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DATABASE OF THE AMAZON AROMATIC PLANTS AND THEIR ESSENTIAL OILS

José Guilherme S. Maia* e Eloísa Helena A. Andrade
Faculdade de Engenharia Química, Universidade Federal do Pará, 66075-900 Belém - PA, Brasil

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The aromatic flora of the Amazon has been inventoried for 30 years. In this sense, were made over 500 field trips to collect over 2500 plants and to obtain more than 2000 essential oils and aroma concentrates, all of them submitted to GC and GC-MS. This work led to the creation of a database for the aromatic plants of the Amazon, which catalogs general information about 1250 specimens. The database has allowed the publication of the chemical composition of the oils and aromas of more than 350 species, associated with a larger number of chemical types. The essential oils of many species offer optimum conditions for economic exploitation and use in national and international market of fragrances, cosmetics, agricultural and household pesticides.

Keywords: database of the aromatic plants from the Amazon; essential oils and aromas.

INTRODUCTION

The aromatic natural resources of the Amazon are considered an appropriate renewable source for the production of essential oils and flavors, as well as it is a clear economic alternative to sustainable development, with real prospect of generating wealth for the region. For the production of new materials, based on the odoriferous flora, it is necessary to extend the scientific knowledge of species with economic potential, aiming to subsidize the public and private sector in the implementation of projects with technological impact, with views to the regional growth of agribusiness. The essential oils and aromas produced in the region can be used as raw materials in the fine chemical industry, for direct application in products such as perfumes, fragrances and cosmetics, or by processing into structural derivative products with use in the industries of medicines (phytopharmaceuticals) or veterinary and horticulture (insecticides, fungicides, bactericides, larvicides).

Aromatic species with occurrence in ecosystems as diverse as the Amazon are under permanent pressure environment, given the action of man in the exploitation of forest resources which is still very predatory, in addition to deforestation and burning required by the development of the region. The rate of extinction of aromatic species that occurs in areas under environmental pressure appears to be very high, considering the difficulty for the recollection of a plant from the same place, which means that it is imperative and urgent to establish inventories of the Amazon aromatic flora in the order to increase the source of new raw materials. In addition, government measures must be taken to protect areas under environmental pressure, particularly from the highland forest and savannas, which are most affected, and the creation of genetic banks of species with high economic potential. The economic use of indigenous aromatic flora is done systematically by the producers of essences, due to lower demand for primary agriculture. However, few countries have many different specimens in ecosystems as diverse as the Brazilian Amazon. Thereby, we will only repeat what is traditionally done in the first world countries, promoting a positive effect on the region's economy.

Previous to the inventory of aromatic flora of the Amazon, that we are promoting for 30 years, the scientific and technical knowledge of the aromatic plants was recorded in a few scientific articles, in books of regional circulation and in the Office of Foreign Trade of the Bank of Brazil, the portfolio responsible for the export of related products. If we look at the extrativism matter, in the past eight decades only the essential oil of rosewood (*Aniba rosaeodora* Ducke and *Aniba duckei* Kosterm.), The oil-resin of Copaiba (*Copaifera* spp) and the seed of Cumaru (*Dipteryx odorata* Willd.) has been commercially exploited in the Amazon region.

In recent years, there has been the existence of a small trade of sachets for flavor and closets of clothes, prepared with imported essences and enriched by roots, powders and scrapings of native plants, as well as alcoholic extracts obtained from some species with occurrence in the region. Among the plants used in the enrichment of the sachets are arataciú (*Sagotia racemosa* Baill., Euphorbiaceae), macacaporanga (*Aniba fragrans* Ducke, Lauraceae) and vetiver [*Vetiveria zizanioides* (L.) Nash, Poaceae]. The plants used for the production of alcoholic extracts, or oil in small volumes, are catinga-de-mulata (*Aeollanthus suaveolens* Mart. ex Spreng., Lamiaceae), casca-preciosa [*Aniba canelilla* (Nees) Mez, Lauraceae], priprioca (*Cyperus articulatus* L., Cyperaceae) and estoraque (*Ocimum micranthum* Will., Lamiaceae).

Among the regional companies that produce or use extracts, perfumes and regional colonies, the main ones are: Chamma da Amazônia (Belém), Ervativa (Belém) and Mysteres d `Amazonie (Manaus). At the national level, some products are marketed by Natura based on commercial exploitation of priprioca, cumaru and breu-branco (*Protium pallidum* Cuatrec., Burseraceae), in association with communities of small producers of Pará and Amapá. At international level, there was the participation of Takasago who tried to cultivate near Belém (PA) the patchouli (*Pogostemon heyneanus* Benth., Lamiaceae) and canforeiro [*Cinnamomum camphora* (L.) J. Presl, Lauraceae], some 20 years ago. The cultivation of such plants has not been successful, probably by high rainfall in the region. The company L´Atellier Parfums, from São Paulo, maintain a close business relationship with the regional companies, on development of colonies and perfums formulations using imported essences and extracts and essential oils produced in the Amazon region. Major international companies in the areas of perfumes and cosmetics, as Firmenich, Givaudan, IFF and Dragoco, have shown great interest in the purchase of new essential oils produced locally, but without the intention to invest in the production of these oils.

From our knowledge, no other aromatic plant besides those mentioned, is part of the trade and exportation of the Amazon region.

In fact, there are no experiments in the Amazon region for cultivation and commercial exploitation of aromatic plants producing essential oils and flavors, based on agronomic work well addressed.

*e-mail: gmaia@ufpa.br

The process is still of extrativism for most listed species or, at most, follows the work of small producers in household gardens, so small scale. For a region with rich flora and with so many economic opportunities is important that the systematic cultivation of the aromatic plants can be done steadily.

It was in this sense that we decided for the establishment of a technology of cultivation and processing in the field for commercial exploitation of the pimenta-longa (*Piper hispidinervum* C. DC., Piperaceae), a shrub endemic in the state of Acre, Brazil, with high yield in essential oil rich in safrole.[1-3] The pimenta-longa was discovered near the old airport in Rio Branco (AC), in July 1972, while expecting a delayed flight to Manaus. Then, we found that this species occurs in a large area with a radius of 100 km around Rio Branco. The world demand for oil rich in safrole is very significant, considering that this phenyl ether is the precursor molecule for obtaining the piperonal and piperonyl butoxide. The first is used in industry for fine fragrances and perfumes. The second is a synergistic agent of pyrethrum [*Chrysanthemum cinerariifolium* (Trevis.) Vis., Asteraceae], a natural insecticide widely used in industrialized countries. The piperonyl butoxide is used to stabilize and strengthen the action of the active pyrethroids in the pyrethrum, resulting in a product with certified "green and biodegradable," without the risk of contamination to the environment, commonly offered by the synthetic insecticides.

Lately, we conclude the work of domestication and management of pimenta-de-macaco (*Piper aduncum* L., Piperaceae), whose essential oil is rich in dilapiol, another phenyl ether with higher pattern of oxygenation than the safrole, which showed fungicide, bactericide, insecticide, larvicide and molluscicide activities.[4-7]

As mentioned above, we are conducting the inventory of the aromatic flora of the Amazon about 30 years. The extensive area of the Amazon region and the absence of scientific and technological knowledge for plants with economic potential motivated this survey, which started in 1980 at the Instituto Nacional de Pesquisas da Amazônia (INPA) in Manaus (AM). The work with the inventory continued at Museu Emílio Goeldi (MPEG) and Universidade Federal do Pará (UFPA) since 1985, with the collaboration of the Comissão Executiva do Plano da Lavoura Cacaueira (CEPLAC), Universidade Federal Rural da Amazônia (UFRA) and Instituto de Estudos e Pesquisas do Amapá (IEPA).

We have strongly contributed to increasing knowledge of the aromatic flora of the Amazon with the publication of books, chapters of books, scientific papers and abstracts of papers in national and international journals. Currently, more than 350 publications on the relevant aspects of botanical and ethnobotanical, the chemical composition of essential oils and flavors, the biological activity and the technology of cultivation and processing of economically viable species were published. These publications derive from the Database of Aromatic Plants of the Amazon, which was established by us.[8-14] Today, the database has a record of more than 1,200 specimens, providing important and valuable information on the economic potential of these plants. The following information can be found in the database: botanical family, identification of botanical species and their synonyms, common names of plants, uses popular, parts of plants that provide essential oil or aroma, oil yields, local collection of the plant, types of habitat, geographical distribution, botanical characteristics, ecological and agronomic aspects, biological activities of the plants and their oils and extracts, chemical composition of essential oils and flavors, chromatograms and massa spectra, references and photographs of plants.

This work presents information on the database of the Amazon aromatic plants and their essential oils to dissemination of knowledge for the Brazilian Society of Chemistry.

MATERIAL AND METHODS

The plants were collected following the traditional method used by botanists in field expedition. The collections were made mainly with fertile material to ensure unequivocal taxonomic identification and the insertion of individual exsiccates in the herbarium**.** The botanical material was pressed and the local of collections and the ethnobotanical data were recorded in the book of field annotation. The plant material for distillation of essential oil was transferred to the laboratory in plastic bags with permanent aeration, for up to five days, weighing an average of 2 kg, enough time for the occurrence of a prior drying. The plant samples were deposited in herbaria of INPA and MPEG. The botanical material was recorded in the books of the laboratory receiving an identification number. It was then dried at room temperature for another 48 h, with natural ventilation, weighed and subjected to hydrodistillation using a Clevenger-type apparatus, or submitted to simultaneous distillation-extraction on Lickens-Nickerson apparatus, using *n*-pentane as organic solvent. The oil was centrifuged, dried in the presence of anhydrous sodium sulfate and calculated your yield based on the moisture content of the plant. The oil was stored in glass vials or ampoules of amber, using flow of nitrogen to remove oxygen from the air and avoid the risk of self-oxidation. The oil was kept in a refrigerated environment at temperature of 5 °C. The yield data were registered in the book of the laboratory.

