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Extraction and characterization of the essential oils from *Spondias mombin* L. (Cajá), *Spondias purpurea* L. (Ciriguela) and *Spondia* ssp (Cajarana do sertão)

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This research aimed at extracting and characterizing the phytochemistry of the essencial oils from *Spondias mombin* L. (Cajá), *Spondias purpurea* L. (Ciriguela) e *Spondias* sp (Cajarana do sertão). We selected five vigorous and healthy trees located in the city of Patos, PB. The leaves were collected and taken to Natural Products Research Lab (NPRL) in the Regional University of Cariri - URCA - in the city of Crato, CE. The extraction method was the steam-dragging distillation through a Clevenger extractor. The chemical analysis of the oils were done by means of a Shimadzu spectrometer. The greatest components found in the Cajá essential oil were: octadecane (43.51%), heptacosane (21.98%) e hexatriacontane (15.37%); the predominant substances in the Cajarana do sertão oil were: Octadecane (31.5%), Indene (22.53%) and tetraacantane (10.51%), and in the Ciriguela, there were: heptacosane (28,80%), nonadecane (19,47%) e tetracosane (17.02%). Among the terpenes, we emphasize the β-caryophyllene (Cajá e Cajarana do sertão) e o α-humuleno (Ciriguela), that present important antimicrobial action. In the Cajarana do sertão, we identified the phytol, known for enhancing the tenacity and balancing the flow of skin natural oil, causing great anti-aging benefits.

Key words: *Spondias*, essential oils, gas chromatography.

INTRODUCTION

The Caatinga is the only exclusively Brazilian biome, with an area of 844 453 km^2, with a native vegetation area of 518 635 km^2 order, which is equivalent to 62.77% of the mapped area of the biome. The biome is approximately 54% of the Northeastern region and 11% of the Brazilian territory. It is between the parallels of the 2°54'S to 17°21' and involves areas of the states of Ceará, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe, southwest of Piauí, interior parts of Bahia and part of Minas Gerais (IBGE, 2010), being considered the richest semi-arid biome in the world in biodiversity (MMA, 2009).

According to Araújo et al. (2007), the northeastern semi-arid region of the polygon of droughts, its characterized by low rainfall (average 700 mm).

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Precipitation almost always focuses in the months from February to May. The potential evaporation is very high (can reach to 3,000 mm / year), this region has average temperatures ranging from 20 to 28°C.

Araújo et al. (2007) report that the forest cover in the semiarid region has declined dramatically, a fact caused by lack of proper management and the type of operation adopted. Emphasize that the exploitation of Caatinga vegetation is used for various purposes, highlighting the use of wood for energy, rural buildings, commercialization of fruits such as medicinal plants, perfume and cosmetics. The essential oils have been shown to be an alternative to add value to forest species of semiarid region. The International Standard Organization (ISO) defines essential oil as the product obtained from parts of plants by distillation with water steam and the product obtained by expression from pericarp of citrus fruit.

For Bakkali et al. (2008), many consider essential oil equivalent to the soul of the plant - it is exactly the produced substance that lends flavor and taste by which it is known. Unlike olive oils and lipid (fatty) oils, essential oils are produced in minimum quantity and are quite volatile (hence its odor fills the entire environment quickly). In general, several hundred of kilograms of fresh plants is needed to produce only one essential oil kilogram. This is to say that the use of a single drop (or less) of the product aromatically equivalent to several hundred grams of the herb, which opens up numerous culinary and therapeutic possibilities.

According to Angnes (2005) and Almeida et al. (2010) the popular medical practice, essential oils have a long tradition of use as medicinal agents. There are pictorial records of six thousand years ago, among the Egyptians, of religious practices associated with curing ills, the royal anointing, and physical well-being search through the aromas, obtained from specific parts of certain plants, such as resins, leaves, flowers and seeds. Flavour were already popular in ancient China and India, hundreds of years before the Christian era, when they were incorporated into incense, potions and various types of accessories, used directly on the body.

The term itself "aromatherapy" would have been created by a French chemist in 1928 and whose name was Maurice Rene Gattefosse. Gattefoss came to be fascinated by the therapeutic possibilities of essential oils and from a personal experience with lavender oil. Until then, Gattefosse used essential oils in their products and creations for the purpose of perfuming, but without any therapeutic basis. Making a distillation in his laboratory, there was an accident where the product was flammable, fell into his arms, causing a serious burn. In an act without thinking, he plunged his arms in a lavender tub, he thought was water and realized immediately that the sensation of pain soon passed. Within days, the wound had healed and in the burn place was not even a scar. This led him to become interested in researching the therapeutic possibilities of essential oils (Mccaffrey et al., 2009).

The antimicrobial properties of extracts and essential oils obtained from medicinal plants have been empirically recognized for centuries, but only recently have been confirmed scientifically. Several researchers study the biological activity of medicinal plants from different regions of the world, guided by the popular use of native species, showing that its extracts and essential oils are effective in controlling the growth of a wide variety of microorganisms, including fungus, yeasts and bacteria (Almeida et al., 2010).

