Caryocar coriaceum Wittm.

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Caryocar coriaceum Wittm.
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Abstract *Caryocar coriaceum* Wittm. is an arboreal species of Caryocaraceae family. The fruit pulp is known popularly as *pequi.* The folk knowledge confers to the oil '*pequi'* vast medical applicability. It can be used for treating colds and pulmonary infections, sore throats, rheumatism, external ulcers, muscle pain and skin inflammation. The fruits of *pequi* are known to have aphrodisiac and anti-abortive properties. The leaves are used to treat menstrual disorders. There are few phytochemical studies on *C. coriaceum*, however, pre-clinical tests of the fixed oil of *C. coriaceum* indicated gastro-protective properties and cicatrization in rodents, with a large reduction in ulcers induced by ethanol and aspirin, topical anti-inflammatory effect and efficacy reduction in skin inflammation with chronic treatment in rodents.

Keywords *Caryocar coriaceum* Wittm. · Traditional medicine · Folk knowledge · Ethnopharmacology · Bioprospection

1 Taxonomic Characteristics

Caryocar (souari trees) is a genus of flowering plants, in the family Caryocaraceae described formerly as a genus by Linnaeus, in 1771. Besides *C. coriaceum*, there are other species of the genus *Caryocar* in Brazil: *C. brasiliense*, *C. villosum*, *C. cuneatum* and *C. glabrum*. (Lorenzi and Matos 2008).

Trees of the genus *Caryocar* yield a strong timber. Some of the species have edible fruits, called souari-nuts or sawarri-nuts.

Caryocar coriaceum Wittm., is an endemic species to Brazil, with cultural, alimentary and ethnopharmacological values (term used here to describe medical practices). It is used in traditional medicine systems (see Elisabetzky 2003).

In 2006, *Caryocar coriaceum* was included in the IUCN Red List of Threatened species.

2 Major Chemical Constituents and Bioactive Compounds

Pequi content of the pulp is rich in nutritional compounds, such as fatty acids, carbohydrates, proteins, carotenoids, vitamin E, and retinol. The fruit pulp also has high levels of pectin and tannins, and polyunsaturated oils. In the fixed oil of C. coriaceum, were identified saturated and unsaturated fatty acids, with the major component fatty unsaturated oleic acid. Featuring even in the composition fatty polyunsaturated linoleic acid (Figueiredo 2012).

Regarding the nutritional value for the species C. *coriaceum* Wittm., the study of Oliveira et al. (2010) showed a protein content of 2.09% and 23.19% of lipids. Pequi's pulp is also rich in vitamin A and minerals, especially P, Ca, Cu and Fe (Araújo 1995).

Edible portions of fruit oil are: the pulp and the almond, for its characteristic taste and smell, as well as being a source of lipids and antioxidant vitamins (A and E), they are well used as food in regional food, replacing other sources of fat, such as grease or bacon. Phytochemical analysis of the essential oil obtained from almonds was composed almost exclusively of ethyl hexanoate (Lorenzi and Matos 2008).

Due to the affordable price, pequi is a valuable food source for the low-income population in the region (Figueiredo et al. 1989; Braga 1960; Silva and Medeiros Filho 2006).

Although the fruit is rich in nutrients and has a variety of uses, especially the species *C. coriaceum*, pequi has received inadequate attention in national and international research. There are only a few studies in the special literature that would involve biometry and the chemical and nutritional characterization of fruits of this species (Oliveira et al. 2010; Silva and Medeiros Filho 2006; Oliveira 2009).

As highlighted by Figueiredo (2012), little has been done to preserve the existing germplasm of this species and study its possible domestication with the aim of sustainable utilization.

Pequi has many uses, such as being used to produce oil with high versatility in regional food for sauces and dressings preparation, in cosmetic industry for producing soaps and creams, as well as being used for fuel production and lubricants (Oliveira et al. 2008; Pianovski et al. 2008).