Two gas chromatographs coupled to quadrupole mass spectrometers (GC-MS, Finnigan Mat model Incos-XL and Thermo model DSQ II) were used in the analysis of essential oils, equipped with silica capillary columns (DB-5 and DB-5 ms , 30 m x 0.25 mm i.d., film thickness of 0.25); carrier gas helium, adjusted to provide a linear velocity of 32 cm/s (measured at 100 °C); the injector temperature to 220 °C; type of injection, splitless, 1 µL of a solution of *n*-hexane 2:1000; temperature programmed for 60-240 °C, with gradient of 3 °C/min; split flow was adjusted to give a 20:1 ratio; septum sweep was a constant 10 mL/min; EIMS: electron energy, 70 eV; ion source temperature and connection parts: 200 ^{o}C. The filter quadrupole swept the range of 40 to 450 daltons every second and the resulting spectra were stored on disks for later analysis. The quantitative data of the volatile constituents were obtained by peak area normalization using two gas chromatographs (HP model 5890-II and Thermo Focus) operated with flame ionization detectors, under the same GC-MS conditions, except for the carrier gas that were hydrogen and nitrogen, respectively.

Individual components were identified by comparison of both mass spectrum and GC retention data with authentic compounds previously analyzed and stored in the data system.[15,16] Other identifications were made by comparison of mass spectra with those existing in the data system libraries and cited in the literature.[17-19] The retention index was calculated for all volatiles constituents using an *n*-alkanes homologous series.

RESULTS AND DISCUSSION

The inventory of the aromatic flora

With respect to the inventory of aromatic flora were more than 500 field trips, which resulted in the collection of some 3,000 specimens of plants in different localities and ecosystems in the Amazon region. More than 95% of the specimens are collected with their full botanical determination, properly recorded and deposited in herbaria of INPA and MPEG. To date, 1,453 specimens were collected in Pará, including 212 fruit and 251 flowers, 224 in the island of Marajo, 370 in Amazonas, 195 in Acre, 185 in Maranhão, 135 in Tocantins, 128 in Roraima, 142 in Mato Grosso and 126 in Amapá, totalizing 2958. Figure 1 shows the distribution by state of these collections. The 12 main families of aromatic plants that predominate in the region are (in descending order): Piperaceae, Asteraceae, Myrtaceae, Lamiaceae, Annonaceae, Lauraceae, Euphorbiaceae, Verbenaceae, Scrophulariaceae, Anacardiaceae, Burseraceae and Rutaceae.

Figure 1. *Map of the collection sites of aromatic plants*

The material was collected from various parts of the plant (leaves, wood, bark, fruit, flower), providing essential oils with very different characteristics. In this sense, more than 2,000 essential oils were obtained in different periods and with the support of various national and international agencies, as shown in Table 1. Lately, it was closed the 5th stage of the inventory, with the support of Biodiversity Program (PPBio) of MCT / CNPq.

Below are some results from the analysis of the essential oils which are part of the information in the database.

The volatile components identified in the cipó-de-alho (*Adenocalymma aliaceum* Miers, Bignoniaceae) are structurally similar to those found in garlic and onions, with predominance of compounds with atoms of sulfur as allyl disulfide and allyl trifulfide, among those with the highest percentage.[20,21] O cipó-de-alho is used as a substitute for garlic and in the alternative medicine of the Amazon population.[22] Another species of the region that has an essential oil with the same characteristics is the mucura-caá (*Petiveria alliacea* L., Phytolaccaceae).[21,22]

The species known as vindicar [*Alpinia speciosa* (Wendl) Schum., Zingiberaceae] is used as spasmolitic and hypotensive, having also the reputation as cardiovascular and central nervous system depressant.[22] The monoterpenes limonene, terpinen-4-ol, α-terpinene and *p*-cymene were the major components found in its volatile oil.[23,24]

The species *Ambrosia artemisiafolia* L. *A. microcephala* DC., *Ichthyothere terminalis* (Spreng.) Malme and *I. cunabi* Mart. (Asteraceae) are used as insect repellent by Amazonian fishermen in lakes infested with mosquitoes.[22] This action is attributed to the monoterpenes and sesquiterpenes hydrocarbons that were identified in their essential oils.[25-27]

The main compounds identified in the essential oil of casca-preciosa (*Aniba canellila* (HBK) Mez, Lauraceae), were 1-nitro-2-phenylethane and methyleugenol.[28,29] The popular name of the plant is due to the smell of its bark which is similar to cinnamon (*Cinnamomum zeylanicum* Blume, Lauraceae) and its use in regional perfumes. The bark and trunckwood are used to relieve stomach pain, flatulence and have antispasmodic action.[30] Nitro derivatives in nature are rare and few have been identified in plants.[31] The essential oil showed cardiovascular activity in rats.[32] The methanol extract of trunkwood presented high antioxidant activity.[33]

The species of rosewood (*Aniba rosaeodora* Ducke and *A. duckei* Kosterm., Lauraceae), already mentioned, provide oil rich in linalool (85-90%), the monoterpene alcohol precursor of linalyl acetate, used in industry for perfumes.[22,34-36] The oil of macacaporanga (*Aniba fragrans* Ducke, Lauraceae) contains linalool at lesser percentage (30-50%)[22,37] and the wood of the plant is used for the manufacture of sachets, sold in craft shops in the town of Belém (PA). The oil from leaves and barkwood of sacaca (*Croton cajucara* Benth. Euphorbiaceae) and from catinga-de-mulata (*Aeollanthus suaveolens* Mart. Ex Spreng, Asteraceae) have also linalool (30-50%).[22,34,38-40] The barkwood of sacaca are used to reduce the cholesterol and to loss weight.[22] The entire plant of catinga-de-mulata is used as anticonvulsant and in the control of epilepsia.[41]

The main constituents found in the oil of puchuri-pequeno [*Aniba puchury-minor* (Mart.) Mez] were elemicin, miristicin, methyleugenol, (*E*)-asarone and (*Z*)-asarone.[22,42,43] The essential oil has a moss-woody fragrance.

The species known as laranjinha (*Calyptranthes spruceana* Berg., Myrtaceae) presents two chemical types evidenced by their essential oils. One of them rich in limonene, perilalldehyde, geranial and neral, and the other dominated by α- and β-pinene, geranial and neral.[44,45] The optical rotation of the two oils has showed opposite signals, indicating its enantiomeric forms. The leaf tea of this species is used by riparian populations against the stomach ailments.[22]

The species known as hortelã-da-folha-graúda (*Coleus amboinicus* Lour., Asteraceae) is used as condiment in local cuisine, to relieve headache and other pains in the body, and possess analgesic property.[22] Its oil is rich in carvacrol (45-60%), an aromatic compound renowned for its antimicrobial activity.[46,47]

The herbaceous known as pataqueira (*Conobea scoparioides* Benth., Scrophulariaceae) has aquatic habit and is used in the preparation of aromatic baths in the Saint John festival. The main components of oil are thymol and its methyl ether, known for its antimicrobial action.[22,48,146] The oil and methanol extract of pataqueira showed sig-

Table 1. Essential oils produced and agencies that furnished the financial support

Phase / Period / Support	Essential oils	Concentrate from		Total
		Fruits	Flowers	
1ª / 1980-1989 / BID, Banco da Amazônia	519	-	-	519
2ª / 1990-1995 / GTZ-Alemanha, DFID-UK	633	65		698
3ª / 1996-1999 / MCT-PPG7, BIRD	450	95	199	744
4ª / 2000-2004 / MCT-PPG7, European Community	439	52	52	543
5ª / 2005-2008 / MCT-PPBio	454	-	-	454
Totais	2495	212	251	2958

nificant antioxidant activity, indicating its future use as a food supplement.[49] An international company has shown great interest in the oil of this plant to make new fragrance, in this sense we are studying the possibility of it being exploited by hydroponic cultivation.

The oil of the species known as erva-de-são-joão (*Eupatorium maximilianii* Schrader, Asteraceae) was identified by a perfumer as having an excellent bouquet, appropriate for the composition of new fragrances.[25] The species known as Japana-branca e japana-roxa (*Eupatorium triplinerve* Vahl), represented by two specimens morphologically distinct, is indicated to treat diseases such as cholera, tetanus and leprosy.[22] The main component identified in their volatile oils was 2,5-dimethoxy-p-cymene (64%).[50]

The plants known as benguê (*Faramea anisocalyx* Poepp. & Endl., Rubiaceae; *Parkia oppositifolia* Spreng ex Benth., Fabaceae) provide essential oils with high levels of methyl salicylate (53-71%).[51,52] The leaves and bark of these plants are used in the treatment of flu and cough by the riverside population in the Amazon region.[47]

The main constituent of essential oils found in several species of *Hyptis* (Lamiaceae) was the 1,8-cineole (24-37%).[53-56] The salva-do-marajó (*H. crenata* Pohl ex Benth.) is a plant endemic to the natural fields of the island of Marajo and is used as a diaphoretic, tonic and stimulating.[22,57] The oil presents a bouquet involving odors of leaf green, wood and citrus, suggesting it to the industry of fragrance. The methanol extract of salva-do-marajó showed significant antioxidant activity.[58]

We found some chemical types for the species known as chumbinho (*Lantana camara* L., Verbenaceae). These types have been identified by the different chemical composition of its oils,[59] besides the color of the flowers of the plant, much used in decoration of parks and public gardens.

The species known as erva-cidreira [*Lippia alba* (Mill.) N. E. Br, Verbenaceae] is used in the Amazon region to replace the *Melissa officinalis* L. (Lamiaceae) in digestive and respiratory problems, such as indigestion, flatulence and asthma.[22] Three chemical types of *L. alba* were identified according to the chemical composition of its oil, a type A rich in 1,8-cineole, carvone and limonene, a type B rich in limonene, carvone and germacrene D, and a type C rich in germacrene D and citral (a mixture in equal proportions of neral and geranial).[60] The citral is also the main constituent of *M. officinalis*, the real erva-cidreira.