Besides antimicrobial activity, essential oils present analgesic properties, anti-inflammatory, antimalarial, anti-carcinogenic, anticonvulsant, antioxidant, gastro-protective and acetylcholinesterasic. This latter property is of great interest in controlling Alzheimer's disease, progressive neurodegenerative disease that primarily affects the elderly population accounts for 50 to 60% of cases of dementia in people over 65 years (Barbosa-filho et al., 2008; Asuquo et al., 2013).

One of the most promising treatments for this disease is the increased levels of the neurotransmitter acetylcholine by inhibiting the enzyme acetylcholinesterase. Essential oils of *Salvia lavandulaefolia* inhibited the enzyme in question both in vitro and in vivo test. Some monoterpenes isolated as alpha- and beta-pinene, and fencholfenchone also were effective in inhibiting acetylcholinesterase (Barbosa-filho et al., 2008; Almeida et al., 2010).

In Brazil, one of the sources initially exploited for the extraction of essential oils, was the rosewood. Its exploitation was such that until today, the InstitutoBrasileiro do MeioAmbiente (IBAMA) included in the Species List in Danger of Extinction (Decree 37/92 of 04/03/1992) (Ferraz et al., 2009). Other vegetables were also explored, such as eucalyptus, lemon grass, mint, orange and cinnamon. Due to the difficulty to import essences, and increased global demand for Brazilian production caused by the Second World War, Brazil with it had most of its sales aimed at exports, which helped to significantly increase production. In the 50's, another factor contributed to the increased extraction of essences within the country; International companies producing perfumes, cosmetics and pharmaceuticals and foodstuffs have settled in the country (Bizzo et al., 2009).

According to Bizzo et al. (2009) flowers, leaves, bark, rhizomes and fruits are raw materials for their production, like the essential oils of rose, eucalyptus, cinnamon, ginger and orange, respectively. They have wide application in perfumery, cosmetics, food and as adjuncts in drugs. They are mainly used as flavorings, fragrances, fragrance fasteners in pharmaceutical compositions and oral and commercialized in raw form or benefited by providing purified substances such as limonene, citral, citronellal, eugenol, menthol and safrole. In general, the species have specific times in which they contain higher amount of active ingredient in its tissue, which change may occur both within one day as in times of the year (Almeida et al., 2010).

The food plants, feed and fiber culture are not the only of importance on the market today. Other species, whose secondary metabolism are valued for its aromatic and therapeutic characteristics, or because they are raw materials for industry, either as active ingredients and flavor and perfumery industry fragrances, or as constituents in product formulations for hygiene and health, and are also widely used in alternative medicine, also have economic importance (Almeida et al., 2010). Because of this, demand has increased by essential oils. Some specific components of these oils are used as aids in synthetic organic chemistry and common structures of transformations, in order to obtain highly functional substances of recognized economic value.

According to Bakkali et al. (2008), there is a lack of chemical composition of essential oils not only from the Myrtáceas, as well as all Brazilian flora rich in relation to secondary metabolism. According to Bakkali et al. (2008), there are about 3000 essential oils known, of which 300 have commercial importance for the pharmaceutical, food, cosmetics and perfumes and agronomy. Among the species that produce essential oils that contribute significantly in global sales volume, the study can highlight the mint (*Mentha pipperita*), citronella (*Cymbopogon winterianus*), capim-limão (*Cymbopogon flexuosos*), eucalyptus (*Eucalyptus*), the rosa (*Rosa damacena*), geranium (*Pelargonium graveolens*), lavender (*Lavanda officinalis*) chamomile (*Chamomilla recutita*), sândalo (*Santalum álbum*), manjerona (*Origanum majorana*) and sálvia (*Salvia officinalis*).

Among the species of the genus *Spondias* belonging to the family *Anacardiaceae* attracting interest from agribusiness are Cajarana do sertão, Umbu, Cajazeira, Umbu-cajá and ciriguela. The demand for the fruits of this genre is mainly due to the interest for industrialization and consumption "in nature". The fruits of *Spondias* are well accepted in the industry for having good quantity of nutrients and good looks. For this reason, its pulp has been quite popular and utilized by the food industry. They are consumed raw, sold in local markets or on some Brazilian highways margins (Santos and Oliveira, 2008).

The *Anacardiaceae* family is represented by about 80 genera and 600 species, which are known to produce tasty fruits, excellent wood, compounds used in industry and medicine. The *Spondias* genus has 18 species, some are grown in the Northeast and are tropical fruit trees in domestication and exploited for their commercial value. Among the species of the genus *Spondias* that stand out in the semi-arid northeast are Cajarana do sertão (*Spondia* ssp), Umbu (*Spondias tuberosa* Arruda Câmara), Ciriguela (*Spondias purpurea* L.) and Cajá (*Spondias mombin* L.).Being the umbuzeiro, the only endemic in the Brazilian semi-arid. Other species also grown in Northeast Brazil are the Umbu-cajá *Spondias* sp.), Cajá-manga (*S. cytherea* Sonn) and (umbuguela (*Spondia* ssp) (Agra et al., 2007; Santos and Oliveira, 2008; Almeida et al., 2010).