3 Morphological Description

C. coriaceum, popularly known by pequizeiro, pequi, piqui and pequá, is a leafy and branchy tree with trunk coated with dark, thick and furrowed skin and opposite leaves, ternate, oval leaflets, glabrous (hairless), green-glistening, rich in tannin, providing dye substance; more or less leathery. The flowers are large, yellow with red stamens, gathered in terminal bunches (Braga 1960; Figueiredo 2012).

"Pequizeiro" tree reaches an average of 6–8 m high, and its inflorescences produce a varied number of large (5.0–7.5 cm in diameter) and colored from green to white and twilight anthesis flowers (hermaphrodite and actinomorphic) (Araújo 1995).

Studies of C. *brasiliense* and C. *villosum*, indicate that the species of this genus are heavily cross-pollinated, and small nectar bats (socicina geoffroyi and Anoura Glossophaga) are the main pollinators, and the Protandry and herkogamy (spatial separation of anthers and stigmas) work as key mechanisms against autogamous. However, despite the steep allogamy, self-pollination can occur in a small proportion (Gribel and Hay 1993; Martins and Gribel 2007).

The flowering usually occurs between August and November, depending on the region, and the fruit ripening takes from 3 to 4 months after the pollination, with low fruit set rate. However, according to Araújo (1995), one Pequi plant can produce 500–2000 fruits/harvest.

Pequi's fruit is a drupe type with depression-globular shape, leathery and fleshy epicarp, and bright green/slightly yellowish color when ripe, with burry endocarp. Its dimensions range from 4 to 7 cm high and 6–8 cm in diameter, with average mass reaching approximately 120 g, but with variation from 100 to 220 g (Araújo 1995, Lorenzi and Matos 2008).

The pulp is oleaginous, mealy and pasty, varying in color from cream-yellow to intense-yellow and sometimes orange. Generally, the fruit contains only one seed developed (putamen or pyrene), but sometimes it can contain up to three or four seeds (Araújo 1995; Silva and Medeiros Filho 2006; Oliveira 2009).

4 Geographical Distribution

Therefore, *C, coriaceum*, specie found in the northern of Ceará, has an important socio-economic role in Chapada do Araripe, covering the States of Ceará, Pernambuco and Piauí. Can also be found in the states of Tocantins and Maranhão (Saraiva et al. 2011).

5 Collection Practice

Thus, *C. coriaceum* is explored in an extractive way, being seasonal, with flowering from September to November and the season between December and April, period of high rainfall in the region. Then in the off-season, there is the extraction of oil from the pulp and almond, which has greater commercial value (Costa et al. 2004; Lorenzi and Matos 2002).

In pequi's harvest period, the communities near Chapada do Araripe perform extractive activities, collecting fruit for marketing. The fruit is not collected directly from the tree; it is collected after fruit falls to the ground because the taste of the fruit pulp collected from the "floor" is much better (Augusto and Goes 2007; Sousa Junior 2012).

6 Traditional Use (Part(s) Used) and Common Knowledge

However, pequi has a large emphasis in traditional medicine context, highlighted as a relevant ethnopharmacological resource. For example, pequi's bark of the tree and skin of the fruits are used in antipyretic and diuretic infusions (Lorenzi and Matos 2008).

The fruit has anti-abortive and aphrodisiac properties and the leaves are used to treat colds, flu, edemas, menstrual changes and as an antifungal (Vieira and Martins 2000; Batista et al. 2010).

In this context, oil is used in the treatment of burns, colds, broncho-pulmonary infections, skin ulcers, inflammation of the skin and musculoskeletal pain (Saraiva 2009).

At the same time, reports show its use in ophthalmic disorders related to vitamin A deficiency, by its high content of carotenoids with provitamin A activity (Santos 2007; Oliveira et al. 2008).

Furthermore, pequi's fruit is almost fully used, because the skin is consumed by bovine animals, the seed (with pulp) is used in the preparation of dishes – quite appreciated in regional food – and the pulp is still used for extraction and homemade or manufacture edible oil, jellies, jams, liqueurs and animal food (Lorenzi and Matos 2008; Oliveira 2009).

The almond, due to its high nutritional value, shape, size and visual appearance, is also used for fresh consumption in the oil extraction and soap manufacturing, and in cosmetics industry as creams and soaps, being potential as another option in the national market of almonds (Lorenzi and Matos 2008; Oliveira 2009).