The oil of erva-do-marajó (*Lippia grandis* Schau., Verbenaceae) presents thymol, its methyl ether and carvacrol as its main constituents.[61] The oil was tested against the protozoan *Tripanossoma cruzii*, responsible for Chagas disease, inhibiting 100% the growth of these pathogens, at low concentrations. The ethyl acetate extract showed strong antioxidant activity supported by high levels of phenolic compounds found in the plant.[62]

Two chemical varieties of the species known as incense (*Melampodium camphoratum* Baker, Asteraceae) were identified. A variety rich in α–phellandrene and camphor, and the another dominated by terpinolene, limonene and δ^3-carene.[63] The plant is used in the treatment of digestive and liver ailments.[22]

Species of *Ocimum* (Lamiaceae) are used as flavoring in the Amazon cooking and have different flavors according to its main volatile components. In the essential oil of basilicão (*O. basilicum* L.) was thymol, *o*-cymene, 1,8-cineole and β-bisabolene,[22] in the oil of alfavaca (*O. gratissimum* L.) was methyleugenol, eugenol and *p*-cymene,[25,64] in the oil of alfavaca-de-campo (*O. micranthum* Wiild.) was β-elemene, β-caryophyllene and isoeugenol[22,25], in the oil of manjericão (*O. minimum* L.) was (*E*)-methyl cinnamate and linalool in the chemical type A, and methylchavicol in the chemical type B.[22,25]

The olfactory analysis of the oil of erva-de-jabuti (*Peperomia circinnata* Link var. *circinnata*, Piperaceae) revealed a bouquet associated with vegetables, tea and salvia, appropriate to the industry of fragrances and cosmetics. The oil presents limonene, elemicin and cubenol as its main constituents.[22,65] Aromatic compounds as elemicin, myristicin, apiole, dillapiole and safrole has been found also in other Amazon *Peperomia* species.[66,67] The oil of *P. rotundifolia* (L.) Dahlst. showed high brine shrimp larvicidal activity (LC_{50} = 1.9 ± 0.1 μg/mL).[67]

Species of *Piper* (Piperaceae) that occur in the Amazon are rich in phenylpropanoids as safrole, dillapiole, miristicin, elemicin and 3.4-methylenedioxypropiophenone or in terpenes as β-caryophyllene, spathulenol, (*E*)-nerolidol, bicyclogermacrene and α-cadinol. Insecticide, fungicide, bactericide, larvicidal and molluscicidal properties are inferred to these species. The main constituent found in the pimenta-de-macaco (*Piper aduncum* L.) was the phenyl ether dillapiole. Many samples of *P. aduncum* were examined and the percentage of dillapiole remained in the range of 31-97%.[68] This essential oil was tested against pathogenic fungi and bacteria, in snails that host the protozoan *Schistosoma mansonii*, in phytophagous insects that infest the traditional cultures in the Amazon region (cocoa, rubber, pepper, banana) and in mosquitoes transmitting malaria and dengue. The oil of pimenta-de-macaco eliminate these pests, completely, in concentrations ranging from 50-600 ppm.[69-72] In the sense to contribute for the management and plant domestication we have generated technologies for biomass field processing (distillation and drying) of *Piper aduncum* taking into account a commercial cultivation based on dillapiole-rich matrices. The oil yield mean was 2.5% with about of 85% of dillapiole during the processing. The biomass of dried leaf reached 20 ton hectare/year.[73]

The essential oils of pimenta-longa and óleo-elétrico or panquilé (*Piper hispidinervum* C. DC and *P. callosum* Ruiz & Pav.) are rich in safrole (70-97%).[74] The safrole is precursor of products used in the industries of perfumes and natural insecticides, and is marketed in the international market of essential oils to US$ 5.00 per kilo.[75] For the pimenta-longa was established a production system in the field, generating technologies for cultivation and processing of the plant biomass. With these technologies was possible to obtain 750 to 1000 kilos of essential oil of pimenta-longa per hectare per year,[76] which could generate an income of US$ 1,875 to US$ 2,500 (per hectare per year), taking into account the production costs of 50%. No other culture in the Amazon region offers this income. The EMBRAPA tried to pass this technology to small producers of Pará and Acre states, however, does not take into account the important aspects of the plant cultivation and processing of biomass. First, because it was used seeds to the plant propagation, rather than clones, leading to the reduction in the level of safrole to a value below that required by the industry. Second, because were used drying and distillation inadequate systems for the oil processing, that it is more dense than water, leading to an oil yield in below expectations. These results reduced the interest of producers by the cultivation and processing of the plant, which means that it will be necessary a hard work to convince them for this alternative agriculture in the Amazon region.

The main constituents of the essential oil of *Piper divaricatum* Meyer are eugenol (2.0-46.0%) and methyleugenol (17-93%).[22,77,78] The oil yield in this plant is also significant, around 3.0%. The vegetative propagation by both seeds or cuttings (clones) is quite simple. A system of cultivation for this species could be similar to those already established for *P. hispidinervum* and *Piper aduncum*. However, the methyleugenol has been used with restrictions in the formulation of fragrances, with the suspicion of being cytotoxic. In revisions of the genus *Piper*, this species is presented as synonymous with *Piper colubrinum* Kunth. The analysis of essential oil of some specimens of *P. colubrinum* showed that its chemical composition is formed entirely by terpenoids, therefore completely different from that of

P. divaricatum. Based on these results it was possible to ensure that they are two distinct species.[78] The oil of *P. divaricatum* showed a significant DPPH scavenging activity (EC_{50} of 16.2 ± 1.9 mg mL^{-1}), which means it has a high antioxidant capacity in comparison to Trolox (EC_{50} of 4.9 ± 1.1 mg mL^{-1}) and BHT (EC_{50} of 3.6 ± 0.1 mg mL^{-1}) used as synthetic standards.[78]

Twenty-two leaf samples of caapeba-cheirosa (*Piper marginatum* Jacq.) were collected in different areas and ecosystems of the brazilian Amazon. The species present a large synonymy based in their different leaf characteristics and distinct scents where some of them smell anise or like very close compounds. Using GC, GC-MS and cluster analysis we identified seven chemotypes for the leaf oils.[79-81] The main components found in chemotype I were safrole and 3,4-methylenedioxypropiophenone. The chemotype II was dominated by *p*-mentha-1(7),8-diene and 3,4-methylenedioxypropiophenone. The major compounds identified in chemotype III were 3,4-methylenedioxypropiophenone, myristicin, (*E*)-β-ocimene and γ-terpinene. In the chemotype IV the principal constituents were 3,4-methylenedioxypropiophenone, β-caryophyllene and α-copaene. The chemotype V was dominated by *trans*-isoosmorhizole, (*E*)-anethole and isoosmorhizole. The main compounds found in the chemotype VI were 2-methoxy-4,5-methylenedioxypropiophenone, *trans*-isoosmorhizole and the isomer methoxy-4,5-methylenedioxypropiophenone. The major constituents in chemotype VII were β-caryophyllene, bicyclogermacrene and (*E*)-asarone. In the popular medicine of Amazon the plant is used as tonic, stimulant, diaphoretic, diuretic, liver ailments and snakebite.[22] Cercaricide property was atributted to the oil and leaves of caapeba-cheirosa.[82]

The sesquiterpenes β-caryophyllene and germacrene D predominate in the oils of caapeba [*Pothomorphe peltata* (L.) Miq. and *P. umbellata* (L.) Miq., Piperaceae].[83] These species are used in internal and external inflammations.[22]

The monoterpenes α-pinene and β-pinene, sabinene, β-phellandrene and α-terpinolene are the main compounds identified in the essential oils from leaves of breu [*Protium paraense* Cuatr., *P. spruceanum* (Benth.) Engl., *P. heptaphyllum* (Aubl.) March. and *P. subserratum* Engl., Burseraceae].[22,84-87] The species of *Protium* produces resins that are exudates from the trees after injury in their trunks made by birds and animals. The resins are used to prepare incense and to aromatize clothes and wardrobes.[22] The oil of *Tetragastris panamensis* (Engl.) Kuntz (Burseraceae) has the same characteristics observed for the *Protium* species.[86]

The oil from the leaves and fruits of capitiú (*Siparuna guianensis* Aubl., Monimiaceae), presents a "animal note", according to the perfumer who carried the olfactory analysis, which would be used in the fragrance industry, depending on a rational system of cultivation for the species. This plant is the size of a shrub with rapid growth and the oil of the leaves showed a yield of 1.8%. We identified some chemical types for *S. guianensis*, after the analysis of the oils. The oxygenated sesquiterpenes atractilone, germacrone, *epi*-α-bisabolol and spathulenol were the main components identified in the studied varieties.[88]

The Waiãpi Indians from the Amazon use the leaves of ucuuba (*Virola surinamensis* (Rol) Warb., Myristicaceae) as remedy for malaria. Its biological action is attributed to (*E*)-nerolidol, a sesquiterpene oxygenated existing in their essential oil.[89]

Among the collected species, some have high oil yield and high content for major volatile components. Oils with these characteristics are required by the international market. Table 2 lists some species that meet this demand.

As mentioned before, the inventory covers several Amazonian ecosystems. The first two phases (1980-1995) of the inventory were dedicated to survey aromatic species occurring in areas of forest, lowland and igapó, besides the campinaranas located in these ecosystems and that arose by intensive use of land by the indians in the recent past.