The Cajá (*Spondias mombin* L.) also called ambaló, cajá-Mirim, cajazeira, cajazinha, taparebá or tapiriba originating in the tropical region of the Americas. It is tall, reaching up to 15 feet tall, deciduous leaves and trunk covered with thick, rough skin that esgalha and branches at the back, giving a high size plant. The canopy is large, showy and imposing when flowering and fruiting phase. The fruits are fragrant nuculânios with fleshy mesocarp, yellow sweet and sour flavor, containing carotenoids, sugars, vitamins A and C (Barbosa-filho et al., 2008), are well appreciated in kind or in the form of pulp, jams and ice cream.

The Cirigueleira (*Spondias purpurea* L.) is also called siriguela, cajarana-of-spain, ciroela, ciriguela and Mexican ciruela. It is a deciduous tree 3 to 6 m in height. Pinnate leaves measuring 18 to 24 cm and 9 to 11 pairs of membranous leaflets about 2.5 cm long. Discrete flowers, unisexual (male and female) and androgynous on the same plant are formed during spring along with the sprouting of new foliage. Fruits of the drupe type, with sweet-acidic pulp are very tasty. The fruit of 15 to 20 g and ellipsoidal form of 3 to 5 cm long, smooth and shiny, purple or wine with firm epicarp, presents a yield of 50% pulp and is used to make juices, ice cream, liquor, wine, jam, compotes and soft drinks in natura. It has a fleshy mesocarp, yellow, 5 to 7 mm thick, is sweet, sour, very pleasant taste. The endocarp (seed) occupies most of the fruit (Asuquo et al., 2013). It is one of the most cultivated species of the genre. It is a species native to Central America but is distributed in Mexico, the Caribbean and several countries in the northern region of South America, probably dispersed by man. According to Almeida et al. (2010), produces, in well-drained soil in tropical and subtropical climates and edible fruit with peculiar and pleasant taste. The adult plant rarely exceeds 7 m high, hardly propagates by seed and its multiplication by human action takes place by stakes. Begin fruiting in the third year after planting in the field. A mature plant can produce between 80 and 120 kg per year. Under the alimentary point of view, this is an extremely rich fruit in carbohydrates, calcium, phosphorus, iron and vitamins A, B and C. The fruits and leaves can be seen on Figure 1.

Cajarana do sertão (*Spondia s*sp) is a plant of the Society Islands in Oceania. It is fast-growing tree, with thick and brittle branches, compound leaves of 11 to 13 leaflets. Flowers arranged in large terminal panicles. The fruits come in bunches. They are Ellipsoids drupes or slightly obovóides of thin yellow skin, measuring approximately 3.0 cm. The pulp is compact, pale yellow, juicy, sweet or acidified, covering a bristly seed long timber beams deeply ingrained in the mass of pulp. Edible natural, tasty, fruit give good soft drinks, popsicles and ice cream (Asuquo et al., 2013).

Barbosa-Filho et al. (2008) studying the umbu-cajazeira

Figure 1. *Spondias purpurea* L. fruits and leaves.

(*Spondias* spp), which is a similar hybrid to Cajarana do sertão (*Spondia* ssp), reports that the fruits have excellent taste and aroma, good appearance and nutritional quality, very consumed in the form "in natura", with average yield of 55 to 65% in pulp, with potential for use as processed as frozen pulp, juice, nectars and ice cream. For descriptions of Almeida et al. (2010), the species of *Spondias* are better adapted to lowland tropical hot. The trees grow best in well-drained fertile soils, but, if properly nurtured, can also develop satisfactorily in several poor soils. It can be seen on Figure 2.

Due to the diverse use of Caatinga species, and the lack of information on the vegetation of the same, it is clear the importance of knowledge of the phytochemical characteristics of the occurrence of species in the Brazilian semi-arid region, in order to create a species database present in the Caatinga and hence indicate the species with the potential to produce essential oils, adding economic value to these species (Agra et a., 2007)

MATERIALS AND METHODS

Characterization and location of study area

The present study was conducted in the city of Patos-PB in the semi-arid backlands depression, distant 301 km from the capital João Pessoa and its headquarters is located in the heart of the state. The state of Paraiba is located in the eastern portion of the Brazilian Northeast, between the meridians 34°45'45" to 38°45'45" West longitude and 06°02'12" and 08°19'18" latitude South, occupying an area of 56,732 km 2. Following the East to the West, in other words from the Coast to the Hinterland, we have: Coastal vegetation, Fields and Forests of Restinga, Mangroves, Humid Forest, Cerrado, Wasteland, Caatinga and MatasSerranas. The climate in Paraíba is characterized by high temperatures and scarce and irregular rainfall. In the inner part of the state the semi-arid climate dominates, registering this area high average monthly temperature of 25 to 30°C, and low rainfall 300 to 1000 mm bad rain distributed throughout the year, which conditions the strongly xerophytic vegetation (Tolke et al., 2011).

The Patos County is located in the state of Paraíba (Figure 3), in the semi-arid backlands depression, distant 301 km from the capital João Pessoa and its headquarters is located in the heart of the state, with road vectors connecting all the Paraíba and enabling access the states of Rio Grande do Norte, Pernambuco and Ceará. Its land area is approximately 512.79 square kilometers with a population of 100,732 inhabitants (IBGE, 2010). Its geographical coordinates are: 7,02°S and 37,27°W, with an altitude of 242 m. The climate according to the Köppen classification is the hot-Bsh semi-arid and dry, average annual temperature of 28°C and relative humidity of 55%. The driest period covers the months from July to February and the wettest in the period from March to June. The average annual rainfall is 675 mm with irregular rainfall distribution, although in recent years this index has been exceeding 1000 mm. Its soils are mostly shallow and rocky, typical of lithic soils, basically represented by the non-calcium-based Bruno soils.

