(DOI): 10.5777/PAeT.V4.N1.12
This article is presented in Portuguese and English with "resumen" in Spanish.
Brazilian Journal of Applied Technology for Agricultural Science, v. 4, n.1, p. 203-220, 2011.

Bibliographic Review

Lippia alba: Chemical, pharmacological and agronomical studies

Iane Brito Tavares [1]
Valéria Gomes Momenté [2]
Ildon Rodrigues do Nascimento [3]

Abstract

Lippia alba (Mill.) N. E. Brown is an aromatic subshrub belonging to the Verbenaceae family, which occurs in practically all regions of Brazil and has a large importance in Brazilian folk medicine. In the popular medicine it is used as analgesic, anti-inflammatory, sedative and antispasmodic. Aiming to contribute for a bigger knowledge of the species, it is presented a revision involving chemical, agronomical and pharmacological studies published. Pharmacological studies had proven sedative and anxiolytic activities. Real effects in other traditional uses can be explained mainly by anti-infectious and analgesic properties. *Lippia alba* also has anti-protozoan, antibacterial and antifungal activities, which can be exploited in organic agriculture.

Key words: Lemon balm; medicinal plants; essential oil.

Introduction

Lemon balm [*Lippia alba* (Mill.) N. E. Brown] is one the plants with real pharmacological importance, with use in the programs of phototherapy. The species is widely used in Brazil due to the properties as calming medicine, soft antispasmodic, analgesic, sedative, anxiolytic and lightly expectorant (MATTOS et al., 2007).

It is a subshrub of variable morphology, reaching measures of until two meters of height, with thin branches of white color, with leaves with variable width, with cut borders and acute apex (MATOS, 2000).

The popular name "cidreira", used in Brazil to designate aromatic species from various botanic families, is also used for *Lippia alba*. The aromas are related to the chemical constituents (terpene) that prevail in the essential oils (complex mixture of lipophilic volatile substances (CASTRO et al., 2004).

Besides the environmental factors which influenced in the production and composition of the essential oil, YAMAMOTO (2006) showed that in the species there is genetic variability in relation to the chemical composition of the essential oil. HENNEBELLE et al. (2008) verified the existence of seven chemical types (chemotypes) in the lemon balm species, whose variability was identified from the analysis of the major chemical constituents of the essential oil and metabolic roots.

The industrial potential of this species is associated to the great agronomical facilities that it presents as rusticity, rapidity of colonization through the vegetative propagation, vigor, allogamy (source of variability) and, also for vegetate and flower all year long, besides presenting high adaptation for several environments (phenotypic plasticity) (YAMAMOTO, 2006).

The correct use of plants for therapeutic aims by the public health serviced requires the use of medicinal plants selected by its efficacy and therapeutic safety (MATOS, 2000), since the quality of the phitotherapic substance is influenced by the quality of the vegetal material obtained (WORLD HEALTH ORGANIZATION, 2007). Several factors influence in the final quality of the product, as: genetic characteristics of the plant, climate variation, soil, sowing period, conditions of drying, storage time and others (KAMADA et al., 1999; CASTRO et al., 2004).

According to TAVARES (2009), if the different responses of the plant in relation to the factors which influence in the quality of the obtained material are known, it will be possible to recommend management techniques which will guarantee not

Recieved on: 16 /11/2010 Accepted for publication on: 26/02/2011

1 Environemntal Engineer, M. Sc., Professor of the Curse of Technology in Environmental Management, Instituto Federal de Educação, Ciência e Tecnologia do Pará, Conceição do Araguaia, Pará, Brasil.

2 Agronomic Engineer, D. Sc., Professor of the Course of Food Engineering, Fundação Universidade Federal do Tocantins, Palmas, Tocantins, Brasil.

3 Agronomic Engineer, Dr., Professor of the Course of Agronomy, Fundação Universidade Federal do Tocantins, Gurupi, Tocantins, Brasil.

only high production, but also the maintenance of the therapeutic value of the plant.

