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Review Article

# Gurguéia nut: a new and potential fruit crop

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## Abstract

Still practically unknown in the world fruit market, Gurguéia nut (*Dipteryx lacunifera Ducke*) is leguminous fruit species native to Brazilian Mid-North region) whose almond is very appreciated by native people. Nevertheless, these species are not very well known. The aims of our work were first to evaluate thoroughly the literature currently available on Gurguéia nut and secondly to supplement this review by agronomic works published about it. Origin and distribution. The study includes a presentation of the origin, geographical distribution and phenotypic variability of Gurguéia nut. Botanical classification and taxonomy. The study includes a presentation of the botany, morphology and floral biology of Gurguéia nut. Plant propagation. The methods available for plant propagation of Gurguéia nut are focused and properly described, with examples of published manuscripts. Compositions and uses. The many uses of Gugrguéia nut plant parts are presented with especial consideration for its almond composition in relation to nutrients, vitamins, proteins and fatty acids, as well as the various possibilities of processing. Conclusion. Our review highlights the fact that the interest shown in Gurguéia nut is recent and, for these reasons, more detailed knowledge on these species is required (agronomic, genetic and technological).

**Keywords**: *brazilian fruit, Dipteryx lacunifera Ducke, fruit composition, non-conventional fruit*

## Castanha do Gurguéia: uma nova e potencial frutífera

## Resumo

Ainda praticamente desconhecida no mercado de frutas do mundo, a castanha do Gurguéia (*Dipteryx lacunifera Ducke*) é uma espécie de fruta leguminosa nativa para a região Meio-Norte do Brasil ), cuja amêndoa é muito apreciada pelos nativos. Contudo, essa espécie não é bem conhecida. Os objetivos do nosso trabalho foram, avaliar cuidadosamente a literatura atualmente disponível sobre a castanha do Gurguéia, e complementar trabalhos agronomicos publicados sobre o assunto. Origem e distribuição. O estudo inclui uma apresentação da origem , distribuição geográfica e variabilidade fenotípica da castanha do Gurguéia. Classificação botânica e taxonomia. O estudo inclui uma apresentação da botânica, morfologia e biologia floral da castanha do Gurguéia. Propagação da planta. Os métodos disponíveis para a propagação da planta da castanha do Gurguéia estão focados e devidamente descritos, com exemplos de manuscritos publicados. Composições e usos. As várias utilizações da castanha do Gugrguéia são apresentados com especial consideração à sua composição de amêndoa em relação aos nutrientes, vitaminas, proteínas e ácidos graxos, assim como as várias possibilidades de processamento. Conclusão. Nossa revisão destaca o fato de que o interesse demonstrado na castanha do Gurguéia é recente e, por estas razões, o conhecimento mais detalhado sobre estas espécies é necessário (agronômica, genética e tecnológica ).

**Palavras-chave:** composição da fruta, *Dipteryx lacunifera Ducke*, fruta brasileira, fruta não-convencional

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## Introduction

The higher and increasing demand, during the last decades, for non-conventional fruits has offered greater variety in the market, the same way expanded marketing opportunities have been of fruit producers' interest, especially in Brazil where there is a large variety of native non-conventional fruits (Cavalcante et al., 2012), most of them poorly known and scarcely studied in the scientific literature.

In Piauí and Maranhão States (Brazil) the vegetal formations are affected by different vegetations such as Amazonia, Brazilian cerrado and semi-arid, that makes possible a large diversity of ecosystems (Cepro, 1996). In these regions there are lots of fruit species little know by most fruit consumers, but, many of them, with economic potential for cultivation as a fruit crop.

Among all species with potential for economic exploration it is possible to detach the Gurguéia nut (*Dipteryx lacunifera Ducke*) a fruit species native to Cerrado and Semi-arid regions of Piauí and Maranhão states (known as Brazilian Mid-North region) whose almond is very appreciated by native people due to its excellent quality, and consumed after tegument extraction and baking the nut. In addition, its nut has been scientifically proved to be a component for use as cereal bars, it could be useful for pharmaceutical and cosmetic industries, beyond the plant stem use as wood by local communities in civil constructions and stake for fencing for domestic animals.