Table 2. Some aromatic species with high oil contents and major volatile components

Apiole (80%):	*Piper krukoffii*
Carvone (50%):	*Lippia rondoniensis*
β-Caryophyllene (40-60%):	*Licaria rigida*, *Copaifera multijuga*
Citral (35-60%):	*Lippia alba*,
Dillapiole (31-97%):	*Piper aduncum*
2,5-Dimethoxy-p-cymene (70%):	*Eupatorium triplinerve*
Eugenol (40-85%):	*Dicipellium caryophylatum*, *Ocimum micranthum*
β-Phellandrene (34-67%):	*Melampodium camphorathum*, *rollinia mucosa*
Linalool (30-95%):	*Aniba rosaeodora*, *A. duckei*, *A. fragrans*, *Croton cajucara*
Methyleugenol (70%):	*Piper divaricatum*
Myristicin (70%):	*Piper arboreum* var. *arboreum*, *Piper* sp
Nitrophenylethane (50-95%):	*Aniba canelilla*
Perillaldehyde (30-55%):	*Pectis elongata*, *Calyptranthes spruceanum*
α-Pinene (70%):	*Ichthyothere cunabi*.
Sabinene (45-66%):	*Eupatorium macrophyllum*, *Ichthyothere terminalis*, *Protium spruceanum*
Safrole (70-95%):	*Piper hispidinervum*, *P. callosum*
Thymol (30-75%):	*Lippia grandulosa*, *L. grandis*, *Conobea scoparioides*
2-Tridecanone (-50-75%):	*Pilocarpus microphyllus*
α-Thujone (95%):	*Tanacetum suaveolens*

The third and fourth phases (1996-2004) of the inventory were devoted to the inventory of the aromatic flora of savannas and natural fields of the Amazon. The works of chemosystematic and phytogeography of Gottlieb and colleagues (1995)[90] indicate the Brazilian savannas as richest in number of species in the Amazon and Atlantic rain forest, and also with more expressive chemism (based on the variety of classes of compounds derived from secondary metabolism plants). In inventories of Amazonian savannas we prove this hypothesis. In fact, the diversity of aromatic and medicinal plants (shrub and herbaceous size) in savannas and natural fields of the states of Mato Grosso, Roraima, Amapá, Tocantins, Maranhão and Pará (including Marajo Island) is much higher than that presented by the forest, lowland and igapó, in all Brazilian Amazon.

In savannas and natural fields were collected more than 1,500 specimens, resulting in the achievement of several oils with high content and excellent fragrance, offering a good indication for the cosmetics industry. A feature observed for these oils was the occurrence of a large number of volatile components, unlike those with occurrence in forest ecosystems, where there is a predominance of a few major constituents. A positive aspect in the inventory and use of aromatic flora of savannas is the fact that they are species of fast growing cycle, which allows less time devoted to its domestication and management. On the other hand, working with species of tree size demand a much greater time to his economic recovery, when the issue is analyzed

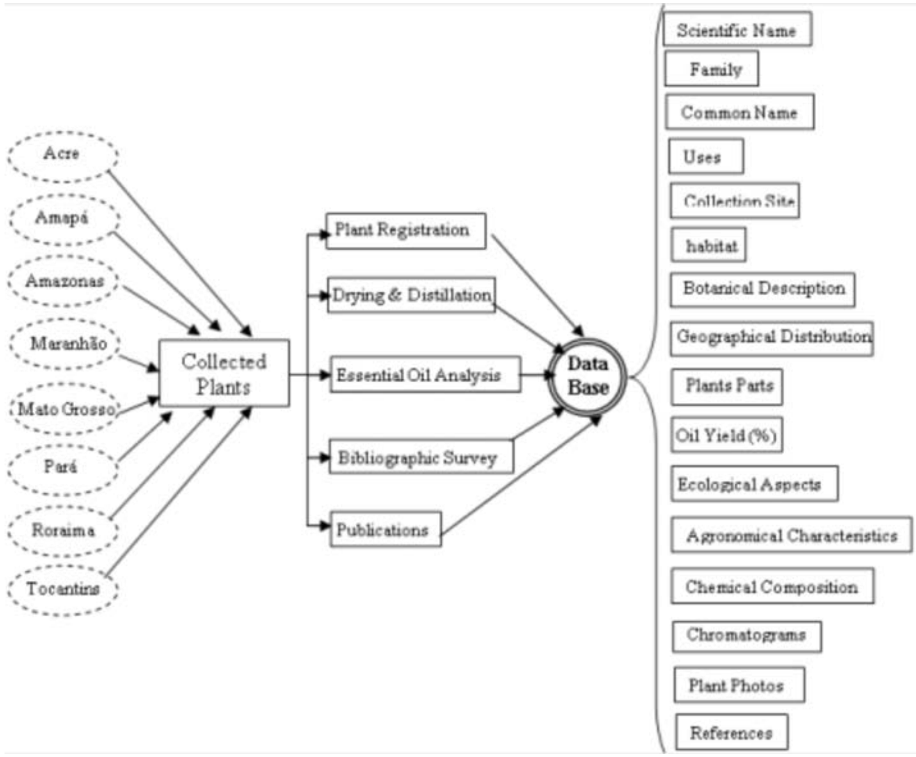

Figure 2. *The flow sheet of the database of aromatic plants*

through systematic cultivation. That is why in the Amazonian forest ecosystems still dominates the extractivism.

The fifth phase of the inventory was directed to the re-collection of species/specimens that showed significant results, being by the high yield in essential oil, or because the analyzed chemical composition was evidenced by the presence of major compounds of economic value, or even because the mixture of volatiles proved to be unusual. In this sense, the work was directed again to areas of savannas and natural fields previously raised.

Database of the aromatic plants and their essential oils

The Database of Aromatic Plants of the Amazon is structured to running in SQL Windows, aimed at giving greater compatibility with other databases of botanical and phytochemical, existing in other institutions. Figure 2 shows a flow sheet with available informations in the database, that currently has over 500 species and about 1,250 entries (specimens).

An example of how the database is presented can be seen with the data of erva-cidreira (*Lippia alba*, Verbenaceae), which are found in Figures 3-6. The Database provides access to four main fields: **General Information** (provides scientific names and the authors, families, geographical distribution, habits, common names, habitat and photographs of the plant), **Characteristics and Aspects** (provides botanical, agronomic, environmental and economic data of the plant), **Popular Uses and References** (shows the use of the popular applications based on ethnobotanical survey and bibliographic references of the plant) and **samples and Products** (shows the samples of the plants, the places of collection, if it is an oil or aroma, and the chemical composition and chromatograms). The database also provides a complete report with all data of the plant, or individual reports of data in each of the four main fields.

There are several specimens registered in the database, many of them for the same species, identified as different chemical types. The

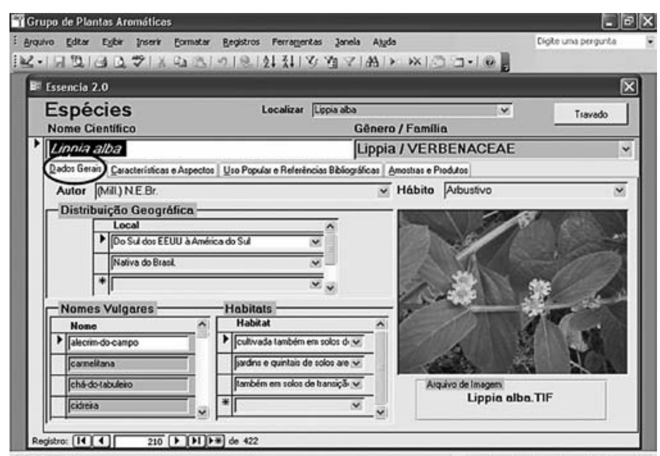

Figure 3. *Database (field 1): General data of Lippia alba*

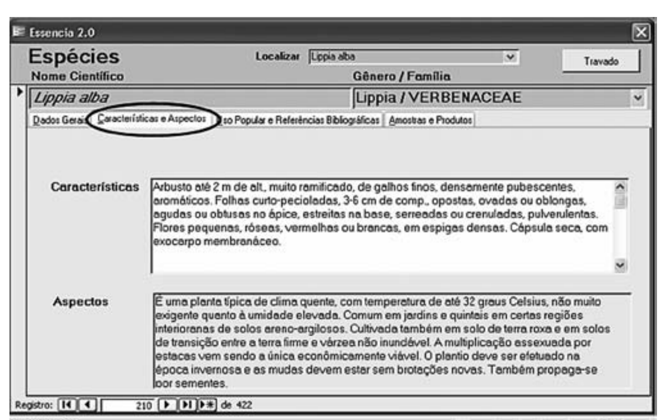

Figure 4. *Database (field 2): Characteristics and aspects of Lippia alba*

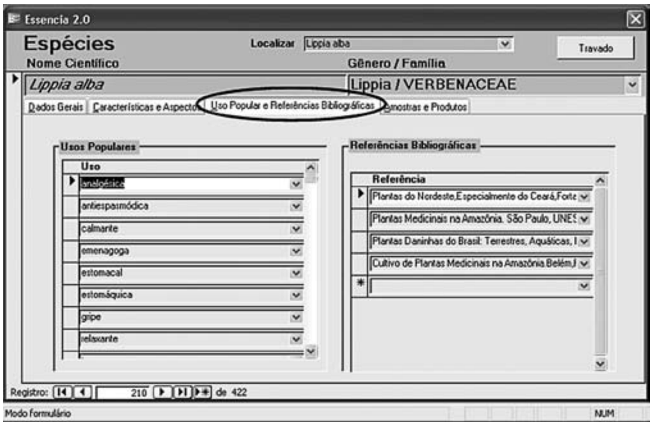

Figure 5. Database (field 3): Popular uses and references of Lippia alba

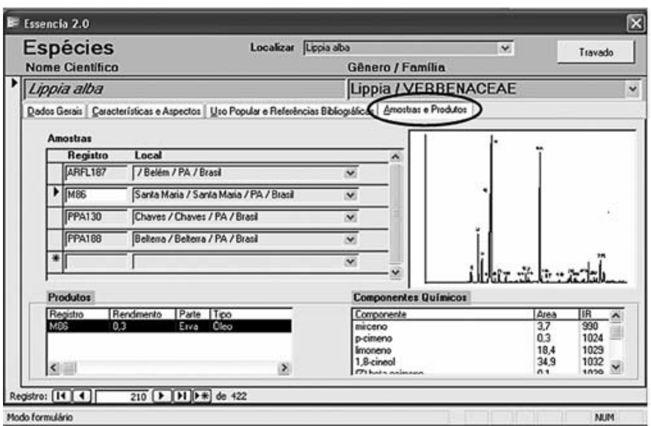

Figure 6. Database (field 4): Samples and products of Lippia alba

Table 3. Olfactory analysis of some essential oils with economic potential for the industry of fragrances