The present work has as objective to perform a bibliographic survey over the photochemical, ethnopharmacologic and agronomic aspects of the lemon balm, aiming to contribute to a higher knowledge of the species.

Characterization and discussions

Botanic descitption

Lemon balm [*Lippia alba* (Mill.) N.E. Brown] (Figure 1) belongs to the family Verbenaceae, which also includes other important medicinal plants as *Aloysia triphylla* (L'Hérit.) Britt, *Verbena officinalis* L. (HENNEBELLE et al., 2008) and *Lippia sidoides* Cham. (MATTOS et al., 2007). The species has wide distribution in the Center and South Americas and in the south of the United States (PASCUAL et al., 2001a; HENNEBELLE et al., 2008), and in Brazil it is found in practically all the regions (JANNUZZI et al., 2007).

According to HENNEBELLE et al. (2008), in Latin America, due to the wide traditional use, the popular names attributed to lemon balm are numerous and they are related to the aromatic odor or medicinal properties of the plants. In Brazil, the most common names are: erva-cidreira, falsa-melissa, chá-de-tabuleiro, erva cidreira-do-campo, salva-do-Brasil, salva-limão and erva-cidreira-brava (MATOS, 2000), chá-da-febre, erva-cidreira-brasileira, alecrim do campo (HOLETZ et al., 2002) and alvia sija (PASCUAL et al., 2001b).

Figure 1. Lippia alba (lemon balm).
(Image provided by the authors).

Lippia alba (Mill.) N. E. Brown has a high number of botanic synonyms: *L. alba* (Mill.) N.E. Brown ex Britton & Wilson; *L. asperifolia* A. Rich.; *L. crenata* Sesse´ & Moc.; *L. geminata microphylla* Griseb.; *L. germinata* H.B.K.; *L. glabriflora* Kuntze; *L. haanensis* Turcz; *L. lantanoides* Coult.; *L. trifolia* Sesse´ & Moc.; *Lantana alba* Mill.; *Lantana canescens* Hort.; *Lantana geminata* (H.B.K.) Spreng.; *Lantana geminata* Spreng.; *Lantana lippioides* Hook. & Arn.; *Phyla geminata* H.B.K.; *Verbena lantanoides* Willd (PASCUAL et al., 2001a).

This plant is a subshrub with variable morphology, it presents thin branches (figure 2), whitish, arched and brittle, with opposed leaves, elliptic with variable width, with cut borders and acute apex. The flowers are reunited in capituliform inflorescences of short axe which present two different sizes (MATOS, 2000).

Figure 2. Botanic aspect of Lippia alba.
(Image provided by the authors).

Lemon balm chemotype I (citral and mircen) have rough big leaves and inflorescence with until 8 external lingulate leaves around a wide set of flowers were still closed. In lemon balm chemotype II (citral and limonene) and III (carvone and limonene), leaves are smaller and soft, and the inflorescences are lower than type I, with a small central disk of flowers surrounded by only three to five lingulate flowers (MATOS, 1998).

The plant leaves of the chemotype III are characterized by a simple epidermis, coated with a cuticle relatively thick and stomata with wide under-stomata chamber, located in both faces, mesophile formed by uni or bistratified palisade parenchyma and three or four layers of spongy parenchyma. In leaves it can be seen also four types of trichomes, one tector (with acute apex and high base by epidermal cells) and three glandular. The sessile glandular trichomes are present in the abaxial face formed by basal, intermediate and bi-cellular capitated portion. The last two types are distributed in both leaf faces (SANTOS, 2003).

Apparently, there are no relevant anatomic differences between the chemotypes of this species (SANTOS, 2003), converse to its organoleptic and morphological characteristics, whose variations are very evident, according to what was described by MATOS (2000).

