.

LEAL AT, FREITAS DRJD, JUNIOR V AND SILVA I. 2003. Perspectivas para o controle do carrapato bovino. ACTA SCI VET 31:1 1-11.

LEITE JPV. 2009. Química dos produtos naturais: Uma abordagem Biossintética. In: LEITE JPV. Fitoterapia: bases científicas e tecnológicas, 1. ed., São Paulo: Editora Atheneu, 328 p.
LIMA MD. 2007. Perfil cromatográfico dos extratos brutos das sementes de Annona muricata L. e Annona squamosa L. através da cromatografia líquida de alta eficiência. Dissertação de Mestrado, Universidade Federal de Alagoas, Maceió-Alagoas, 102 p.

LOZANO A, ARAÚJO EL, MEDEIROS MFT AND ALBUQUERQUE UP. 2014. The apparenzy hypothesis applied to a local pharmacopoeia in the Brazilian northeast. J Ethnobiol Ethnomed 10:2 1-17.

LÜMMEN, P. 1998. Complex I inhibitors as insecticides and acaricides. Biochim Biophys Acta Bioenerg 1364:2 287-296.

LUNA JS. 2006. Estudo de Plantas Bioativas. Tese de Doutorado, Universidade Federal de Pernambuco, Recife-Pernambuco, 254 p.

MACHADO KC, MACHADO KC AND FREITAS RM. 2014. Uso de marcadores moleculares na depressão: prospecção tecnológica. Rev GEINTEC 4:3 1008-1016.

MAGALHÃES KN, GUARNIZ WAS, SÁ KM, FREIRE AB, MONTEIRO MP, NOJOSA RT AND BANDEIRA MAM. 2019. Medicinal plants of the Caatinga, northeastern Brazil: Ethnopharmacopeia (1980–1990) of the late professor Francisco José de Abreu Matos. J Ethnopharmacol 237: 314-353.

MATOS LCP, FONTANA CAVF AND SILVA MVL. 2018. Processo de extração de óleo de semente de graviola (Annona muricata L.) e produto obtido. BR 10 2016 029177 1.

MORAES FILHO MO, OLIVEIRA CC, FERREIRA JM, SANTOS CC AND MORAES MEA. 2018. Fitoterápico formulado a partir de um extrato acetônico padronizado obtido das folhas da Annona muricata. BR 10 2012 026697 0.

NASCIMENTO GNLD, VALADARES MC, NISHIJO H AND AVERSI-FERREIRA TA. 2012. Investigation of the toxic potential of crude ethanol extract of Annona coriacea (araticum) seeds in acute exposed mice. Rev Bras Farmacog 22:3 580-586.

NOVAES P, TORRES PB AND SANTOS DYAC. 2016. Biological activities of Annonaceae species extracts from Cerrado. Braz J Bot 39:1 131-137.

NOVAES P, TORRES PB, CORNU TA, LOPES JC, FERREIRA MJP AND SANTOS DYAC. 2019. Comparing antioxidant activities of flavonols from Annona coriacea by four approaches. S AFR J BOT 123: 253-258.

PEREIRA JC AND MARIO LRJ. 2014. Phytol a Natural Diterpenoid with Pharmacological Applications on Central Nervous System: A Review. Recent Pat Biotechnol 8:3 194-205.

RANFT M, NAVICKAS V, SIGGEL L, ASSMANN A, BALDENIUS KU, PETERS A, STEIDEL J AND BENKERT U. 2014. Method for blocking permeable zones in oil and natural gas bearing subterranean formations by in-situ xyloglucan degalactosylation. WO2014154814.

RASKIN I AND POULEV A.  2002. Elicited plant products. US20020132021.
REIS CN. 2011. Annona muricata: análise química e biológica dos frutos de gravioleira. Dissertação de Mestrado, Universidade Estadual do Norte Fluminense Darcy Ribeiro, Campos dos Goytacazes, Rio de Janeiro, 150 p.

RIBEIRO DA, OLIVEIRA LGS, MACÊDO DG, MENEZES IRA, COSTA JGM, SILVA MAP AND ALMEIDA SOUZA MM. 2014. Promising medicinal plants for bioprospection in a Cerrado area of Chapada do Araripe, Northeastern Brazil. J Ethnopharmacol 155:3 1522-1533.

RIBEIRO JF, BRITO MA, SCALOPPI JÚNIOR EJ AND FONSECA CEL. 2000. Araticum (Annona crassiflora Mart.). Jaboticabal: Embrapa Cerrados, 52 p.

RIBEIRO RV, BIESKI IGC, BALOGUN SO AND MARTINS DTO. 2017. Ethnobotanical study of medicinal plants used by Ribeirinhos in the North Arauáua microregion, Mato Grosso, Brazil. J Ethnopharmacol 205 69-102.

RUPPRECHT JK, YU-HUA H AND McLAUGHLIN JL. 1990. Annonaceous acetogenins: a review. J Nat Prod 53:2 237-278.