***Mentha rotundifolia*:** root scent, angelica.

***Peperomia circinnata* var. *circinnata*:** green pepper, bitter, cucumber, tea, salvia.

***Siparuna guianensis* and *Ipomoea* sp:** animalized note.

***Piper arboreum* var. *arboreum*:** celery ketone, cooked legumes, like anise.

***Piper marginatum*:** spices, honey, cardomon, anise.

***Ocimum micranthum*:** cypress, lightly camphor, fruit scent.

***Lippia lupulina*:** green, bitter, roots, land, mould, woody.

***Baccharis tridentata*:** thujone, tagetes, tenaisic, bitter almond.

***Lantana camara*:** mentha, cypress, green, bitter, mint, tea, salvia, woody.

***Lippia citriodora*:** mentha, carvone, mint, thyme, carvacrol.

***Lippia grandis*:** laurel, humus, thymol, carvone.

***Lippia grandulosa*:** carvacrol, thymol, strong.

***Costus* sp:** thyme, alecrim, salvia, anise.

***Mikania lindleyana*:** green leaf, absinthium, animalized note, anise.

***Eupatorium conyzoides*:** mustard seed, piquant.

***Protium heptaphyllum*:** pinene, resin, incense, sandalwood.

***Humiria balsamifera*:** roots, woody, vetiver, cedar.

***Ocotea fasciculata*:** woody, cedar, roots, fruit scent, linalyl.

***Aniba fragrans*:** floral, citrus, linalool, linalyl, citronelol.

erva-cidreira, exemplified above, has three chemical types records in the database.[60] In the type A predominate 1,8-cineole, limonene, carvone and sabinene; in the type B limonene, carvone and myrcene; and in the type C neral, geranial, germacrene D and β-caryophyllene. It is very likely to identify different varieties based on chemical analysis of their essential oils. This is due to environmental differences in the places where occur these specimens, generally distant from one another.

Integrating the Database of Aromatic Plants of the Amazon there is a bank of essential oils that is kept in refrigerated environment. This bank of oils is often subjected to olfactory analysis by experienced perfumers. In this sense, for oils with a yield above 1% were generated data for their possible use in the industry of fragrances and cosmetics. The Table 3 records some examples of essential oils with economic potential for the composition of new fragrances.

As mentioned above, the database has information about 500 species, which account for more than 1,250 specimens, many with unique information about the chemical composition of their essential oils. We publish data on chemical composition of essential oil of about 350 species, as seen in Table 4. In respect of data from other species that make up the database, we can provide some information by e-mail addresses: gmaia@ufpa.br and eloisandrade@ig.com.br.

Table 4. Essential oils and aromatic species already reported in the scientific literature

No.	Species	Main constituents (%)	Ref.
1	*Abarema jupunba* Britton & Killip var. *Jupunba* (Fabaceae)	methyl salycilate (24.3), *trans*-linalool oxide (22.6), 6-vinyltetrahydro-2,2,6-trimethyl-2H-piran-3-ol (15.0)	91
2	*Acacia* cf *longifolia* var. *mucronata* Willd. (Fabaceae)	linalool (80.3)	91,92
3	*Achyrocline satureioides* (Lam.) DC. (Asteraceae)	α-pinene (31.9) β-caryophyllene (29.6)	91
4	Adenocalymma alliaceum Miers (Bignoniaceae)	diallyl disulfide (49.7), di-2-propenyl trisulfide (32.7)	20,21,22,91,93,94
5	*Aeollanthus suaveolens* Mart. ex Spreng (Asteraceae)	(E)-β-farnesene (32.8), linalool (31.6), δ-decen-2-lactone (xx)	58,210,247,252
6	*Allamanda cathartica* Linn. (Apocynaceae)	linalool (39.3), dendrolasin (20.2), β-caryophyllene (15,7)	91,95

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
7	*Alpinia speciosa* (Wendl.) Schum. (Zingiberaceae)	type A: 1,8-cineole (23.1), terpinen-4-ol (22.7), sabinene (14.5) type B: limonene (25.1), γ-terpinene (17.4), terpinen-4-ol (20.4), sabinene (14.5)	22,23,24,84,96-100
8	*Alpinia purpurata* (Viell.) Schum. (Zingiberaceae)	tipo A: β-pinene (27.8), α-pinene (16.9), linalool (8.4); tipo B: 1,8-cineole (21.8), (*E*)-methyl cinnamate (12.9), β-pinene (15.3)	22,24,91
9	*Ambrosia artemisiafolia* L. (Asteraceae)	β-himachalene (33.8), γ-elemene (10.3)	22,25-27,91
10	*Ambrosia microcephalla* DC. (Asteraceae)	bornyl acetate (12.8), β-bisabolene (18.8), β-himachalene (13.0)	22,26
11	*Anacardium occidentale* L (Anacardiaceae)	Flowers red type: β-caryophyllene (26.0), methyl salycilate (12.8), benzyl tiglate (11.3); leaves red type: (*E*)-β-ocimene (28.8), α-copaene (13.9), δ-cadinene (9.1); Fruits red type: palmitic acid (19.6), oleic acid (19.6) Fruits yellow type: palmitic acid (11.4), furfural (10.0)	22,91,101,102
12	*Aniba affinis* (Meissn.) Mez (Lauraceae)	benzaldehyde, benzyl benzoate, benzyl salycilate	103
13	*Aniba burchellii* Kosterm. (Lauraceae)	α-pinene (12,1), benzyl salycilate (45.6)	84, 104,105,106
14	*Aniba canelilla* (H.B.K.) Mez (Lauraceae)	leaves type A: nitrophenylethane (68.5), linalool (8.8); bark type A: nitrophenylethane (60.5), methyleugenol (21.3); trunkwood type A: nitrophenylethane (50.2), methyleugenol (23.0); leaves type B: nitrophenylethane (95.3); bark type B: nitrophenylethane (58.2), methyleugenol (34.7); trunkwood type B: nitrophenylethane (47.4), *epi*-α-cadinol (19.9), methyleugenol (10.5)	22, 28-33,37,107-110
15	*Aniba citrifolia* (Nees) Mez (Lauraceae)	safrole (16.7), β-pinene (11.2), α-pinene (10.6)	22,111
16	*Aniba duckei* Kosterm. (Lauraceae)	linalool (81-87)	22,34-36,112, 113,269
17	*Aniba firmula* (Nees & C. Mart.) Mez (Lauraceae)	benzyl benzoate (69.9), benzyl salycilate (39.2)	37
18	*Aniba fragrans* Ducke (Lauraceae)	linalool (32.4), spathulenol (19.1), limonene (14.5), bicyclogermacrene (7.1)	22,37
19	*Aniba gardneri* (Meisn.) Mez (Lauraceae)	leaves: benzil benzoate (44.1), sesquiterpenes (43.5); trunkwood: benzyl benzoate (78.1), phenylethyl benzoate (14.3)	37
20	*Aniba hostmanniana* (Nees) Mez (Lauraceae)	trunkwood: 2,4,5-trimethoxyallylbenzene (98.6); bark: 2,4,5-trimethoxyallylbenzene (94.5)	37
21	*Aniba parviflora* (Meissn) Mez (Lauraceae)	type A: sequiterpenes (51.0) benzyl salicylate (34.3) type B: benzyl benzoate (97.8)	84,96,104,105
22	*Aniba permollis* (Nees) Mez (Lauraceae)	benzyl benzoate, benzyl salycilate	37
23	*Aniba pseudocoto* (Rusby) Kosterm. (Lauraceae)	methyleugenol, cadineno	37
24	*Aniba puchury-minor* (Mart.) Mez (Lauraceae)	leaves: elemicin (21.5), spathulenol(11.3), (*Z*)-asarone (8.3), myristicin (6.4); bark: methyleugenol (43.1), (*E*)-asarone (29.9)	22,42,43
25	*Aniba riparia* (Nees) Mez (Lauraceae)	type A: benzyl benzoate(31.9), terpinen-4-ol (9.3); type B: α-humulene (14.9), β-caryophyllene (16.9), bicyclogermacrene (14.1), type C: (*E*)-nerolidol (19.4), α-humulene (10.9), elemol (16.2)	114,115
26	*Aniba rosaeodora* Ducke (Lauraceae)	linalool (81-87)	22,34-36,112, 113,269
27	*Aniba santalodora* Ducke (Lauraceae)	benzyl benzoate	116