Biossynthesis

The essential oil is a complex mixture of lipofilic volatile substances (secondary methabolits), generally odoriferous and liquid. They may be called volatile oils, ethereal oils or essences due to some of its physic-chemical characteristics, as volatility, solubility in organic solvents (as ether) and intense aroma, many times pleasant (MATTOS et al., 2007). In lemon balm, the essential oil is stored in leaves, more precisely in secretor trichomes (present in the leaf epidermis) and in the palisade and spongy parenchyma (GOMES et al., 1993).

The biosynthesis of the secondary metabolits is performed by specific metabolic root of the organism, with a close relation of these roots and those responsible for the synthesis of primary metabolites. These metabolite roots are interconnected so that the roots which synthesize primary metabolites provide molecules which are used as precursors in the main roots of the synthesis for the secondary metabolites. The primary process is photosynthesis, though which plants use solar energy for the production of organic compounds. These compounds are precursors of secondary metabolites. (CASTRO et al., 2004).

The essential oils are produced in the three roots of the secondary metabolism: shikimate (aromatic compounds), mevalonate (derived from terpenoids) and malonate (saturated and insaturated grass acids, polyphenols and polyacetylenes), mainly in the two last ones (CORAZZA, 2002). These are constituted mainly by terpenes (monoterpenes and sesquiterpenes) (CRAVEIRO and QUEIROZ, 1993; CASTRO et al., 2004).

The terpenoids (isoprenoids) are formed by the condensation of units of isoprene, which is obtained from the pyrolisys of C_{10} compounds. This condensation is performed trough the reaction of the type head-tail (regular terpenes) or head-head (irregular terpenes) from isopentenypyrophosphate (IPP) and from dimethylallylpyrophosphate (DMAPP). IPP and DMAPP are C_5 units activated which are biologically equivalent to isoprene. The biosynthesis of IPP occurs from the root of the acetate trough a mevalonate intermediate (CASTRO et al., 2004). According to the same authors, isoprenes are classified according to the number of units of isoprene (u.i.), which makes them: monoprene (C_{10}, two u.i.), sesquiterpene (C_{15}, three u.i.), diterpenes (C_{20}, four u.i.), sesterpene (C_{25}, five u.i.), triterpenes (C_{30}, six u.i.) and tetraterpenes (C_{40}, seven u.i.).

The biosynthesis of the essential oil is affected by several factors as climate, soil, geographic regions, length of the day and night, plant age, organ in which it is located, stresses (MATTOS et al., 2007). The composition and concentration of the chemical compounds in the essential oil depend on the genetic control and on the stimuli as response to the factors of the environment, changing continuously with time and space (MATTOS, 2000; SANTOS, 2003; EHLERT, 2003). Besides that, there is the stability of these compounds after the extraction, considering that some of them are not used by industries due to their low stability (MATTOS et al., 2007).

Chemical composition

JULIÃO et al. (2003) reported that the composition of the essential oil of lemon balm ranges in a way that it was suggested the grouping of genotypes in chemotypes (chemical type), separated by their major elements. ZOGHBI et al. (1998), analyzed by CG-MS the essential oils of the aerial parts of the genotypes of lemon balm collected in three cities of the state of Pará, and suggested that the samples were divided in three groups, according to the chemical compounds which prevailed, as: the first one, type A (sampled in Santa Maria, was characterized by 1,8-cineole (34.9%), limonene (18.4%), carvone (8.6%) and sabinene (8.2%). In the second one, type B (collected in Belterra), it prevailed limonene (32.1%), carvone (31.8%) and mircene

(11.0%). The third one, type C (collected in Chaves) was represented by neral (13.7%), geranial (22.5%), germacrene-D (25.4%) and β-caryophillene (10.2%).

In the northeast of Brazil, it was also verified the occurrence of different chemical types (chemotyopes) of lemon balm, whose variability was identified from the analysis of chemical constituents of the essential oil. These chemotypes received the designations according to the major constituents found: citral (55.1 %), b-mircene (10.5 %), and limonene (1.5 %) in chemotype I; citral (63.0 %) and limonene (23.2 %) in chemotype II; carvone (54.7 %) and limonene (12.1 %) in chemotype III (MATOS et al., 1996; MATOS, 2000).