According to the reasons previously mentioned, Gurguéia nut constitutes a fruit species with potential to be commercially explored, especially were climatic conditions such as climate and soil are favorable for the growth and development of the plant, without exclude adaptation studies for other tropical regions of the world.

On the other hand, such as any other native potential fruit species, it is registered a lack of basic agronomic information for the cultivation of Gurguéia nut as a fruit crop, what has encouraged researchers to study this species in different areas such as seed technology, plant propagation and genetic diversity.

The aims of our work were to draw up an exhaustive list of literature currently available on Gurguéia nut, grouping the references by topics (origin and distribution, botanical classification and taxonomy, plant propagation and composition and uses) and to complete the list with agronomic works that have not been published in international journals, but are useful for those involved in promoting the new species.

## Development

*Origin and distribution*

The Cerrado region located in North-Eastern and Central part of Brazil constitutes one of the largest genetic reserves of Brazilian native species, thus it is characterized as a precious food source which needs to be preserved and studied aiming its socio-economic use. Specifically, in Brazilian Mid-North region, which envolves part of Cerrado and Semi-Arid region, there are many native fruit species with potential for social and economic use such as bacuri (*Platonia insignis*), yellow mombin (*Spondias mombin*), little cashew (*Anacardium humile*), mangaba (*Hancornia speciosa*), chichá (*Sterculia chicha*), sapucaia (*Lecythis pisonis*) and Gurguéia nut (*Dipteryx lacunifera Ducke*), most of them still poorly known by the world fruit market.

Gurguéia nut also known as castanha-de-burro, fava-de-morcego and garampara (in Portuguese) is a species native to Brazilian Mid-North region specifically Piauí and Maranhão States (Carvalho et al., 2005) where its explored based on spontaneously generated plants and its almonds are commercialized in open markets. Although Gurguéia nut occurrence has been reported in Cerrado regions, it is common to find spontaneous plants under semi-arid climate of Piaui State, Brazil. In figure 1 it is possible to identify the Brazilian Mid-North region where this species can be found.

In study aiming to evaluate the physical characteristics of the fruit and the nutritional composition of the pericarp and almond of 23 Gurguéia nut genotypes from Piaui state, Ribeiro et al. (2012a) reported that the Gurguéia nut genotypes presented significant phenotypic variability for most of the physical and chemical-nutritional characteristics, indicating that this variability is important for using in future genetic breeding programs of this species. Accordingly, those genotypes with larger fruit length means do not result, necessarily, in larger or smaller almond thickness, as well as genotypes with larger or smaller almond thickness do not result in larger longitudinal diameter of the pericarp cavity.

Ribeiro et al. (2012b) evaluated the genetic diversity of Gurguéia nut and concluded that a high variability is observed among genotypes, detaching that genotypes G-17 and G-18 are the most divergent and the genotypes G-3 and G-16 are the most similar.