Collect of samples

Five trees were selected from *Spondiasmombin* L. (Cajá), *Spondiaspurpurea* L. (Ciriguela) and *Spondiassp* (Cajarana do sertão) who had good health, located in the city of Patos-PB, with the following coordinates:. Cajá: 07°03'593' 'S and 37°16'498' 'W and altitude of 253 m; Ciriguela: 07°03'550" S and 37°16'539"W

Figure 2. *Spondia ssp* tree.

Figure 3. Map of Paraíba showing the location of the city of Patos. Source – IBGE (2010).

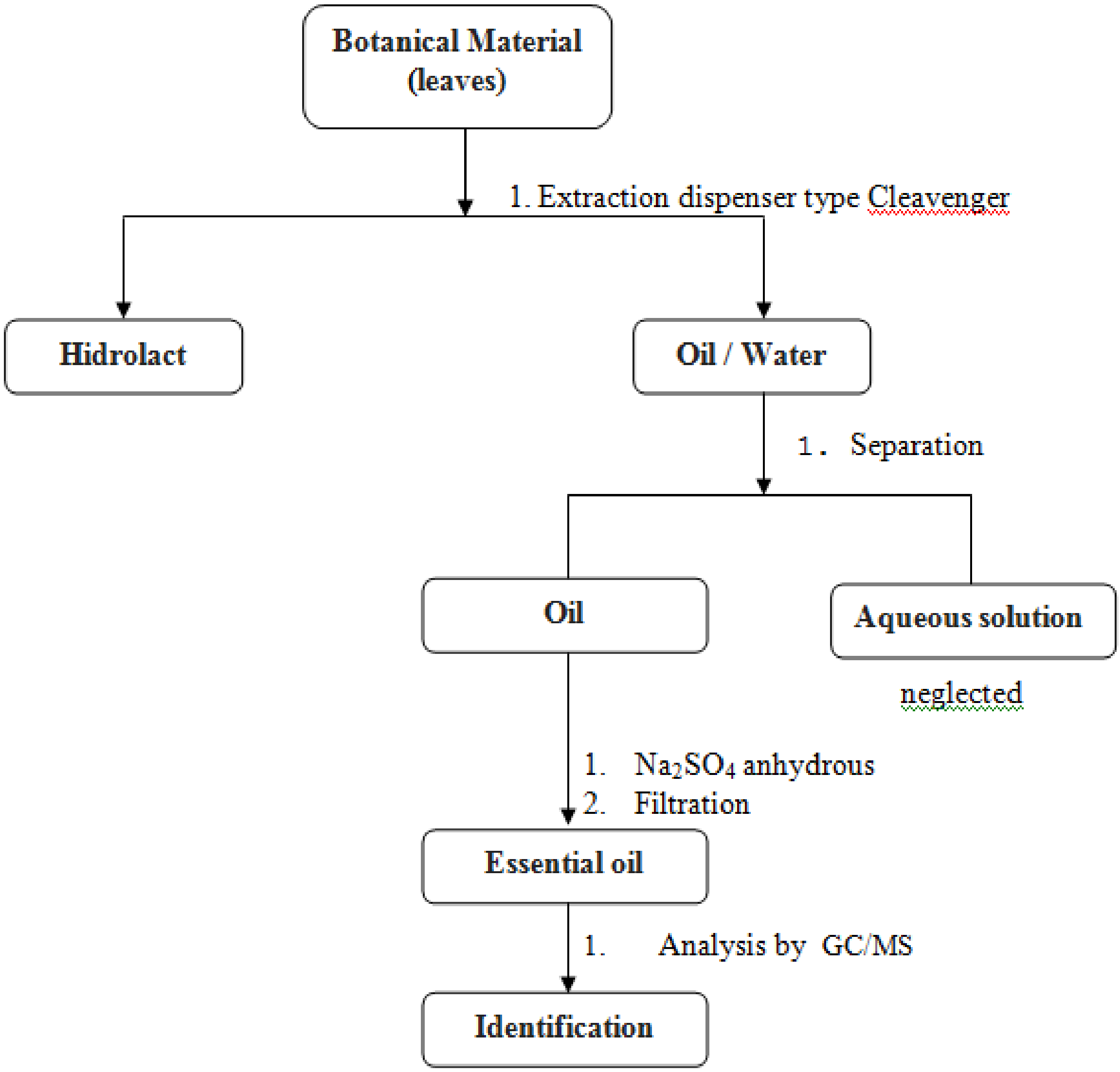

Figure 4. Flow chart depicts the method for the extraction of essential oils from the hog plum leaves.

and altitude of 256 m and Cajarana do sertão: 07°03'608"S and 37°16'488" W and altitude of 256 m, of which samples were collected while fruit, branches with leaves, flowers and fruits, at 7, 10, 14 and 17 h, with the help of pruning shears in ten different points of the canopy of each tree and mixed to form uniform samples, packed in plastic bags black in color, identified and put in the refrigerator until the travel time (23 h of the same day) to the Research Laboratory of Natural Products (LPPN) Regional University of Cariri - URCA - in Crato-CE. Part of excicatas were made of the samples that were deposited in the Herbarium CaririenseDárdano de Andrade- Lima Regional University of Cariri - URCA and the rest were for the extraction of essential oils.