TAVARES et al. (2005) analyzed the essential oil of three lemon balm chemotypes (citral, carvone and linalol) cultivated in the same environmental conditions. For the chemotype citral, it was identified 29 compounds, which represented 92.2% of the essential oil. In the chemotype carvone, the 26 compounds indentified total 89.1% of the essential oil. And in the chemotype linalool it was identified 42 constituents, representing 93.5% of the essential oil. The authors observe that the diversity in the composition of essential oil of these chemotypes is not due to environmental factors, but to genetic issues.

SILVA et al. (2006) identified twenty four compounds in the essential oil of lemon balm plants, and the major component was citral (mixture of neral and geranial) which ranges from 70.6 to 79.0%. The oxygenated monoterpenes found were: linalool (1.7-2.2%), nerol (0.5-2.5%), geraniol (0.802.0%) and acetate of geranila acetate (0.8-1.4%). In smaller amount, the sesquiterpenes, germacrene B (0.3-1.5%) and β-caryophyllene (0.4-0.7%) were also identified, and the higher occurrence was verified in the summer.

HENNEBELLE et al. (2008), reported the occurrence of seven chemotypes of lemon balm, based on the major chemical compounds of the essential oil: chemotype 1 – citral, linalool, β-caryophyllene; chemotype 2 – tagetenone; chemotype 3 – limonene with variable rates of carvone; chemotype 4 – mircene; chemotype 5 - γ-terpinene; chemotype 6 - camphor-1,8-cineole; chemotype 7 – *estragole*. After this classification, it was identified a chemotype in which citral was the major compound, with low concentration of linalool (<5%), corresponding to a subtype of the chemotype 1 (BARBOSA et al., 2006).

The essential oil of lemon balm maintains qualitatively the chemical profile, even with variations in the cultivation environments. In six experiments performed by YAMAMOTO (2006), four of them performed in Campinas-SP, and the other two in Monte Alegre do Sul and Pindorama-SP, it was observed only quantitative variations in the chemical composition of the essential oil of 20 genotypes of this species. According to the researcher, it was not detected any qualitative variation, as the appearance of a new substance of the disappearance of another one, according to the different studies environments and, in relation to this oil yield, the magnitude of the interaction genotypes x environments was a little ample, indication high genotype determination for this characteristic.

Etnopharmacological aspects and biological activities

Etnopharmacological researches of lemon balm evidenced that there are several traditional uses (PASCUAL et al., 2001b; PINTO et al., 2006; MATTOS et al., 2007). The most frequent are: analgesic/anti-inflammatory/antipyretic; sedative; culinary spice; diarrhea and dysentery treatment; skin disease treatment; gastrointestinal disorders; hepatic disease treatment; menstrual disorders, antispasmodic; respiratory disease treatment, syphilis and gonorrhea treatment. HENNEBELLE et al. (2008), reported that the species is mainly used against: digestive, respiratory, cardiovascular diseases; as sedative and antihypertensive. According to the same authors, relating the biological and ethnopharmacological activities, some results were positive, even though they were partial, confirming the sedative and anxiolytic activities. Besides that, other medicinal effects may be explained by the anti-infectious and analgesic properties of the plant.

MATOS (1996), studying the production of lemon balm in the state of Ceará observed that plants with high concentration of limonene-carvone (chemotype III), presented mucolytic action (MATTOS et al., 2007), whereas plants with high concentration of limonene-citral (chemotype II) have sedative, antispasmodic and anxiolytic action. Lemon balm leaves of the chemotype mircene-citral (chemotype I) are used as teas, presenting calming and soft antispasmodic properties, in function of citral and analgesic due to the action of mircene (VALE et al., 2002).