Therefore, the therapeutic value of pequizeiro to popular medicine has been researched and some ethnopharmacological and ethnobotanical studies show its real effectiveness, emerging an important bioprospecting research (Batista et al. 2010; Lorenzi and Matos 2008).

7 Modern Medicine Based on Its Traditional Medicine Uses

In the essence of published studies about the medicinal uses of pequi, as well as several other species of traditional use, there is the technique of bioprospecting. Therefore, bioprospecting is basically the identification and evaluation of specific biological material extracted from nature, for its applicability and utility in generating new processes and products. Thus, resources found in nature are experienced, seeking to obtain new resources to be used in everyday life (Palma and Palma 2012).

In the contemporary view of bioprospecting, there are environmental and social aspects associated with new economic paradigms. That is, it is related to biotechnology, with the "biodiversity" and with the agents directly and indirectly involved with the completion of this activity, as entrepreneurs, local communities, indigenous groups, environmental groups, research institutions, international organizations, among others (Palma and Palma 2012).

Bioprospecting also allows the identification of priorities relating to lines of research or for the strengthening of old research. In this sense, some bio-prospective studies nationally and internationally published, corroborate the therapeutic uses of pequi in the Traditional Medicine context (Lorenzi and Matos 2008).

For example, as in some studies in general, there is Passos et al. (2002) research performed with the extract of pequi's leaves, finding antifungal activity by inhibiting the growth of *Cryptococcus neoformans*, *Paracoccidioides brasiliensis* and *Candida albicans*.

In addition, molluscicidal action against *Biomphalaria glabrata* (schistosomiasis vector) was identified in Batista et al. (2010) research, leishmanicide effect by

inhibiting the proliferation of the promastigote form of *Leishmania amazonensis* and antimicrobial activity by inhibiting the growth of enterobacteria, according to studies of Paula-Junior et al. (2006).

It is important to mention the research of Alves et al. (2000) showing actions against *Bacillus cereus*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*.

Interference with *T. cruzi parasitemi*a curve has been demonstrated in pequizeiro bark extract, thus reducing the number of parasites in the blood (Herzog-Soares et al. 2002).

In this sense, antioxidant and preventive activities for tumors were also observed (Paula-Junior et al. 2006; Khouri et al. 2007), effects against Sarcoma in animals by oleanolic acid content and protease and evidence of hemolytic activity of *C. brasiliense* lectin, as well as in vivo enterotoxic activity in mice (Perez 2004).

It is also noteworthy that pequi's oil is a rich source of vitamin C, with phenolic compounds such as flavonoids, saponins and essential oils in the mesocarp (Miranda-Vilela et al. 2008).

On the other hand, these components have antioxidant properties, mitigating the effects of mutagens and carcinogens agents. In addition, oxidative stress is one of the major risk factors for cardiovascular disease (Alonso 2000; Miranda-Vilela et al. 2008; Tseng et al. 2004).

Furthermore, preclinical studies of C. *coriaceum* fixed oil indicate the gastroprotective activity in rodents with a significant reduction of ulcers induced by ethanol and aspirin, besides to healing activity, topical anti-inflammatory effect in mice, and reduction of skin inflammation, with chronic treatment (Penha 2007; Quirino 2009; Saraiva 2009).

The main compound of fixed oil from the pulp of *C. coriaceum* (OFCC) is the unsaturated fatty oleic acid. The saturated fatty acids increase low-density lipoprotein (LDL) by inhibiting LDL receptor activity and increase the production of apolipoprotein (Aguilar et al. 2012).

In this way, the substitution of saturated fat by poly-unsaturated fat has reduced levels of total cholesterol (TC) and LDL cholesterol levels, decreasing LDL-cholesterol production rates and/or increasing LDL clearance rates (Aguilar et al. 2012).

On the other hand, there is a decreasing in high density lipoprotein (HDL), which together with the reduction in LDL-c, LDL/HDL ratio decreases. Monounsaturated fat also has the same effect on blood cholesterol but the magnitude of the reduction in HDL is lower when compared to poly-unsaturated fats (Aguilar et al. 2012).