Essential oil extraction

The extracted essential oils (1000 g leaves of each plant) (Figures 4 and 5) were obtained by hydrodistillation using a Clevenger type apparatus for a period of 3 h. Then the mixtures oil / water were collected, dried over anhydrous sodium sulfate (Na_2SO_4), filtered and stored under refrigeration until analysis.

Analysis by gas chromatography connected to a mass spectrometry (GC/MS)

The analyzes of the chemical compositions of the obtained oil were performed using a Shimadzu GC-17A spectrometer / QP5050A MS (GC / MS): DB-5HT capillary column (30 mx 0.251 mm); Carrier gas: helium 1.0 ml / min; 72.3 kPa pressure column; line speed = 37.2 cm / sec; the total flow 85 ml / min; carrier flow 85 mL / min; injector temperature 280°C; detector temperature 280°C; column temperature 60 (2 min) - 180°C (1min) at 4°C / min, then 180 to 260°C at 10°C / min (10 min). Operating under ionization energy of 70 eV. Hydrocarbon standards were injected with Kovats indices corrected by the straight line equation. The identification of the chemical compositions were carried out after analysis of the chromatograms of the respective oils (Figures 6 and 7), based on the spectral fragmentation using computer library (Wiley 229), the retention rates and comparison with the literature data (Adams,

Figure 5. Essential oil extractor, model Clevenger do LPPN-– URCA - Crato-CE.

2001; Alencar et al., 1990).

RESULTS AND DISCUSSION

In this experiment the first collection, the study found that the distillation did not contain essential oils and the second collection the study found the presence of essential oils, which shows the influence of time on the production of essential oil, which is in agreement with studies by Gonçalves et al. (2009) and Miranda et al. (2013). The sampling time for the extraction of essential oils has influence in some species. Thus, the material harvest time can be an important aspect in the production of oils.

According to Rocha et al. (2011) who studied the effect of lemon grass cutting time [(*Cymbopogom citratus* (DC) Stapf] as to campim citronella (*Cymbopogon winterianus* Jowitt) found that the actual harvest between 9 and 11 h provided better essential oil content and higher percentages of major constituents.

Nascimento et al. (2006) studying basil capim-santo

Table 1. Sample and oil mass and its percentage product.

Espécie	Leaves mass (g)	Oil mass (g)	Yield (%)
Spondiaspurpurea	2000	0,0518	0.0026
Spondiasmombin	1550	0,0564	0.0036
Spondiassp	1850	0,0746	0.0040

Table 2. Chemical compounds of the Cajá leaves essential oils (*Spondiasmombin* L.).

Constituent	Retention Time (min)	Percentage (%)
Ethyl acetate	3.56	0.70
4-hydroxy-4-methyl-2-pentanone	4.08	6.41
β-caryophyllene	30.83	1.24
2,4,10,15 tetrametilheptadecano	52.11	1.41
Octadecane	53.10	43.51
Tetracosane	55.33	8.62
Heptacosane	61.90	21.98
Hexa-triacontane	65.37	15.37
Total identified	-	99.24

(*Andropogum* sp) noted that the most essential oil content was obtained reaping the 8 h and distilling fresh leaves. Miranda et al. (2013) (*Cymbopogon citratus* (D.C) found that, when tested six harvest times, the best content occurred at 9 am and the worst at 7:17 h. In this study experiment was made a first crop (fresh leaves) on March 16 at the times of 7, 14 and 17 h and found that the distillation did not contain essential oils. Studying some articles, the study found that some species had best essential oils of income when the samples were collected in the time between 9 and 11 h. So the study made a second crop and selected 10 h time. Made distillations the study found the presence of essential oils.

Table 1 presented relationship between the data from the collection and the extraction of essential oils from species *Spondias mombin* L. (Cajá), *Spondias purpurea* L. (Ciriguela) and *Spondias sp*. (Cajarana do sertão). It is observed in Table 1, that the *Spondia ssp* had the highest production of essential oils followed by the species *Spondias mombin* and *Spondia* ssp although they are very close values. The values found for the *Spondias* study were lower than those found by Dhar and Dhar (1997), studying the *C. jwarancusa* species, which in stage I (green plants), yield was 0.5% and in stage IX (when the plants showed a third of leaves in brown color) yield of 1.64%. Santos et al. (2007) studied the *Lantana camara* L., obtained an oil yield of 0.12%.

The constitution of the essential oils of the studied Cajarana do sertão although it is mono- and sesquiterpenes, showed differences in their chemical composition, with a differentiation in the relative level of these components. The major compounds found in Cajá essential oil (*Spondias mombin* L) is octadecane (43.51%), heptacosano (21.98%) and hexatriacontano (15.37%) (Table 2); the oil Cajarana do sertão (*Spondia ssp*) predominate substances: octadecane (31.5%), indene (22.53%) and tetraacantano (10.51%) (Table 3). While the essential oil of Ciriguela (*Spondiaspurpurea* L.) (Table 4) are: heptacosano (28.80%), nonadecane (19.47%) and Tetracosane (17.02%).