The pharmcacological indications are: analgesic/anti-inflammatory/antipyretic, sedative, treatment of diarrhea and dysentery, anti-microbial, anti-viral, cytostatic, anticonvulsants (PASCUAL et al., 2001a). PASCUAL et al. (2001b) identified a powerful antiulcerogenic activity in the infusion of lemon balm leaves in the gastric ulcer of Wistar mice induced by indomethacin.

MATTOS (1998) affirmed that the infuse prepared with the fresh plant may be ingested freely since it does not have toxic action. However, ALMEIDA et al. (2002), reported that lemon balm, even presenting very high contents of calcium in leaves (1388 mg/100g), macronutrient of great nutritional importance, the consumption of this vegetable should be restricted, due to the high content of aluminum in leaves (47,9 mg/100g).

Calcium is one of the nutritional compounds of great importance in the human health. Around 99% of the body content of calcium is found in the skull, making it rigid, and representing a readily available source for the maintenance of the normal levels of its plasma concentration (BEDANI and ROSSI, 2005). Aluminum is a neurotoxic compound which, in a long time, may cause serious encephalopathy in patients which suffer renal dialysis, and it may lead to neurological disturbs (FREITAS et al., 2001).

Lemon balm also has some compounds responsible for the anti-protozoan, bactericide and fungicide activities. The microorganisms susceptible to some of the compounds present in the plant are (HOLETZ et al., 2002; SENA FILHO et al., 2006; HENNEBELLE et al., 2008):

- Bacterias: *Bacillus subtilis, Lactobacillus casei, Enterococcus faecalis, Micrococcus luteus, Staphylococcus aureus, Staphylococcus aureus* MRSA (BMB9393), *Staphylococcus epidermidis, Streptococcus mutans, Enterobacter aerogenes, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Salmonella* sp., *Serratia marcescens, Shigella flexneri, Shigella sonnei, Mycobacterium smegmatis, Mycobacterium tuberculosis;*

- Fungi: *Candida albicans, Candida albicans sorotipo* B., *Candida guilliermondii, Candida krusei, Candida parapsilosis, Candida tropicalis, Chrysonilia sitophila, Cryptococcus neoformans* T1-444 Sorotipo A, *Fonsecaea pedrosoi 5VPL, Trichophyton rubrum T544;*

- Protozoan: *Entamoeba histolytica, Giardia lamblia, Trichomonas vaginalis, Plasmodium falciparum.*

Lemon balm has also antiviral activity. Extracts of dichloromethane and ethyl acetate from lemon balm leaves inhibited the growth of poliovirus type 2 (strain present in the vaccine SABIN II) and n-butanol extract of virus of simple herpes (cepa 29-R) (ANDRIGHETTI-FRÖHNER et al., 2005).

Agronomic use

DUBEY et al. (1983) observed fungitoxic effect of lemon balm over the soil fungus *Rhizoctonia solani*, which reaches several crops, as beans and soybean. SCHWAN-ESTRADA et al. (2000) reported the potential of different medicinal plants, as lemon balm, in the control of phytopathogenic fungi. RAO et al. (2000) related the superiority of its effect in relation to commercial fungicides in sugarcane and suggested the possibility of application of this species as agricultural defensive.

IBRAHIM et al. (2001) reported several insecticide actions, repellents and phytotoxic activities for some oils which are rich in limonene.

BRAND et al. (2006) observed that crude extracts of lemon balm inhibited the mycelia growth of *Sclerotinia sclerotiorum* in 43.89% and ROZWALKA et al. (2008) observed reduction of the fungitoxic effect of the essential oil of lemon balm over the mycelia growth of *Glomerella cingulata* and *Colletotrichum gloeosporioides*, which cause anthracnose in fruits of guava, from the third day of inoculation. The authors considered two hypotheses to justify the reduction of the inhibition: the volatility of the inhibitr compounds or instability in the presence of light, heat, humidity.

Conclusions

The ethnopharmacology presents several traditional uses of lemon balm, but the pharmacological indications are restricted. Some medicinal effects may be related to the anti-infective and analgesic properties of the plant.