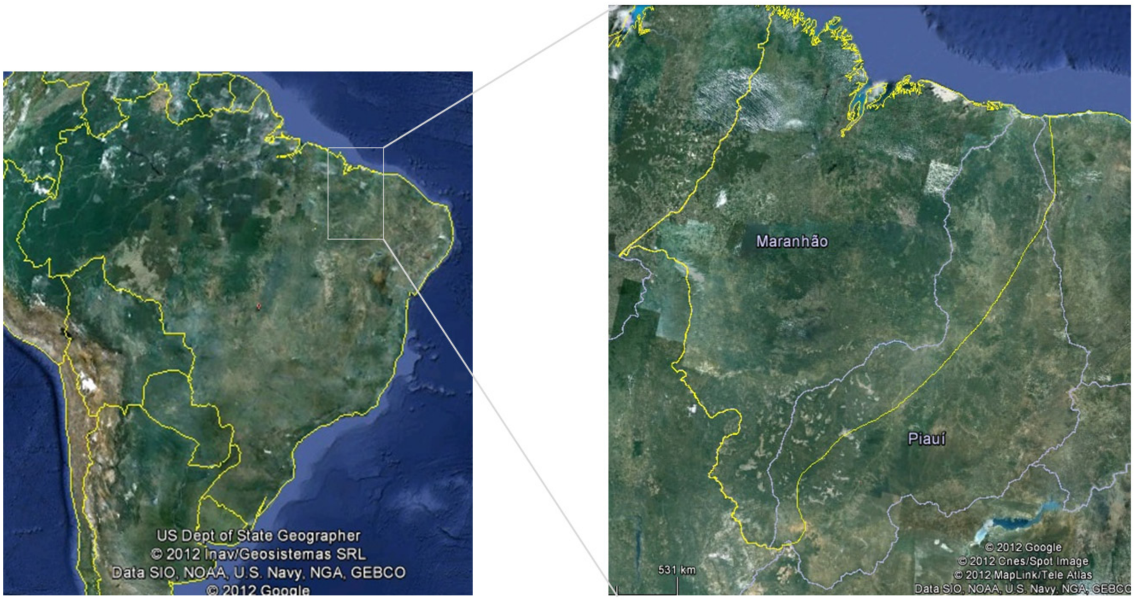


**Figure 1.** Brazilian Mid-North region where Gurguéia nut plants are natively found.

*Botanical classification and taxonomy*

Gurguéia nut plant is a tree belonging to Leguminoseae family, Dipteryx genus and *Dipteryx lacunifera Ducke species. Dipteryx genus includes other species more known by the fruit consumer such as baru* (*Dipteryx alata* Vog.) *a nut species native to Brazilian Cerrado (Takemoto et al., 2001; Torres et al., 2003)* and frequently found in south region of Piaui and Maranhão States.

Gurguéia nut plant has stem with grayish bark with patches of dark color and irregular shapes; axial and deep root system; plant with 6 m in average height, and 10 m in highest height, whether grown in fertile soils; oval canopy reaching an average of 4 to 5 m in diameter, the leaves are alternate, compost, petiolate, without stipules and rachis winged, with number of leaflets about 11, alternate, measuring about 8 cm, with oval blade, with 4-6 cm length and 2.5 to 3.0 cm wide; the inflorescence is a panicle formed at the end of the branches, in the axils of superior leaves, with honey smelling flowers, constantly visited by bees.

According to Queiroga Neto et al. (2009a), Gurguéia nut almond constitutes about 6.5% of the fruit, the average weight, length, width, and thickness of the almond are 1.03 g, and 2.45, 1.44 and 0.58 cm, respectively.

Plant flowering occurs during the first half of the year (January, February), standing with ripe fruits in the second semester (from September) when all leaves fall.

In figure 2 it can be seen some spontaneous plants native to Bom Jesus County (Piaui State, Brazil), leaves and inflorescence of Gurguéia nut.

The fruit is a brown, woody and unilocule capsule very resistant, with an elongated and dark brown almond, as can be seen in figure 3. This almond has a pleasant taste that make it very appreciated by native people.

*Plant propagation*

Information about plant propagation of Gurguéia nut is still hard to obtain in the scientific literature and little is known, especially about vegetative propagation, independently of its type.