Essential oils extracted from plants, from the chemical point of view, mainly consist of a mixture of lipids which are called terpenes. These terpenes are hydrocarbons and some may have oxygen in their structure, which are called terpenoids. The formation of these terpenes are based units isoprene (2-methyl-1,3-butadiene) according to the number of units may be called hemiterpenes (1), monoterpenes (2), sesquiterpenes (3), diterpenes (4), sesterpenos (5), tetraterpenes (8) and polyterpenes with many units. The analysis permits us to identify some components to be common to all three essential oils studied. In Table 5 comparison can be clearly seen.

In the analysis of the chromatograms of the species studied Cajá, Cajarana do sertão (Figure 6) and Ciriguela (Figure 7), where the x axis is in minutes and temperature TIC means: total ion chromatogram and the y-axis is the intensity measured in the presence of compounds IK (Kovats index). Tables 2, 3 and 4 showed the presence of terpenoids, among them mono- and sesquiterpenes on which 30,000 terpenes are known, classified according to the number of isoprene units: hemiterpenóides, C5; monoterpenoids C10; sesquiterpenoids. C15; diterpenoids, C20; triterpenoids andtetraterpenóides C30, C40 (Rocha et al., 2011). They have different functions in plants. The monoterpenes are the main constituents of the essential oils, acting in

Table 3. Chemical compounds of the Cajarana do sertão leaves essential oils (*Spondias* sp).

Constituent	Retention time (min)	Percentage
Indene	31.06	22.53
Decyl-octahydro-indene	37.62	6.19
Palmitic acid	50.78	8.22
Phytol	52.20	6.33
Acid eicosatrieno	52.48	3.07
Octadecane	54.21	31.5
Di-ethyl Hexanodionato	55.36	9.12
Tetra-acantane	61.91	10.51
Total identified	-	97.47

Table 4. Chemical compounds of the Ciriguela leaves essential oils (*Spondias purpurea* L.).

Constituent	Retention time (min)	Percentage
2-hydroxy-2-methyl-4-pentanone	4.06	2.70
β-caryophyllene	30.83	2.35
Indene	31.03	1.43
α-humulene	32.66	0.85
Germacremo-D	34.00	2.34
γ-cadineno	35.95	1.94
Caryophyllene oxide	38.94	1.20
Nonadecane	53.35	19.47
Adinol	55.35	1.07
Tetracosane	55.52	17.02
Lupenol	59.11	4.93
Heptacosano	59.23	28.80
Octadecane	63.36	9.81
Total identified	-	93.91

Table 5. Common components of the Cajá, Cajarana do sertão and Ciriguelas leaves' essencial oils.

Constituent	Leaves
Octadecane	Cajarana do sertão, Ciriguela e Cajá
Heptacosane	Cajá e Ciriguela
β-caryophyllene	Cajá e Ciriguela
Tetracosane	Cajá e Ciriguela
Indene	Cajarana do sertão, Ciriguela

attracting pollinators. The sesquiterpenes, generally have protective functions against fungi and bacteria, while many diterpenoids lead to plant growth hormones. Triterpenoids and derivatives steroidal feature a range of functions such as protection against herbivores, some are antimitotic, others act on seed germination and inhibition of root growth (Joy et al., 2007).

Among the terpenes found in the chromatograms in the species studied, the study highlights the β-caryophyllene (Cajarana do sertão, Ciriguela) and the α-humulene (Ciriguela), which has important antimicrobial action. Studies made by Rocha et al. (2011), with essential oil of Abiesbalsamea, found that 96% of the essential oil was composed of monoterpenes α and β-pinene, α and β-caryophyllene, humulene, which have significant antimicrobial activity against distinct pathogenic microorganisms.

The anticancer activity of some sesquiterpenes have also been reported, such as α-humuleno whose action was observed in solid tumor cells MCF-7, PC-3, A-549,