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
28	*Aniba terminalis* Ducke (Lauraceae)	type A: (E)-β-ocimene (22.3), α-phellandrene (8.7) type B: α-phellandrene (32.8), linalool (21.7), *p*-cymene (16.7)	91,117,118
29	*Annona ambotay* Aubl. (Annonaceae)	β-caryophyllene (10.2)	99,100,119,120
30	*Annona montana* Macfad. (Annonaceae)	type A: β-caryophyllene (17.0), α-humulene (15.3), germacrene D (11.3), δ-cadinene (9.8); type B: bicyclogermacrene (29.9), β-caryophyllene (18.0), germacrene D (9.9) limonene (9.1)	121
31	*Annona montana* Macf. var. *marcgravii* (Mart.) Fr. (Annonaceae)	β-caryophyllene (11.2), sabinene (6.2)	91
32	*Annona muricata* L. (Annonaceae)	β-caryophyllene (23.5)	91
33	*Annona squamosa* L. (Annonaceae)	α-pinene (25.3), sabinene (22.7), limonene (10.1) β-caryophyllene (26.9), β-elemene (7.0), α-muurolol (7.0)	122,123
34	*Annona glabra* L. (Annonaceae)	α-pinene (15.0), (E)-β-ocimene (18.3), limonene (20.6)	124-127
35	*Aristolochia rodriguesii* Hoehne (Aristolochiaceae)	α-pinene (25.4), β-pinene (28.3), bornyl acetate (8.2)	128,129
36	*Artocarpus heterophyllus* Lam. (Moraceae)	butyl 3-methylbutanoate (25.6), isopentyl isovalerate (28.4)	130
37	*Astrocaryum vulgare* Mart. (Arecaceae)	ethyl hexanoate (47.5)	124,125,131
38	*Astronium fraxinifolium* Schott ex Spreng (Anacardiaceae)	type A: (Z)-β-ocimene (42.2), limonene (13.2), bicyclogermacrene (13.3), (*E*)-β-ocimene (13.3); type B: δ-3-carene (26.3), limonene (18.5)	132,133
39	*Astronium urundeuva* (Allemao) Engl. (Anacardiaceae)	δ-3-carene (78.1)	132,133
40	*Averrhoa carambola* Linn. (Oxalidaceae)	palmitic acid (17.3), myristic acid (9.0), oleic acid (12.7), linalool (9.6)	91
41	*Baccharis tridentata* Vahl (Asteraceae)	β-caryophyllene (13.5), germacrene D (23.1) benzaldehyde (22.9), benzyl benzoate (16.1)	134,135
42	*Bacopa axillaris* (Benth.) Standl. (Scrophularidaceae)	methyleugenol (35.9), camphor (28.1)	136
43	*Bactris gasipaes* H.B.K. (Arecaceae)	limonene (52.9)	124,125,131
44	*Bauhinia platypetala* Burch ex Benth. (Fabaceae)	α-pinene (24.9), β-cayophyllene (13.7), β-pinene (13.0)	91,137
45	*Bellucia grossularioides* (L.) Triana (Melastomataceae)	pentadecanone (10.0), palmitic acid (13.1), δ-cadinene (7.0)	91
46	*Bixa orellana* L. (Bixaceae)	type A: α-pinene (14.7), β-pinene (9.8), β-caryophyllene (26.8); type B: α-pinene (29.8), sabinene (19.9), (*Z*)-β-ocimene (17.3), β-caryophyllene (14.0)	91
47	*Borrelia verticillata* (L.) G.F.W. Meyer (Rubiaceae))	tridecanol (46.5), palmitic acid (17.4)	91
48	*Brassavola martiniana* Lindl. (Orchidaceae)	hexyl acetate (14.2), *p*-cymene (11.5), methyl salicylate (9.7), (*E,E*)-β-farnesene (16.7)	91
49	*Brassia chloroleuca* Barb. Rodr. (Orchidaceae)	methyleugenol (8.8), (*E,E*)-β-farnesene (18.8)	91
50	*Brickellia paniculata* (Mill.) Robinson (Asteraceae)	β-caryophyllene (46.8), (*E*)-β-farnesene (8.2)	91
51	*Byrsonima chrysophylla* Kunth (Malpighiaceae)	linalool (6.8), nonanal (13.6), (*E*)-2-dodecenal (5 .3)	91
52	*Calycophyllum spruceanum* Hook. f. ex Schum. (Rubiaceae)	*p*-cymene (6.7), *cis*-linalool oxide (11.4), *trans*- linalool oxide (6.0), linalool (7.9), *p*-anisaldehyde (11.0), (*E,E*)-α-farnesene (21.8).	91
53	*Calyptranthes spruceana* Berg. (Myrtaceae)	type A: limonene (34.4), perillaldehyde (19.9), geranial (13.6); type B: β-pinene (34.4), geranial (19.3), α-pinene (15.2), neral (12.5)	22,44,45,99,100, 138,139

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
54	*Carapa guianensis* Aubl. (Meliaceae)	β-caryophyllene (7.0), α-humulene (13.4), germacrene D (21.0)	22 ,140,141
55	*Carica papaya L.* (Caricaceae)	sample A:linalool (15.3), phenylacetonitrile (17.1), methyl phenylisothiocianate (10.9), dendrolasin (19.0) sample B: linalool (30.7), phenylacetonitrile (12.7), methyl phenylisothiocianate (10.9), dendrolasin (31.7)	91
56	*Caryocar brasiliense* Camb.	ethyl hexanoate (52.9)	359
57	*Caryocar villosum* (Aubl.) Pers. (Caryocaraceae)	(*E*)-nerolidol (19.8), β-bisabolol (18.1), 2-heptanone (19.3), furfural (14.6)	142
58	*Cassia fistula* L. (Fabaceae)	(E)-methyl cinnamate (9.9), butyl stearate (5.9)	91
59	*Cassia javanica* L. (Fabaceae)	linalool (33.7), α-terpineol (6.0), geraniol (8.4), (*E,E*)-α-farnesene (7.4)	91
60	*Catasetum discolor* (Lindl.) Lindl. (Orchidaceae)	α-pinene (13.4), alcohol (56.0)	91
61	*Catasetum macrocarpum* Rich. ex Kunth (Orchidaceae)	hexyl acetate (8,.5), *p*-cymene (10,.2), 1,8-cineole (8,3), (*E,E*)-α-farnesene (10.9)	91
62	*Cattleya labiata* Lindl. (Orchidaceae)	β-caryophyllene (10.8), β-bisabolene (6.2), benzyl benzoate(14.9), tricosane (8.7)	91,143
63	*Citrus aurantium* L. var. *amara* (Rutaceae)	sample A: sabinene (9.7), δ-3-carene (6.3), limonene (15.6), phenylacetaldehyde (10.0), linalool (14.3), (*E,E*)-farnesol (6.6); sample B: limonene (85.5)	22,46,91
64	*Citrus limonum* Risso (Rutaceae)	limonene (50.2), geranyl acetate (11.9)	22,46
65	*Citrus medica* L (Rutaceae)	linalyl acetate (38.3), linalool (25.9), α-terpineol (9.5)	22
66	*Citrus nobilis* Lour. (Rutaceae)	sabinene (45.1), linalool (24.0), (*E*)-β-ocimene (8.1)	22
67	*Clerodendron phylippinum* Schauer in DC (Verbenaceae)	1-octen-3-ol (8.7), linalool (55.0),	91
68	*Clibaudium sylvestres* Baill. (Asteraceae)	germacrene D (13.1), α-santalene (11.5), spathulenol (9.7), α-pinene (9.3)	134
69	*Clinostemon mahuba* Aubl. (Lauraceae)	β-caryophyllene (31.3), β-selinene (17.9), δ-cadinene (10.6), β-pinene (8.8)	22,111
70	*Clitoria racemosa* Sesse & Moc. (Fabaceae)	palmitic acid (57.9), indole (8.6)	91
71	*Coffea arabica* L. (Rubiaceae)	phenylacetaldehyde (8,4), benzyl cyanide (10.5), nerol (15.9), geraniol (29.6)	91
72	*Cola acuminata* Scott & Endl. (Sterculiaceae)	1,8-cineole (22.0), nonanal (10.2), 3-methoxyacetophenone (21.4), palmitic acid (16.6)	91
73	*Coleus amboinicus* Lour. (Lamiaceae)	sample A: carvacrol (44.4), γ-terpinene (15.2), β-caryophyllene (7.3), patchoulyl alcohol (7.0); sample B: carvacrol (60.6), γ-terpinene (15.1), *p*-cymene (6.4), β-caryophyllene (6,.3)	22
74	*Coleus barbatus* (Andrews) Benth. (Lamiaceae)	β-caryophyllene (10.7), α-humulene (8.5)	22,25,46,47
75	*Conobea scoparioides* Benth. (Scrophulariaceae)	type A: thymol (52.0), methylthymol (36.0); type B: methylthymol (42.4), thymol (17.9), α-phellandrene (9.6)	22,48,49,144-148
76	*Conyza bonariensis* (L.) Cronquist (Asteraceae)	type A: 9-*epi*-β-caryophyllene (23.3), germacrene D (15.3), β-caryophyllene (14.4) type B: limonene (22.9), (*E*)-β-farnesene (20.1), β-caryophyllene (13.3) type C: (*E*)-β-farnesene (19.1), germacrene D (13.2), β-caryophyllene (13.0)	22,46,47,149-151
77	*Copaifera duckei* Dwyer (Fabaceae)	*trans*-α-bergamotene (24.2), β-bisabolene (20.0), β-caryophyllene (16.4)	22,152
78	*Copaifera martii* Hayne (Fabaceae)	flowers: germacrene B (35.3), β-caryophyllene (31.0), germacrene D (8.3); leaves: germacrene B (37.4), β-caryophyllene (12.4), germacrene D (12.2), β-elemene (8.2)	152,153