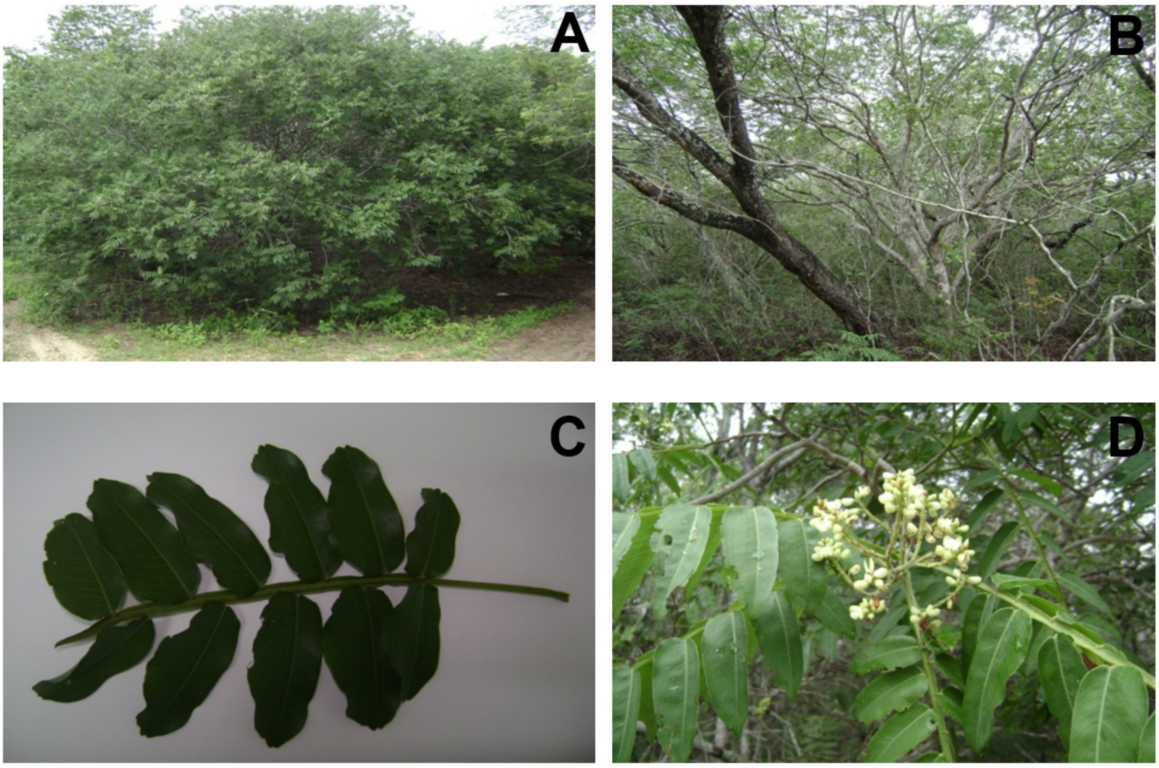


**Figure 2.** Native plants (A and B), leaf (C) and inflorescence (D) of Gurguéia nut in Brazil.

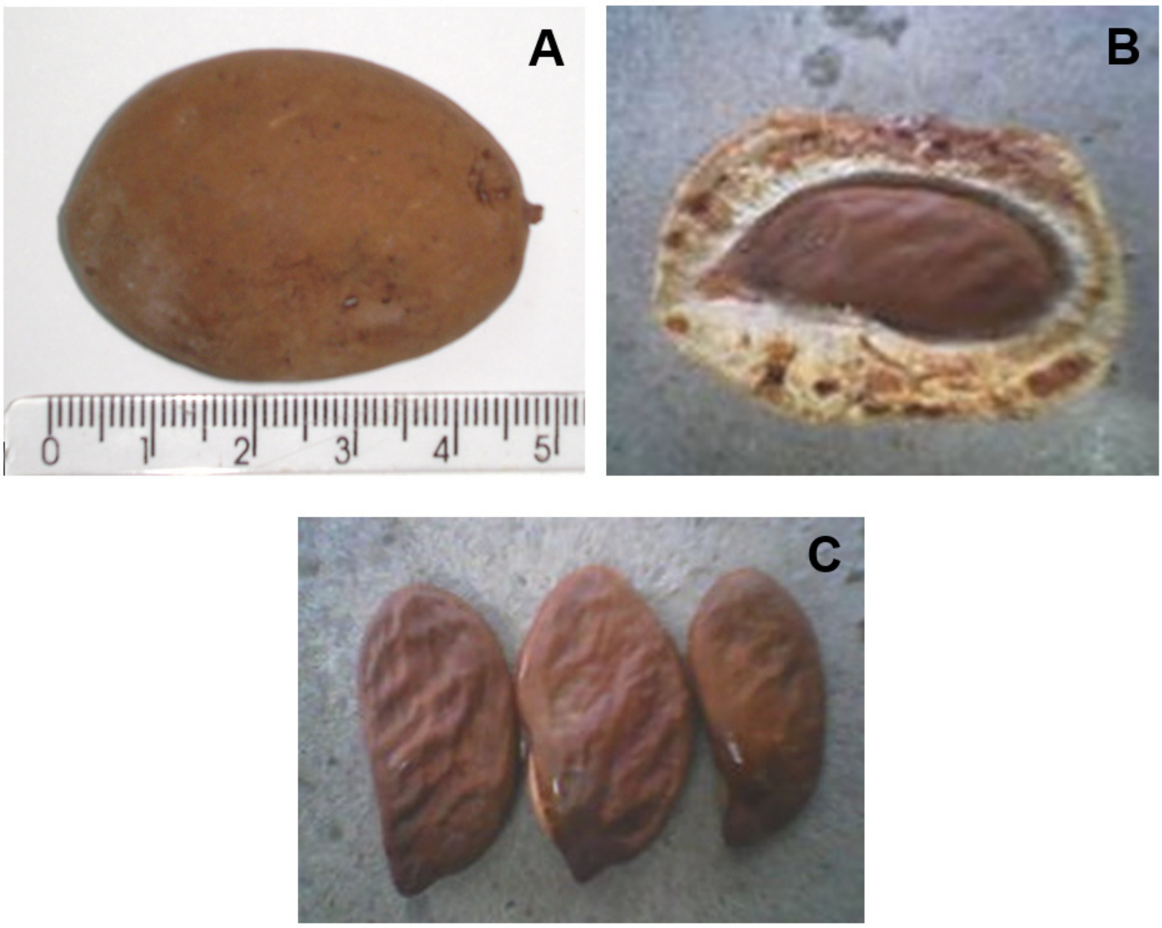


**Figure 3.** Fruit external part (A), fruit longitudinal face (B) and almonds (C) of Gurguéia nut.

It is important to detach that under native conditions, bats transport Gurguéia nut fruits until their feed landing, where they eat all the fruit pulp, keeping the seed under conditions to emerge, although the seeds are also transported by other animals, thus making possible the dissemination of this species.

Nowadays, Gurguéia nut plant propagation is performed by seeds, without any seed treatment, and the germination percentage is very low due to the seed dormancy. Commonly, when seeds are exposed to favorable environmental conditions (available water, proper temperature regime, oxygen supply and light) and they don't germinate, they are considered dormant (Baskin & Baskin, 1998). One of the most important causes of seed dormancy is the tegument impermeability, which difficult or do not allow water and/or oxygen absorption by the seed and, consequently, seed germination do not occurs.

Seed dormancy imposed by an impermeable tegument is frequently observed in seeds from Leguminosae family (Carvalho & Nakagawa, 2000), the same family of Gurguéia nut. This kind of seed dormancy could be overcome through scarification, a term that refers to any treatment that promote the integument rupture or weakening, allowing the water passage and initiating the germination process; or immersion in water allows the water to reach inside the seed (Mayer & Poljakoff-Mayber, 1963).