In this context, it is important to detail these and some other published studies, such as Saraiva et al. (2011) research assessing the topical effect of *C. coriaceum* against different irritant agents in vivo, in order to verify its effect against dermatoses.

Therefore, Saraiva et al. (2011) research found that the species showed a similar profile of topical anti-inflammatory activity, indicating its potential use against inflammatory skin diseases.

In the study by Oliveira et al. (2010), it was sought to evaluate the effects of the *C. coriaceum* fixed oil (OFCC) on topical inflammation and cutaneous wound healing. In this way, the tests showed that the OFCC was able to reduce inflammation depending on the doses.

Fresh OFCC (100%) inhibited ear edema in 38.01% at the time of 15 min and in 39.20% in 1 h, after induction of the inflammation. Topical administration of OFCC ointment (12%) showed a significant reduction in the unhealed wound area, with the increase in the percentage of wound contraction (96.54%) compared to the other groups. Thus, the conclusion was that *C. coriaceum* inhibits topical inflammation and speeds up the repair of skin wounds.

In Oliveira's research (2013) the antinociceptive activity and anti-inflammatory pequi oil in zymosan-induced arthritis in rats was investigated. The author states that besides the detected anti-inflammatory action, pequi's oil can prevent the inflammatory mechanical hyperalgesia.

On the other hand, in the study of Lacerda Neto (2013), the objective was to verify the gastro-protective activity of a hydroethanolic extract of *C. coriaceum* leaves (EHFCC). Thus, EHFCC gastroprotective activity was evaluated by methods of gastric damage induced by ethanol and a reduction of the lesion area of 69.43% was observed.

Furthermore, quantification of mucus production showed that EHFCC positively influences it and the intestinal motility test reported a decrease in motility under EHFCC action, being as another contribution to its gastro-protective effect (Lacerda Neto 2013).

Thus, the author concludes by highlighting that the described results show the biological potential of EHFCC as a grant for the study of gastro-protection and especially in the formulation of new herbal medicines for the treatment of peptic ulcer (Lacerda Neto 2013).

In *C. coriaceum* influences for cardiovascular diseases, Figueiredo's study (2012) evaluated the toxic effects of *C. coriaceum* fixed oil in biochemical and histopathological parameters of rodents. From the results, the author showed that subchronic toxicity was not revealed at high doses for the evaluated parameters.

Furthermore, it was demonstrated anti-inflammatory and antioxidant activity of *C. coriaceum* fixed oil. The importance of this study was also due to be the first study to report a possible lipid-lowering and hypo-triglyceride activity of *coriaceum* species, showing species with a pharmacological potential related to the management and treatment of cardiovascular diseases, world problems of epidemiological importance (Figueiredo 2012).

Thus, from this information, it can be said that the large and reputable popular use of pequi in Traditional Medicine is supported by the available scientific literature, although further studies to clarify other therapeutic actions of Pequi are necessary for ethnobotanical surveys.

8 Conclusions

The importance of *C. coriaceum* or pequi to traditional communities is not only in the economic context, but also in the context of practices related to Traditional Medicine.

During this chapter, the therapeutic use of pequi was highlighted as being widespread and accepted among the local population of Chapada do Araripe and surrounding regions. Therefore, it is used for a variety of pathologies, suggesting that this species is inserted in a complex set of culturally relevant plants.

However, it is observed that there are a few published studies concerning the applicability of this plant as a viable or complement alternative to conventional pharmacological treatment used for different diseases, ranging from skin diseases to cardiovascular diseases.

In fact, new bioprospective studies should be conducted, addressing chemical, pharmacological characteristics and clinical applicability of *C. coriaceum* species, in order to an efficient use of the properties provided by this plant.