Lemon balm has chemical compounds responsible for the anti-protozoan, bactericide and antifungal activities, and may be exploited in the agriculture for the control of phytopathogenic diseases.

References

ALMEIDA, M.M.B.; LOPES, M. de F.G.; NOGUEIRA, C.M.D.; MAGALHÃES, C.E. de C.; MORAIS, N.M.T. de. Determinação de nutrientes minerais em plantas medicinais. **Ciência e Tecnologia de Alimentos**, v.22, n.1, p.94-97, 2002.

ANDRIGHETTI-FRÖHNER, C.R.; SINCERO, T.C.M.; da SILVA, A.C.; et al. Antiviral evaluation of plants from Brazilian Atlantic Tropical Forest. **Fitoterapia**, v.76, p.374–378, 2005. BARBOSA, F. da F.; BARBOSA, L.C.A.; MELO, E.C.; BOTELHO, F.M.; SANTOS, R.H.S. Influência da temperatura do ar de secagem sobre o teor e a composição química do óleo essencial de *Lippia alba* (Mill) N. E. Brown. **Química Nova**, v.29, n.6, p.1221-1225, 2006.

BEDANI, R.; ROSSI, E.A. O consumo de cálcio e a osteoporose. **Semina: Ciências Biológicas e da Saúde**, v.26, n.1, p.3-14, 2005.

BRAND, S.C.; JUNGES, E.; MILANESI, P.; BLUME, E.; MUNIZ, M.F.B. Extratos vegetais aquosos no crescimento micelial de *Sclerotinia sclerotiorum*. In: **Anais do XV Congresso de Iniciação Científica**. Pelotas: UFPel, 2006. Disponível em: <http://www.ufpel.edu.br/cic/2006/arquivos/conteudo_CA.html#00 546>. Acesso em: 02 nov. 2009.

CASTRO, H.G. de; FERREIRA, F.A.; SILVA, D.J.H. da; MOSQUIM, P.R. **Contribuição ao estudo das plantas medicinais: metabólitos secundários. 2.ed.** Visconde do Rio Branco: UFV, 2004. 113 p.

CORAZZA, S. **Aromacologia**. São Paulo: SENAC, 2002. 414 p.

CRAVEIRO, A.A.; QUEIROZ, D.C. Óleos essenciais e química fina. **Química nova**, v.16, n.3, p.224-228, 1993.

DUBEY, N.K.; KISHORE, N; SRIVASTAVA, O.P.; DIKSHIT, A.; SINGH, S.K. Fungitoxicity of some higher plants against *Rhizoctonia solani*. **Plant and Soil**, v.72, p.91-94, 1983.

EHLERT, P.A.D. Épocas de plantio, idades e horários de colheita na produção e qualidade do óleo essencial de *Lippia alba* (Mill.) N. E. Br**., quimiotipo limoneno-carvona**. Tese (Doutorado em Agronomia) - Faculdade de Ciências Agronômicas - UNESP, Botucatu, 2003. 106f.

FREITAS, M.B.; BRILHANTE, O.M.; ALMEIDA, L.M. Importância da análise de água para a saúde pública em duas regiões do Estado do Rio de Janeiro: enfoque para coliformes fecais, nitrato e alumínio. **Caderno de Saúde Pública**, v.3, n.17, p.651-660, 2001.

GOMES, E.C.; MING, L.C.; MOREIRA, E.A.; MIGUEL, O.G. Constituintes de óleo essencial de *Lippia alba* (Mill) N. E. Br. (Verbenácea). **Revista Brasileira de Farmácia**, v.74, n.2, p.29-32, 1993.

HENNEBELLE, T.; SAHPAZ, S.; JOSEPH, H.; BAILLEUL, F. Ethnopharmacology of *Lippia alba*. **Journal of Ethnopharmacology**, v.116, p.211-222, 2008.