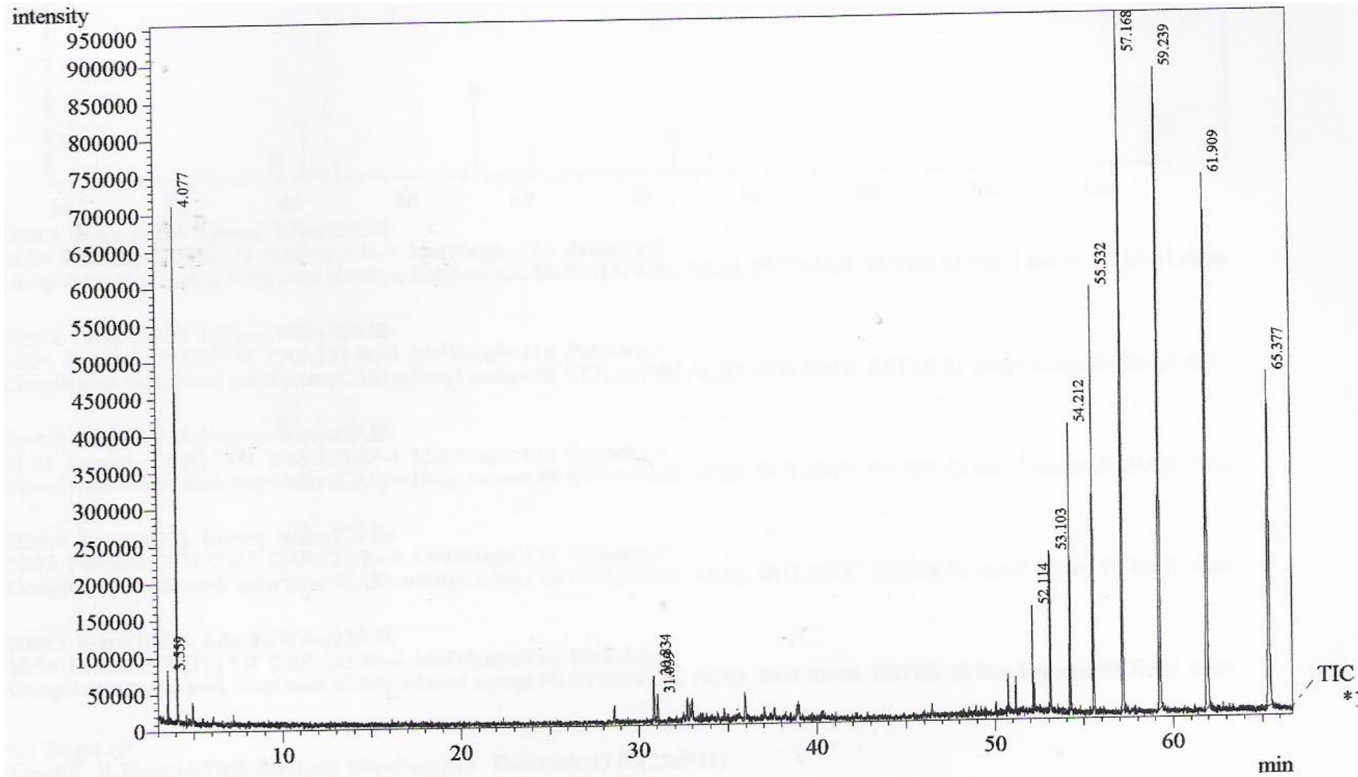

Figure 6. Chromatographic analysis of the Cajá essential oil.

DLD-1, M4BEU and CT-26. This compound was able to induce a dose and time-dependent decrease of cellular glutathione content and increased production of reactive oxygen species (ROS). These results suggested that both glutathione depletion and the production of ROS such as may be implied in its cytotoxic action (Martins et al., 2010).

Morais et al. (2006) reports that recent research with *Croton. zenhtneri*, *Croton. Nepetaefolius* and *Croton. argyrophylloides*, which is scientifically recognized by the anti-inflammatory properties, revealed that the anti-inflammatory action plan is a result of the essential oil action and that the active ingredient responsible for the action was identified as the α-humulenesesquiterpene.

Constantin et al. (2001) studying essential oils of *Piper reginelli* leaves, whose major components were myrcene and linalool and *Piper cernuum* with bicyclogermacrene and β-caryophyllene as major, showed activity against *Candida albicans* and *Staphylococcus aureus*, the authors attributed this activity to the major compounds. Costa et al. (2007) studying essential oils of *Lantana camara* L. and *Lantana sp*., found the predominance of sesquiterpenes, bicyclogermacrene (19.42%), isocariofileno (16.70%), valencene (12.94%) and sesquiterpene (12.34%) in the oil *L. camara*, while bicyclogermacrene (13.93%), germancreno D (27.54%) and β-caryophyllene (31.50%), stood out as major in *Lantana* sp oil. The *in vitro* antibacterial activity tests showed *L. camara* oil as inhibitor of growth of almost all tested bacteria (mainly *Proteus vulgris* (ACTCC 13315) and *Escherichia coli* (ATCC 25922) *S aureus* appear as resistant to the action of components present in the oil. The oil of *Lantana sp.* was more significant against *S. aureus* (ATCC 10390).

In the chromatogram of the Cajarana do sertão, terpenephytol was identified, it is known to improve the toughness and balance of the natural flow of oil from the skin, causing large anti-aging benefits and according to Dewick (2002) and Silva-Junior and Almeida (2013), the phytol is the reduced form of geranylgeraniol, that is one of the simplest diterpenes and important nature, since forming the lipophilic side chain of vitamin K and clorofilas. Also it was found in the hog plum fatty acid, palmitic, which according Melos et al. (2007) there are many studies in the literature reporting allelopathic activities relevant to many of the substances in green fronds *A. tetraphyllum*. For example, seeds of twenty-five different species of economic significance were treated with vegetable oils with the objective of evaluating the effect of such oils on the germination of such seeds. It was observed that among the species tested, there was complete inhibition of germination of *Allium cepa*, *Tritium aestivum* and *Zea mays*. The oil contained in its composition, long chain saturated fatty acids, palmitic and oleic acids. There are also reports in the literature identifying oleic, stearic and myristic, palmitic, linoleic and