According to Guimarães et al. (2008), the low germination rate of Gurguéia nut seeds seems to be associated to the woody capsule resistance which recovers the almond (seed), rather than a tegument dormancy mechanism. These authors tested four treatments and concluded that seeds without coat and seeds with cracked coat present seed germination higher than 50%, indicating that the seed dormancy mechanism of Gurguéia nut is essentially physics. In addition, Cavalcante et al. (2011), reported that no seed germination was recorded for hot water soak for 15 and 20 minutes, whereas for the other methods, values ranged from 70%, recorded for registered for room temperature water soak for 48 hours, to 85% registered for room temperature water soak for 24 hours.

In relation to suitable substrates for seedlings, Falcão Neto (2010) concluded that seedling emergence of Gurguéia nut was better as red Oxisol:sand:bovine manure (1:1:1) shifted to washed sand with the latter one was found to be best. Substrate affects seedling formation of gurguéia nut, indicating that washed sand may be used in this process.

Falcão Neto et al. (2011) studied the effect of liming and fertilizing with nitrogen (N), phosphorus (P) and potassium (K) on seedling production of Gurguéia nut and reported that nitrogen doses affect seedling formation and the substrate treatment with liming and NPK affects leaflet number and shoot dry mass of Gurguéia nut seedlings. The same authors recommend, for limed substrate, 75 mg of N $dm^{-3}$ of substrate.