SANTANA NETO AF, RIBEIRO RC, IMBROINISE RCR, SILVA NQ AND BARROS LV. 2018. Método de produção de microestruturas e nanocápsulas de ciclodextrina contendo óleo da Annona veprerotum Mart. BR 10 2017 003197 7.

SANTOS FC AND VOGEL FS. 2012. Resistência do carrapato Rhipicephalus (Boophilus) microplus frente ao amitraz e cipermetrina em rebanhos bovinos no Rio Grande do Sul de 2005 a 2011. Rev port ciênc vet 111: 121-124.

SARAIVA ME, ULISSES AVRA, RIBEIRO DA, OLIVEIRA LGS, MACÊDO DG, SOUSA FDFS AND SOUZA MMA. 2015. Plant species as a therapeutic resource in areas of the savanna in the state of Pernambuco, Northeast Brazil. J Ethnopharmacol 171: 141-153.

SILVA MS, TAVARES JF, QUEIROGA KF, ANGRA MF AND BARBOSA FILHO JM. 2009 Alcaloides e outros constituintes de Xylopia langsdorffiana (Annonaceae). Quim Nova 32:6 1566-1570.

SILVA MSP, BRANDAO DO, CHAVES TP, FORMIGA FILHO ALN, COSTA EMMB, SANTOS VL AND MEDEIROS ACD. 2012. Study bioprospecting of medicinal plant extracts of the semiarid northeast: contribution to the control of oral microorganisms. eCAM 6 p.

SIQUEIRA CA, OLIANI J, SARTORATTO A, QUEIROGA CL, MORENO PR, REIMÃO JQ AND FISCHER DC. 2011. Chemical constituents of the volatile oil from leaves of Annona coriacea and in vitro antiprotozoal activity. Rev Bras Farmacog 21:1 33-40.

SOUSA LADD, SOARES SF, PIRES JÚNIOR HB, FERRI PH AND BORGES LMF. 2008. Avaliação da eficácia de extratos oleosos de frutos verdes e maduros de cinamomo (Melia azedarach) sobre o Rhipicephalus (Boophilus) microplus (Acari: Ixodidae). Rev Bras Parasit Vet 17:1 36-40.

SOUSA OV, DEL-VECCHIO-VIEIRA G, PINHO JJ, ALVES MS AND KAPLAN MA. 2011. Pharmacological effects of the hexane and dichloromethane fractions from Annona coriacea Mart.(Annonaceae) leaves. LAT AM J PHARM 30:5 868-873.
SOUZA OV, DEL-VECHIO-VIEIRA G AND KAPLAN MAC. 2007. Analgesic and anti-inflammatory properties of Annona coriacea Mart. (Annonaceae) leaves methanol extract. LAT AM J PHARM 26:6 872-877.

SOUZA OV, DEL-VECHIO-VIEIRA G, ALVES MS, PINHO JIRG, YAMAMOTO CH, AND KAPLAN MA. 2012. Pharmacological effects of two polar fractions from Annona coriacea Mart in animal models. Afr J Pharm Pharmacol 6:13 948-955.

SOUZA SR, CASTRO AAJF, FARIAS RRS, SOUSA GM AND CASTRO NMCF. 2013. Fitoecologia do Complexo de Campo Maior, Piauí, Brasil. In: SANTOS-FILHO FS, SOARES AFCL AND ALMEIDA JÚNIOR EB. Biodiversidade do Piauí: pesquisas & perspectivas, 1. ed., v. 2, cap. 3, editora CRV, Curitiba, p. 73-100.

SOUZA PCC, MARTIM SR AND SILVA PD. 2015. Food product comprises bitter ginger extract, araca-boi, soursop, camu-camu, cupuassu and mapati. BR201106468.

SOUZA RKD, SILVA MAP, MENEZES IRA, RIBEIRO DA, BEZERRA LR AND SOUZA MMA. 2014. Ethnopharmacology of medicinal plants of carrasco, northeastern Brazil. J Ethnopharmacol 157: 99-104.

TOLEDO C E, BRITTA EA, CECOLE LF, SILVA ER, MELLO JC, DIAS FILHO BP AND UEDA-NAKAMURA T. 2011. Antimicrobial and cytotoxic activities of medicinal plants of the Brazilian cerrado, using Brazilian cachaça as extractor liquid. J Ethnopharmacol 133:2 420-425.

WANG LW, NAVICKAS V, RANFT M, BOYKO V, WENZKE B, ASSMANN A, BALDENIUS KU, KRENNRICH G AND SIGGEL L. 2014. Process for preparing partially degalactosylated xylolucan and its use for oilfield applications. WO2014154806.

WEAVER SC AND REISEN WK. 2010. Present and future arboviral threats. Antiviral Res 85:2 328-345.

WOLF, F. 2010. Compositions and methods for increasing vitamin c uptake into cells and methods for retarding skin ageing, lightening skin and modulating hair colour. WO2010111745.