HOLETZ, F.B.; PESSINI, G.L.; SANCHES, N.R.; CORTEZ, D.A.G.; NAKAMURA, C.V.; DIAS FILHO, B.P. Screening of Some Plants Used in the Brazilian Folk Medicine for the Treatment of Infectious Diseases. **Memórias do Instituto Oswaldo Cruz**, v.97, n.7, p.1027-1031, 2002.

IBRAHIM, M.A.; KAINULAINEN, P.; AFLATUNI, A.; TIILIKKALA, K.; HOLOPAINEN, J.K. Insecticidal, repellent, antimicrobial activity and fitotoxicity of essential oils: with special reference to limonene and its suitability for control of insect pests: review. **Agricultural and Food Science in Finland**, v.10, p.243-259, 2001.

JANNUZZI, H.; MATTOS, J. K.A.; SILVA, D. B.; GRACINDO, L.A.M.; VIEIRA, R.F. Avaliação agronômica e química de dezessete acessos de erva-cidreira [*Lippia alba* (Mill.) N.E.Brown] - quimiotipo citral, cultivados no Distrito Federal. **Revista Brasileira de Plantas Medicinais**, v.13, n.3, 2011.

JULIÃO, L.S.; TAVARES, E.S.; LAGE, C.L.S.; LEITÃO, S.G. Cromatografia em camada fina de extratos de três quimiotipos de *Lippia alba* (Mill) N. E. Br. (erva-cidreira). **Revista Brasileira de Farmacognosia**, v.13, p.36-38, 2003. *(suplemento)*

KAMADA, T.; CASALI, V. W.D.; BARBOSA, L.C.A.; FONTES, I.C.P.; FINGER, F.L. Plasticidade fenotípica do óleo essencial em acessos de manjericão (*Ocimum basilicum* L.). **Revista Brasileira de Plantas Medicinais**, v.1, n.2, p.13-22, 1999.

MATOS, F.J.A. **Plantas Medicinais**: guia de seleção e emprego de plantas usadas em fitoterapia no Nordeste do Brasil. 2. ed. Fortaleza: Imprensa Universitária, 2000. 346 p.

MATOS, F.J.A. **Farmácias vivas**: sistema de utilização de plantas medicinais projetado para pequenas comunidades. 3. ed. Fortaleza: EUFC, 1998. 220 p.

MATOS, F.J.A.; MACHADO, M.I.L.; CRAVEIRO, A.A.; ALENCAR, J.W. The essential oil composition of two chemotypes of *Lippia alba* grown in Northeast Brazil. **Journal of Essential Oil Research**, v.8, p.695–698, 1996.

MATTOS, S.H.; INNECCO, R.; MARCO, C.A.; ARAÚJO, A.V. **Plantas medicinais e aromáticas cultivadas no Ceará**: tecnologia de produção e óleos essenciais. Fortaleza: Banco do Nordeste do Brasil, 2007. p. 61-63. *(série BNB - ciência e tecnologia 2)*

MATTOS, S.H. **Estudos fitotécnicos da *Mentha arvensis L. var. piperacens* Holmes como produtora de mentol no Ceará**. Tese (Doutorado em Fitotecnia) – Departamento de Fitotecnia, Universidade Federal do Ceará, Fortaleza, 2000. 111f.

PASCUAL, M.E.; SLOWING, K.; CARRETERO, E.; VILLAR, A. Antiulcerogenic activity of *Lippia alba* (Mill.) N.E. Brown (Verbenaceae). **Il Fármaco**, v.56, p. 501-504, 2001a.

PASCUAL, M.E.; SLOWING, K.; CARRETERO, E.; SANCHEZ-MATA, D.; VILLAR, A. Lippia: traditional uses, chemistry and pharmacology: a review. **Journal of Ethnopharmacology**, v.76, p.201-214, 2001b.

PINTO, E. de P.P.; AMOROZO, M.C. de M.; FURLAN, A. Conhecimento popular sobre plantas medicinais em comunidades rurais de Mata Atlântica – Itacaré, BA, Brasil. **Acta Botanica Brasilica,** v.20, n.4, p.751-762, 2006.