The nutritional status of Gurguéia nut has been studied by (Falcão Neto et al., 2011) who concluded that nitrogen and phosphorus absorption are enhanced by nitrogen doses, increasing until 150 mg of N $dm^{-3}$ of substrate; potassium, calcium and sulphur shoot concentrations are increased by substrate treatment with liming and NPK fertilizing, although no visual symptoms of deficiency have been visualized for non treated substrate. This author recommends no nitrogen fertilizing for seedlings produced on a substrate composed by soil which did not received liming and NPK fertilizing.

In figure 4 it is possible to identify seed germination, seedling emergence and adult seed propagated seedlings on time to be transplanted of Gurguéia nut.

*Compositions and uses*

Different parts of Gurguéia nut plants have been used for lots of purposes. It is possible to use the wood of the stem, which has high strength and durability as the stake for fencing, but is little used because the local population prefers the consumption as fruit and almonds as a source cosmetic, medical, food, and especially as a source of incomes in the almonds marketing, as well as in the manufacture of coal with the endocarp produced for domestic consumption.

Due to be appreciated by native people, the Gurguéia nut almond has been studied aiming at its use in the food, pharmaceutics and cosmetic industries. This way, Carvalho (2008) concluded that it is viable to use Gurguéia nut almond with pineapple for production of cereal bars that could promote benefits for environment through the use of the pineapple skin which is considered a waste by the food industry, but also make possible the use of the Gurguéia nut almond, which is poorly known but it presents nutritional value compatible to other almonds already commercially explored.

Carvalho (2008) reported that Gurguéia nut is a good source of energy, carbohydrate, protein and crude fiber indicating that its almond, according to nutritional parameters, has the potential to be used in the almond market.

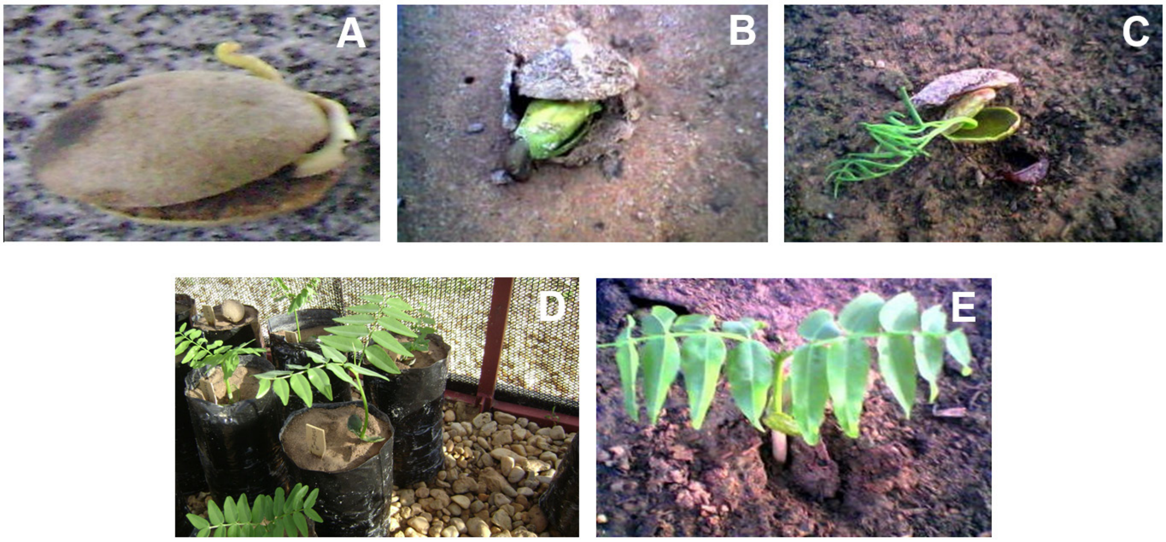

**Figura 4.** Seed germination (A), seedling emergence (B and C) and adult seed propagated seedlings on time to be transplanted (D and E) of Gurguéia nut.