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
79	*Copaifera multijuga* Hayne (Fabaceae)	β-caryophyllene (5.4), α-humulene (6.1), α-copaene (4.3)	152,154,155
80	*Copaifera reticulata* Ducke (Fabaceae)	β-caryophyllene (40.3), β-bisabolene (10.6), α-humulene (6.8)	22,152
81	*Cordia multispicata* Cham. (Boraginaceae)	linalool (10.6), β-caryophyllene (28.8)	91
82	*Coryanthes macrantha Hook.* (Orchidaceae)	hexadecanol (68.3)	91
83	*Cosmos caudatus* Kunth (Asteraceae)	(*E*)-β-ocimene (65.2), 1,3,8-*p*-menthatriene (17.2), germacrene D (14.0)	91,134,135,156
84	*Couroupita guianensis* Aubl. (Lecythidaceae)	linalool (21.5), geraniol (8.0), eugenol (18.9), (*E*,*E*)-farnesol (16.0)	91,157
85	*Croton cajucara* Benth. (Euphorbiaceae)	linalool (30-50), germacrene D (12.6), bicyclogermacrene (9.6)	22,34,112,158,159
86	*Croton grandulosus* Jacq. (Euphorbiaceae)	β-caryophyllene (18.0) bicyclogermacrene (52.1), spathulenol(12.9)	159,160
87	*Croton lanjouwensis* Jabl. (Euphorbiaceae)	type A: β-caryophyllene (11.7), bicyclogermacrene (18.3), linalool (9.4); type B: β-caryophyllene (21.9), bicyclogermacrene (27.1), β-elemene (10.8); type C: α-pinene (88.5)	161
88	*Croton matourensis* Aubl. (Euphorbiaceae)	type A: α-pinene (34.0) α-phellandrene (17.2) *p*-cymene (14.5) α-thujene (12.9); type B: α-pinene (86.7)	84,104-106,159,160,162
89	*Croton palanostigma* Klotzsch (Euphorbiaceae)	leaves: linalool (25.4%), (*E*)-caryophyllene (21.0%), methyleugenol (17.2%), β-elemene (6.0%); fine stems: α-pinene (41.4%), limonene (29.0%), sabinene (11.5%), β-pinene (5.7%); branches: methyleugenol (24.1%), (*E*)-methylisoeugenol (15.3%), α-pinene (11.2%), (*E*)-caryophyllene (8.5%); fruits: linalool (42.7%), methyleugenol (16.3%), β-elemene (6.4%); trunk bark: α-pinene (31.6%), methyleugenol (25.6%), (*E*)-methylisoeugenol (23.7%)	363
90	*Croton pullei* Lanj. (Euphorbiaceae)	type A: β-caryophyllene (21.0) bicyclogermacrene (16.0) germacrene D (27.0); type B: α-pinene (13.8) germacrene D (8.1) germacrene B (12.1)	159,160,163
91	*Croton sacaquinha* Croizat (Euphorbiaceae)	β-caryophyllene (50.8) α-humulene (16.3), germacrene D (13.0)	159,160,163
92	*Croton trinitatis* Millsp. (Euphorbiaceae)	type A: β-caryophyllene (18.3), bicyclogermacrene (20.4), spathulenol(14.3); type B: germacrene D (14.3), (E)-caryophyllene (32.8), α-selinene (9.3)	159,160,163
93	*Curcuma longa* L (Zingiberaceae)	(*Z*)-γ-atlantone (20.3) , *ar*-turmerone (15.5), (*E*)-γ-atlantone (15.6)	164
94	*Cymbopogon citratus* (DC.) Stapf (Gramineae)	geranial (23.3), neral (22.3), γ-eudesmol (6.7)	22
95	*Dalbergia decipularis* Rizz. et Matt. (Fabaceae)	nerolidol (97.2)	165-167
96	*Dipteryx odorata* (Aubl.) Willd. (Fabaceae)	germacrene D (31.1), bicyclogermacrene (13.0), spathulenol(13.0).	91,168,169
97	*Discypellium caryophyllatum* Nees (Lauraceae)	eugenol (95.5)	165-167
98	*Duguetia calycina* Benoist (Annonaceae)	spathulenol (22.6), germacrene D (4.9), bicyclogermacrene (4.5)	170,171
99	*Duguetia eximia* Diels (Annonaceae)	α-eudesmol (80.3)	172

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
100	*Duguetia flagellaris* Huber (Annonaceae)	spathulenol (25.4), bicyclogermacrene (9.5), germacrene B (8.7), germacrene D (7.1)	170,172-175
101	*Duguetia picnastera* Sandwith (Annonaceae)	spathulenol (52.2)	172,175
102	*Duguetia riparia* Huber (Annonaceae)	germacrene B (45.5), caryophyllene oxide (28.9)	172,175,176
103	*Duguetia surinamensis* R.E. Fr. (Annonaceae)	spathulenol, bicyclogermacrene	175
104	*Duguetia truncifolia* Maas (Annonaceae)	spathulenol (15.3), α-pinene (8.3), α-calacorene (4.1)	170,172,175
105	*Encyclia fragrans* (Sw.) Lemée (Annonaceae)	*trans*-verbenol (10.2), terpinen-4-ol (18,3), (*2Z,6E*)-farnesol (15.4), heneicosane (8.5).	91,177
106	*Encyclia vespa* (Vell.) Dressler & Pollard (Annonaceae)	α-pinene (11.8), γ-terpinene (7.5), linalool (8.9), *trans*-verbenol (13.6), terpinen-4-ol (20.3)	91,143,177
107	*Endopleura uchi* (Huber) Cuatrecasas (Humiriaceae)	eugenol (14.0), (Z)-3-hexenol (5.8), ethyl 9-octadecanoate (5.8)	178,179
108	*Eperua bijuga* Mart. ex Benth. (Fabaceae)	(E)-caryophyllene, methyl eperuate	180
109	*Ephedranthus amazonicus* R. E. Fr. (Annonaceae)	(*E*)-methyl cinnamate (85.6), (*Z*). Methyl cinnamate (7.4)	360
110	*Epiphyllum oxypetalum* (DC.) Haw. (Cactaceae)	benzyl salicylate (9.7), methyl linoleate (21.1)	91
111	*Ervatamia coronaria* (Jacq.) Stapf (Apocynaceae)	α-cadinol (32.0), benzyl benzoate (8.2), tricosane (6.0)	91
112	*Eryngium foetidum* L. (Apiaceae)	(*E*)-2-dodecanal (52.3), dodecanal (8.9), tetradecanol (8.1)	22,46,47
113	*Eschweilera coriacea* (DC.) Mori (Lecythidaceae)	hexanal (11.6), (*E*)-β-ocimene (23.4),	91,157
114	*Esenbeckia almawillia* Kaastra (Rutaceae)	α-cubebene (10.4) elemicin (7.4) γ-eudesmol (7.0) sesquiterpene alcohol (34.4), myristicin (14.2)	181,182
115	*Etlingera elatior* (Jack) R.M. Sm. (Zingiberaceae)	α-pinene (53.1), dodecanal (15.4), dodecanol (12.4)	91
116	*Eucalyptus* cf. *globulus* Labill. (Myrtaceae)	1,8-cineole (12.9), γ-terpinene (17.1), terpinolene (9.0), α-terpinyl acetate (21.8)	91,183,184
117	*Eugenia cumini* (L.) Druce (Myrtaceae)	type A: α-pinene (20.8) sabinene (9.2) (*Z*)-β-ocimene (7.8) limonene (7.1); type B: α-pinene (27.7) (Z)-β-ocimeno (31.2) (E)-β-ocimeno (13.9)	185
118	*Eugenia jambos* L. (Myrtaceae)	γ-terpinene (21.1), α-pinene (11.3) sabinene (10.8)	185
119	*Eugenia malaccencis* L. (Myrtaceae)	limonene (37.3) phenylethyl alcohol (20.8) geraniol (10.6)	185
120	*Eugenia patrisii* Vahl (Myrtaceae)	germacrene D (48.6)	185
121	*Eugenia punicifolia* (H.B.K.) DC. (Myrtaceae)	β-caryophyllene (3.9), γ-elemene (7.9), α-humulene (5.4)	22,138,186,187
122	*Eugenia stipitata* Mc Vaugh (Myrtaceae)		185
123	*Eugenia uniflora* L. (Myrtaceae)	germacrone (32.8), curzerene (30.0), germacrene B (13.2)	22,138,185,187-189
124	*Eupatorium amygdalinum* Lam (Asteraceae)	germacrene D (17.4) caryophyllene oxide (17.4)	156,190,191
125	*Eupatorium conyzoides* Mill. (Asteraceae)	germacrene D (16.8), β-caryophyllene (7.1), bicyclogermacrene (7.1), spathulenol (8.3)	156,190,191
126	*Eupatorium laevigatum* Lam. (Asteraceae)	germacrene D (8,.6), globulol (16.2), aristolene (23,6)	190-193
127	*Eupatorium macrophyllum* L. (Asteraceae)	sabinene (46.7), limonene (23.3)	156,190