References

Aguilar EC, Jascolka TL, Teixeira LG, Lages PC, Ribeiro ACC, Vieira ELM et al (2012) Paradoxical effect of a pequi oil-rich diet on the development of atherosclerosis: balance between antioxidant and hyperlipidemic properties. Braz J Med Biol Res 45(7):601–609

Alonso JR (2000) Tratado de fitomedicina, bases clínicas e farmacológicas. Isis Ediciones, Buenos Aires

Araujo FD (1995) A review of *Caryocar brasiliense* (Caryocaraceae) – na economically valuable species of the central brazilian cerrados. Econ Bot 49(1):40–48

Augusto LGS, Góes L (2007) Integrated understanding for health surveillance in a forest environment: the case of the Araripe Plateau in Ceará State, Brazil. Cad Saúde Pública 23(4):549–558

Batista JS, Silva AE, Rodrigues CMF, Costa KMFM, Oliveira AF, Paiva ES, Nunes FVA, Olinda RG (2010) Avaliação da atividade cicatrizante do óleo de pequi (C*aryocar Coriaceum* Wittm) em feridas cutâneas produzidas experimentalmente em ratos. Arq Inst Biol 77(3):441–447

Braga R (1960) Plantas do Nordeste, especialmente do Ceará, 2nd edn. Imprensa Oficial, Fortaleza

Costa IR, Araujo FS, Lima-Verde LW (2004) Flora e aspectos auto-ecológicos de um encrave de cerrado na chapada do Araripe, Nordeste do Brasil. Acta Bot Bras 18(4):759–770

de Alves TMA, Silva AF, Brandão M, Grandi TSM, de EFA S, Smânia Junior A et al (2000) Biological screening of Brazilian medicinal plants. Mem Inst Oswaldo Cruz 95(3):367–373

Figueiredo PRL de (2012) Influência do óleo fixo da polpa de *Caryocar Coriaceum* Wittm. sobre o perfil lipídico em modelo animal [dissertation]. Regional University of Cariri, Crato

Lacerda Neto LJ de (2013) Avaliação da atividade antibacteriana e gastroprotetora do extrato hidroetanólico das folhas de Caryocar coriaceum Wittm [dissertation]. Regional University of Cariri, Crato

de Oliveira FFB (2013) Efeito antinociceptivo e anti-inflamatório do óleo da polpa de pequi (*Caryocar coriaceum* Wittm.) na artrite induzida por zymosan em ratos. Federal University of Ceará, Fortaleza

Sousa Júnior JR de (2012) Conhecimento e manejo tradicional de *Caryocar coriaceum* Wittm. (Pequi) na Chapada do Araripe, Nordeste do Brasil [dissertation]. Rural Federal University of Pernambuco, Recife