In a general form, almonds are excellent nutritive sources, containing (in 100g of almonds) 18.6 g of proteins, 254.0 mg of calcium, 475.0 mg of phosphorus, 4.4 mg of iron and 0.67 mg of B2 vitamin, thus they are a good source of proteins and fat, contain reasonable quantities of vitamins such as thiamine, riboflavin and niacin, beyond adequate amounts of iron and phosphorus (Nascente, 2012). In human, the lack of vitamins can cause many diseases such as beriberi, caused by the absence of thiamine (Voet et al., 2000). The amount of calcium in nut Gurguéia presents higher values than the Pará nuts (172.0 mg) and cashew nuts (24.0 mg) (Franco, 1999). Furthermore, Gurguéia nut almonds could be combined with other cereals and fruits for production of different processed snacks with great acceptance by consumers (Souza & Menezes, 2006; Gutkoski et al., 2007).

In study about physico-chemical and nutritional characteriation of the oil and protein from Gurguéia nut almonds, Queiroga Neto (2005) observed that it has high lipid content (45.6%) and average contents of proteins (14.7%) and ash (2.5%) which were enhanced in the defatted flour for 26.4% and 4.6%, respectively. The physico-chemical oil properties presented the following average values: specific density 0.9100, peroxide index 2.8, oleic acid acidity 0.6, iod index (Hübl) 0.71 and saponification 179. The average composition in fatty oils is: saturaded 20.6%, monounsaturated 65.1% and polyunsaturated 14.3%, while the main fatty acids were C16:0 (10.4%), C18:0 (5.4%), C20:0 (3.4%), C22:0 (0.9%) and C24:0 (0.6%); and the unsaturated were C18:1 (65.1%) e C18:2 (14.1%). When the proteins were fractionated it was obtained 50.5% of globulins, 24.1% of albumins, 13.8% of glutelins and 0.3% of prolamins. The mono and polyunsaturated fatty acids are essential for human health, since these acids contribute to the reduction of the fractions of low density lipoprotein (LDL) and very low density (VLDL), responsible for increased serum cholesterol (Freitas & Naves, 2010). Accordingly, Costa & Jorge (2012) studied the characterization and fatty acids profile of the oils from Amazon nuts and walnuts, including Gurguéia nut, and concluded that the physico-chemical properties of oils from nuts and walnuts were comparable to those of good quality conventional oils, and, additionally, the oil seeds are a good source of unsaturated fatty acids, especially oleic and linoleic acids. Oleic acid has been considered essential for the beneficial properties in reducing oxidation of LDL-cholesterol, atherogenic form (Soares, 2002).

Another study about partial evaluation of *Dipteryx lacunifera* almond as a nutritional food performed by Queiroga Neto et al. (2009a) observed that the lipid and the protein contents of whole almond flour were about 41.8 and 13.3 g per 100 g, respectively, while in defatted almond flour, the protein content was 26.4 g per 100 g on dry weight basis. The polyacrylamide gel in the presence of sodium dodecyl sulfate and 2β-mercapto-ethanol (PAGE-SDS-2βMe) revealed the presence of twenty proteins with molecular weights ranging from 7.8 to 97.3 kDa. The proteins with molecular weights 18.0, 39.6, 57.6, 69.2, and 97.3 kDa were the prominent ones, while those corresponding to 7.8, 12.0, 14.7, 25.3, 31.3, 33.7, and 83.9 kDa were present in small concentrations. Defatted almond flour did not present trypsin inhibitory and hem agglutinating activity. In addition, the tannin content of the flour was 0.63 mg/g that, in comparison to FAO reference protein, showed all essential amino acids (except methionine) in good concentrations. The protein quality of the nuts and seeds should be investigated because of their appearance relevant to human nutrition, including the bioavailability of its essential amino acids (Freitas & Naves, 2010).

Ribeiro et al. (2012b) reported that Gurguéia nut is a natural source of phosphorus, potassium, magnesium, lead, crude fiber, total carbohydrates and energy.