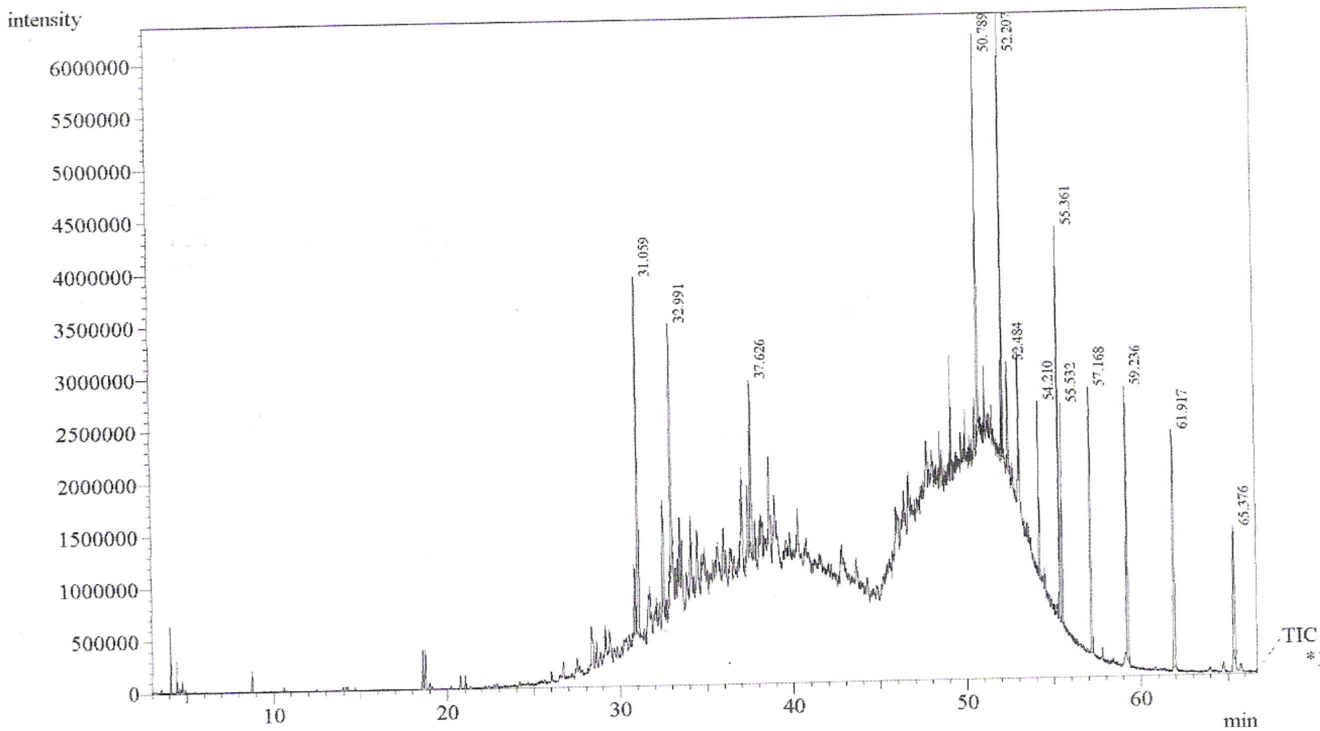

Figure 7. Chromatographic analysis of the Cajarana dosertão essential oil.

linolenic and other long-chain fatty acids as allelopathic agents, and the myristic acid and palmitic are the most potent sorghum germination inhibitors and the inhibitory capacity is inversely proportional to the size of the carbonchain acids. Saturated and unsaturated fatty acids in vegetable substances are common and evolutionarily are important to ferns, as a barrier against water loss.

Conclusions

Based on the results obtained, it can be concluded that sample collection time (leaves) interfere with the production of essential oils, since the analysis of the extracts from leaf samples collected 7 h did not contain essential oil. The presence of linear saturated hydrocarbons, of long chain (18 to 40 carbon atoms) were the main components in all species studied according to the chromatograms and these components mostly have even number of atoms in the literature where it quantifies the odd hydrocarbons in plant species as major. Therefore, there is little literature about his, because essential oils are rare. Some work is needed so that one can understand in detail the behavior of essential oils studied. In this sense it becomes important to submit some suggestions that may contribute to increasing the utility of these oils.

The *Spondia smombin* L species (Cajá) and *Spondias purpurea* L (Ciriguela), because they have in their essential oils terpene β-caryophyllene, even in small proportions, deserves attention and can be done *in vitro* test to try to find some possible inhibitions with antibacterial action; antiphlogistic; inhibiting activity of the enzyme acetylcholinesterase (AChE) in combination with 1,8-cineole and anti-parasitic (schistosomiasis).

The *Spondias* sp species (Cajarana do sertão) due to its essential oil in the terpenePhytol, which is a component of chlorophyll and known to improve the toughness and balance to the natural flow of oil from the skin, which becomes acid phytanic in contact with skin enzymes, resulting in broad anti-aging benefits and defense against the ravages of time and the fatty acid Palmitic Acid, trials to confirm the use of this essential oil in rejuvenating cream formulations.

The extraction of oils from these species can bring to this northeastern region of Brazil ways to sustainable development, in addition to the sale of its fruits that have an exotic flavor. As a consequence, the study has a possible way to keep people in their place of origin, working in their natural habitat, thus preserving it and reforesting it.

Conflict of Interests

The authors have not declared any conflict of interests.

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