Elisabetsky E (2003) Etnofarmacologia. Cienc Cult 55(3):35–36
Figueiredo RW, Maia GA, Figueiredo EAT. Propriedades físico-químicas e composição dos ácidos graxos da fração lipídica da polpa e amêndoa do piqui (*Caryocar coriaceum* Wittm). Rev Ciênc Agron 1989; 20(½):135–139
Gribel R, Hay JD (1993) Pollination ecology of *Caryocar brasiliense* (Caryocaraceae) in Central Brazil cerrado vegetation. J Trop Ecol 9:199–211
Herzog-Soares JA, Alves RK, Isac E, Bezerra JCB, Gomes MH, Santos SC et al (2002) Atividade tripanocida in vivo de Stryphnodendron adstringens (barbatimão verdadeiro) e Caryocar brasiliensis (pequi). Rev Bras Farmacognosia 12(1):1–2
Khouri J, Resck IS, Poças-Fonseca M, Sousa TMM, Pereira LO, Oliveira ABB et al (2007) Anticlastogenic potential and antioxidant effects of an aqueous extract of pulp from the pequi tree (*Caryocar brasiliense* Camb). Genet Mol Biol 30(2):442–448
Lorenzi H, Matos FJA (2002) Plantas medicinais no Brasil: nativas e exóticas. 1.ed. Instituto Plantarum, Nova Odessa
Lorenzi H, Matos FJA (2008) Plantas medicinais no Brasil: nativas e exóticas, 2nd edn. Instituto Plantarum, Nova Odessa
Martins RL, Gribel R (2007) Polinização de *Caryocar villosum* (Aubl.) Pers. (Caryocaraceae) uma árvore emergente da Amazônia Central. Rev Bras Bot 30(1):37–45
Miranda-Vilela AL, Resck IS, Grisolia CK (2008) Antigenotoxic activity and antioxidant properties of organic and aqueous extracts of pequi fruit (*Caryocar brasiliense* Camb.) pulp. Genet Mol Biol 31(4):956–963
Oliveira MEB (2009) Características físicas, químicas e compostos bioativos em pequis (Caryocar coriaceum Wittm.) nativos da chapada do Araripe- CE [thesis]. Rural Federal University of Pernambuco, Recife
Oliveira MEB, Guerra NB, Barros LM, Alves RE (2008) Aspectos agronômicos e de qualidade do pequi. Embrapa Agroindústria Tropical, Fortaleza
Oliveira MEB, Guerra NB, de AHN M, Alves RE, dos Matos NMS, Sampaio FGM et al (2010) Características químicas e físico-químicas de pequis da Chapada do Araripe, Ceará. Rev Bras Frutic 32(1):114–125
Palma CM, Palma MS (2012) Bioprospecção no Brasil: análise crítica de alguns conceitos. Cienc Cult 64(3):22–26
Passos XS, Santos SC, Ferri PH, Fernandes OFL, Paula TF, Garcia ACF et al (2002) Atividade antifúngica de *Caryocar brasiliensis* (Caryocaraceae) sobre *Cryptococcus neoformans*. Rev Soc Bras Med Trop 35(6):623–627
Paula-Junior WP, Rocha FH, Donatti L, Fadel-Picheth CMT, Weffort-Santos AM (2006) Observação: a citação encontra-se na lista de referências como. Leishmanicidal, antibacterial, and antioxidant activities of Caryocar brasiliense Cambess leaves hydroethanolic extract. Rev Bras Farmacogn 16(sup):625–630
Penha ARS (2007) Estudo de atividade antiulcerogênica de plantas da chapada do Araripe [monograph]. Regional University of Cariri, Crato
Perez E (2004) Diagnose fitoquímica dos frutos de Caryocar brasiliense Camb. Caryocaraceae [dissertation]. University of Paraná, Curitiba
Pianovski AR, Vilela AFG, Silva AAS, Lima CG, Silva KK, Carvalho VFM et al (2008) Uso do óleo de pequi (*Caryocar brasiliensis*) em emulsões cosméticas: desenvolvimento e avaliação da estabilidade física. Rev Bras Ciênc Farm 44(2):249–259
Quirino GS (2009) Atividade cicatrizante e gastroprotetora de Caryocar coriaceum Wittm [dissertation]. Regional University of Cariri, Crato
Santos RI (2007) Metabolismo básico e origem dos metabólitos secundários. In: CMO S, Schenkel EP, Gosmann G, JCP M, Mentz LA, Petrovick PR (eds) Farmacognosia: da planta ao medicamento, 6th edn. Editora da UFRGS; Florianópolis: Editora da UFSC, Porto Alegre, pp 403–434
Saraiva RA (2009) Efeito do óleo fixo do mesocarpo interno de Caryocar Coriaceum Wittm. em modelos animais de inflamação induzida por agentes flogísticos [dissertation]. Regional University of Cariri, Crato

Saraiva RA, Araruna MKA, Oliveira RC, Menezes KDP, Leite GO, Kerntopf MR et al (2011) Topical anti-inflammatory effect of Caryocar coriaceum Wittm. (Caryocaraceae) fruit pulp fixed oil on mice ear edema induced by different irritant agents. J Ethnopharmacol 136(3):504–510

Silva MAP, Medeiros-Filho S (2006) Morfologia de fruto, semente e plântula de piqui (*Caryocar coriaceum* Wittm.). Rev Ciênc Agron 37(3):320–325

Tseng CF, Lin CC, Huang HY, Liu HC, Mao SJT (2004) Antioxidant role of human haptoglobin. Proteomics 4:2221–2228

Vieira RF, Martins MVM (2000) Recursos genéticos de plantas medicinais do cerrado. Uma compilação de dados. Rev Bras Plantas Med 3(1):13–36