RAO, G.P.; SINGH, M.; SINGH, P.; SINGH, S.P.; CATALAN, C.; KAPOOR, I.P.S.; SINGH, O.P.; SINGH, G. Studies on chemical constituents and antifungal activity of leaf essential oil of *Lippia alba* (Mill.). **Indian Journal of Chemical Technology**, v.7, p.332-335, 2000.

ROZWALKA, L.C.; LIMA, M.L.R.Z.C.; MIO, L.L.M.; NAKASHIMA, T. Extratos, decoctos e óleos essenciais de plantas medicinais e aromáticas na inibição de *Glomerella cingulata* e *Colletotrichum gloeosporioides* de frutos de goiaba. **Ciência Rural**, v.38, n.2, p.301-307, 2008.

SANTOS, M.R.A. **Estudos agronômicos e botânicos de erva cidreira (quimiotipo limoneno-carvona)**. Dissertação (Mestrado em Fitotecnia) – Departamento de Fitotecnia - UFC, Fortaleza. 89f.

SCHWAN-ESTRADA, K.R.F.; STANGARLIN, J.R.; CRUZ, M.E.R. Uso de extratos vegetais no controle de fungos fitopatogênicos. **Floresta**, v.30, p.129-137, 2000.

SENA FILHO, J.G.; MELO, J.G.S.; SARAIVA, A.M.; GONÇALVES, A.M.; PSIOTTANO, M.N.C.; XAVIER, H.S. Antimicrobial activity and phytochemical profile from the roots of *Lippia alba* (Mill.) N.E. Brown. **Brazilian Journal of Pharmacognosy**, v.16, n.4, p.506-509, 2006.

SILVA, N.A.; OLIVEIRA, F.F.; COSTA, L.C.B.; BIZZO, H.R.; OLIVEIRA, R.A. Caracterização química do óleo essencial da erva cidreira (*Lippia alba* (Mill.) N. E. Br.) cultivada em Ilhéus na Bahia. **Revista Brasileira de Plantas Medicinais**, v.8, n.3, p.52-55, 2006.

TAVARES, E.S.; JULIÃO, L.S.; LOPES, D.; BIZZO, H.R.; LAGE, C.L.S.; LEITÃO, S.G. Análise do óleo essencial de folhas de três quimiotipos de *Lippia alba* (Mill.) N. E. Br (Verbenaceae) cultivados em condições semelhantes. **Revista Brasileira de Farmacognosia**, v.1, n.15, 2005.

TAVARES, I.B. **Propagação vegetativa, adubação orgânica e idades de colheita de quimiotipos de erva-cidreira** [*Lippia alba* (Mill.) N. E. Brown]. Dissertação (Mestrado em Produção Vegetal) – Universidade Federal do Tocantins, Gurupi. 2009. 84 f.

VALE, T.G.; FURTADO, E.C.; SANTOS JUNIOR, J.G.; VIANA, G.S.B. Central effects of citral, myrcene and limonene, constituents of essential oil chemotypes from *Lippia alba* (Mill.) N.E. Brown. **Phytomedicine**, v.9, p.709-714, 2002.

WORLD HEALTH ORGANIZATION. **WHO guidelines on good manufacturing practices (GMP) for herbal medicines**. France: WHO Press, 2007. 92 p.

YAMAMOTO, P.Y. **Interação genótipo x ambiente na produção e composição de óleos essenciais de *Lippia alba*** (Mill.) N. E. Br. Dissertação (Agricultura Tropical e Subtropical) - Instituto Agronômico - USP, Campinas, 2006. 90f.

ZOGHBI, M.G.B.; ANDRADE, E.H.A.; SANTOS, A.S.; SILVA, M.H.L.; MAIA, J.G.S. Essential oils of *Lippia alba* (Mill.) N. E. Br. growing wild in the Brazilian Amazon. **Flavour and Fragrance Journal**, n.1, v.13, p.47-48, 1998.