Queiroga Neto et al. (2009b) evaluated the characterization and thermal stability of seed oil from Gurguéia nut and reported that its oil presents physiochemical properties characterized by the legislation and related with its chemical composition in fat acids, supposing high resistance to the oxidative degradation. The thermal stability of the oils depends on its chemical structure, and oils containing saturated fatty acids are more stable than the unsaturated fatty acids. Moreover, the investigation of the thermal stability of oils and fats is very important, because the oil can be used for food and industrial purposes (Faria et al., 2002). However, Gurguéia nut nutritional quality, comparatively with commercial oils is committed by the indexes, relatively low, of essential fat acids.

Vieira Júnior et al. (2007) in research about Gurguéia nut performed the isolation of the furanocassane-type diterpene, named vinhaticoic acid, along with β-farnesene and spatulenol from fruit shells of *D. lacunifera*, concluding that oleic acid (75.8 ± 4.3%) was the major component and the essential oil extracted from the fruit shells of *D. lacunifera* was analysed by HRGC/MS and nine sesquiterpenes were identified; β-farnesene (48.6%) and spatulenol (21.61%) were the major constituents. Terpenes act as antioxidants, i.e., they protect lipids, blood and other body fluids from the attack of free radicals, some reactive oxygen species, hydroxyl groups, peroxides and superoxide radicals (Chasquibol et al., 2003).

In study about the potentialities of *D. lacunifera* Ducke seeds oil for biodiesel production, Araújo et al. (2010) concluded that the yield in oil was of 46.11 ± 0.37% and the methyl biodiesel obtained is congruent with the specifications of the National Petroleum Agency (ANP), but the oxidation stability was lower than the set value. Moreover, the addition of the synthetic antioxidants on biodiesel, including the liquid in the cashew nut shell, provided care of the specification.

Ayres et al. (2008) evaluated the antibacterial activity of useful plants, including Gurguéia nut, and chemical constituents of the roots of *Copernicia prunifera*, and observed that hexane extract of the fruit shells of Gurguéia nut were obtained with a yield of 9.8, 4.6 and 7%, respectively. In a general form, Gurguéia nut extracts are partially active (inhibition zones of 9-14 mm) or showed no significant activity (halos smaller than 9 mm) for all bacteria tested.

Gurguéia nut fruits antiradical activities of compounds eriodictyol, butin, 3',4',7-trihydroxyflavone and sulfuretin together with the positive controls rutin, butylated hydroxy toluene (BHT), and *tert*-butylhydroquinone

(TBHQ), were evaluated with the DPPH assay and were found to decrease in the order rutin > 3',4',7-trihydroxyflavone > eriodictyol > sulfuretin > butin > TBHQ > BHT (Vieira Júnior et al., 2008).

In addition, Gurguéia nut fruits serve as food for many animals such as bats, monkeys, rodents and insects (beetles). The cattle also eat the pulp of the fruit during harvest time, where after ruminating they expel the fruits without the pulp through the feces or the mouth itself, contributing to the spread of this species.

**Conclusions**

Our bibliographical study gives an initial evaluation about origin, almond composition, uses, importance and potential of Gurguéia nut for commercial orchards.

Commercially, Gurguéia nut appears to have numerous selling points; the almonds are attractive in oil and taste, and they have very good internal properties of high interest for human health and, consequently, for the food industry.

The almonds contain proteins, calcium, phosphorus, iron and B2 vitamin, thus they are a good source of proteins and fat, contain reasonable quantities of vitamins such as thiamine, riboflavin and niacin. In addition, it is a good source of energy, carbohydrate, protein and crude fiber, viable to use with pineapple for production of cereal bars, while its seeds presents oil for biodiesel production.

As far as agronomy is concerned, these species are generally easy to multiply and cultivate, but its vegetative propagation is still unknow which constitutes a technical problem for this species because the time necessary for the first harvest is long, when plants are propagated by seeds. In general, they produce a lots of fruits and few diseases and pests are

encountered at the present time.

Finally, our review also highlights the fact that the interest shown in these species is recent and, for this reason, more detailed knowledge of this plant is required. The agronomy, genetics and the technological qualities of this species that is still relatively unknown merit further research.

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