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
128	*Eupatorium marginatum* Poepp. (Asteraceae)	type A: 2,5-dimethoxy-p-cymene (64.2), α-selinene (19.1); type B: β-caryophyllene (11.2), α-curcumene (36.0); type C: α-zingiberene (57.5), (E)-γ-bisabolene (9.7); type D: α-selinene (9.0), α-gurjunene (19.5) germacrene D (14.8); type E: germacrene D (28.8), bicyclogermacrene (16.0), β-pinene (8.0), β-phellandrene (7.3)	156,190
129	*Eupatorium maximilianii* Schrader (Asteraceae)	type A: hydrocarbon sesquiterpene (16.8), germacrene B (13.2), β-caryophyllene (10.5); type B: germacrene B (11.7), β-caryophyllene (11.8), (E)-nerolidol (8.4)	22,25,99,100
130	*Eupatorium paniculatum* Poepp. et Endl. (Asteraceae)	β-caryophyllene (46.8)	50
131	*Eupatorium squalidum* DC. (Asteraceae)	type A: germacrene D (21.6), spathulenol(14.2), globulol (25.1); type B: germacrene D (10.5), caryophyllene oxide (30.0), β-caryophyllene (9.5)	156,190,191
132	*Eupatorium triplinerve* Vahl (Asteraceae)	2,5-dimethoxy-p-cymene (66.7), β-pinene (4.6)	22,46,47,50,194
133	*Euterpe oleracea* Mart. (Arecaceae)	type A: 3-hexen-1-ol (72.3) type B: 3-hexen-1-ol (64.7), 2-ethylbutanol (16.3)	195-198
134	*Faramea anisocalyx* Poepp. & Endl. (Rubiaceae)	methyl salicylate (53.1), acetovanilone (27.3)	22,46,47
135	*Fusaea longifolia* (Aubl.) Safford (Annonaceae)	spathulenol (12.8), δ-elemene (4.2), β-elemene (3.8)	170,200,201
136	*Genipa americana* L. (Rubiaceae)	(*E*)-nerolidol (26,9), pentadecanone (60,2)	91
137	*Gongora quinquinervis* Ruiz & Pavón (Orchidaceae)	(*E*)-β-ocimene (7.6), *m*-cresol (7.6), β-bisabolene (6.7)	91
138	*Gossypium hirsutum* L. (Malvaceae)	α-pinene (21.4), β-caryophyllene (11.1), palmitic acid (11.3)	91
139	*Guarea kunthniana* A. Juss. (Meliaceae)	germacrene D (62.9)	91
140	*Guatteria juruensis* Diels (Annonaceae)	spathulenol (77.5)	201-203
141	*Guatteria microcalyx* R.E. Fr.(Annonaceae)	β-caryophyllene (13.8), α-copaene (12.5), δ-cadinene (6.7)	170,202,203
142	*Guatteria poeppigiana* Mart. (Annonaceae)	spathulenol (53.0), khusinol (10.9)	202-204
143	*Guatteriopsis blepharophylla* (Mart.) R.E. Fr. (Annonaceae)	caryophyllene oxide (51.0)	202,203,205
144	*Gustavia augusta* L. (Lecythidaceae)	2-pentadecanone (32.7), benzyl benzoate (11.7), 2-heptadecanone (6.4)	91
145	*Hyptis affinis* Benth. (Lamiaceae)	β-caryophyllene (22.8), sabinene (17.9), α-terpineol (31.0)	206
146	*Hyptis atrorubens* Poit. (Lamiaceae)	type A: estragole (13.40), limonene (7.6); type B: germacrene D (68.3)	206
147	*Hyptis brevipes* Baker (Lamiaceae)	α-copaene (21.8), dillapiole (14.0), cubebol (13.8)	206
148	*Hyptis cana* Pohl. ex Benth. (Lamiaceae)	1,8-cineole (27.0), borneol (22.8), α-pinene (13.8)	207
149	*Hyptis crenata* Pohl ex Benth. (Lamiaceae)	type A: 1,8-cineole (23.9), borneol (21.8), β-caryophyllene (18.8); type B: 1,8-cineole (36.7), α-copaene (14.5), β-pinene (7.9)	22,46,47,57,58, 208-210
150	*Hyptis coccinea* Benth. (Lamiaceae)	type A: sabinene (34.5), bicyclogermacrene (14.2), spathulenol (13.2), β-caryophyllene (10.5); type B: germacrene D (34.9), bicyclogermacrene (25.6)	55,211
151	*Hyptis desertorum* Pohl ex Benth. (Lamiaceae)	germacrene D (25.0), selin-11-en-4-α-ol (14.7), β-elemene (11.1)	55,211
152	*Hyptis dilatata* Benth. (Lamiaceae)	type A: 1,8-cineole (27.9), camphor (14.8), β-caryophyllene (16.8); type B: δ-3-carene (18.0), fenchone (31.3), β-caryophyllene (13.3); type C: 1,8-cineole (21.5), α-pinene (26.4), β-pinene (13.8), bicyclogermacrene (18.3)	55,212

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
153	*Hyptis fasciculata* Benth. (Lamiaceae)	1,8-cineole (27.0), β-selinene (11.3), β-caryophyllene (10.6)	211
154	*Hyptis goyazensis* Benth. (Lamiaceae)	1,8-cineole (23.9), borneol (13.0), α-pinene (12.8), β-pinene (8.4)	22,53,84,96,104, 105,213
155	*Hyptis hirsuta* Kunth (Lamiaceae)	β-caryophyllene (32.8)	211
156	*Hyptis lantanifolia* Poit. (Lamiaceae)	β-caryophyllene (18.1), bicyclogermacrene (25.5), spathulenol (17.8), germacrene D (12.1)	55
157	*Hyptis lophantha* Mart. ex Benth. (Lamiaceae)	type A: α-pinene (31.7), β-pinene (13.3), terpinolene (25.8); type B: α-pinene (26.4), β-pinene (13.8), 1,8-cineole (21.5), bicyclogermacrene (18.3)	55
158	*Hyptis multiseta* Benth. (Lamiaceae)	*cis*-β-guaiene (12.1)	55
159	*Hyptis mutabilis* (Rich.) Brig. (Lamiaceae)	type A: α-phellandrene (18.4), α-pinene (16.8), β-caryophyllene (13.1); type B : *p*-cymene (15.1), β-caryophyllene (12.4), thymol (7.9)	22,46,47,53, 213-216
160	*Hyptis suaveolens* Poit. (Lamiaceae)	1,8-cineole (30.4), γ-elemene (13.6), β-caryophyllene (10.4)	22,53,84,96,104, 105,213
161	*Hyptis velutina* Pohl ex Benth. (Lamiaceae)	β-caryophyllene (24.7) bicyclogermacrene (12.3), p-cymene (10.4)	211
162	*Hyptis villosa* Pohl ex Benth. (Lamiaceae)	bicyclogermacrene (26.6), spathulenol (18.9), germacrene D (8.6)	211
163	*Ichthyothere cunabi* Mart. (Asteraceae)	α-pinene (8.5), myrtenal (6.7), *trans*-pinocarveol (5.1)	22,25-27,84,96, 104,105
164	*Ichthyothere terminalis* (Spreng.) Malme. (Asteraceae)	sabinene (18.0), p-cymene (8.3), α-copaene (6.7); leaves: limonene (35.8), α-pinene (19.8), sabinene (14.8); Fine stems: limonene (19.6), α-pinene (14.0), sabinene (6.9)	22,25-27
165	*Inga edulis* Mart. (Fabaceae)	linalool (20.0), tricosane (11.4), palmitic acid (7.6)	91
166	*Ipomoea asarifolia* Roem. & Schult. (Convolvulaceae)	pentadecane (9.8), palmitic acid (21.8), stearic acid (7.6)	91
167	*Ipomoea fistulosa* Mart. ex Choisy. (Convolvulaceae)	β-caryophyllene (10.7), germacrene D (27.6), palmitic acid (8.9), heneicosane (10.6)	91
168	*Jacaranda copaia* (Aubl.) D. Don. (B ignoniaceae)	1-octen-3-ol (14.6), nonanal (7.1), germacrene D (16.7), bicyclogermacrene (9,9)	91
169	*Jasminum officinale* L. (Oleaceae)	benzyl acetate (8,0), benzyl benzoate (8,6), phytol (13,8), (E)-phytil acetate (6.8)	91
170	*Jatropha curcas*L. (Euphorbiaceae)	2-heptanone (7.2), linalool (14.8), pentacosane (39.0)	91
171	*Lantana camara* L. (Verbenaceae)	type A: limonene (16.5), α-phellandrene (16.4), germacrene D (13,2); type B: germacrene D (28,4), germacrene B (9,1), β-caryophyllene (5.6); type C: γ-curcumene + *ar*curcumene (27.6), α-zingiberene (19.2), α-humulene (10.7)	22,59,91,218-220
172	*Lecythis usitata* Miers (Lecythidaceae)	phenylacetaldehyde (28.2), linalool (22.1), phenyl ethyl alcohol (40.8)	91,157
173	*Licania tomentosa* Benth. (Chrysobalanaceae)	hexanol (11,1) pentyl isobutirate (7.4), 4-heptanol (10,5) hexanal (7,1)	221,222
174	*Licaria armeniaca* (Nees) Kost. (Lauraceae)	type A: (*E*)-β-farnesene (11.9), β-bisabolol (10.3) *trans*-α-bergamotene (9.2); type B: β-caryophyllene (20.7) α-copaene (14.5), caryophyllene oxide (13.7)	223
175	*Licaria guianensis* Aubl. (Lauraceae)	type A: spathulenol (15.0), borneol (10.7), α-cadinol (7,8); type B: limonene (14.4), β-caryophyllene (10.9); type C: α-selinene (15.5), β-caryophyllene (9.8)	223
176	*Licaria macrophylla* (A.C. Smith) Kost. (Lauraceae)	sesquiterpene alcohol (40.0), elemol (25.0)	224
177	*Licaria puchury-major* (Mart.) Kost. (Lauraceae)	safrole (36.1) 1,8-cineole (24.1) limonene (12.2) α-terpineol (10.7)	225-228

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
178	*Licaria rigida* Kosterm. (Lauraceae)	β-caryophyllene (59.4), caryophyllene oxide (12.1), α-humulene (7.8)	22
179	*Lippia alba* (Mill.) N.E. Br. (Verbenaceae)	flowers: myrcene (46.1), γ-terpinene (8.0), α-guaiene (5.9) type A: 1,8-cineole (34.9), carvone (28.6), limonene (18.4); type B: limonene (29.3), carvone (28.1), germacrene D (19.8), myrcene (10.0); type C: germacrene D (25.4), geranial (22.5), neral (13.7), β-caryophyllene (10.2)	22,60,91,218,229
180	*Lippia lacunosa* Mart. & Schauer (Verbenaceae)	bicyclogermacrene (15.1), germacrene A (10.3), β-caryophyllene (8.5), β-elemene (8.0)	211,230
181	*Lippia lupulina* Cham. (Verbenaceae)	myrcene (6.6), α-copaene (6.2), β-caryophyllene (10.2), germacrene D (12.9), bicyclogermacrene (15.4)	91,211,230-232
182	*Lippia gracilis* Schauer (Verbenaceae)	thymol (38.9) p-cymene (11.3), β-caryophyllene (9.3)	211,230
183	*Lippia grandis* Schau. (Verbenaceae)	thymol (65.8), methylthymol (11.5), p-cymene (6.6)	22,61,218,220,224
184	*Lippia glandulosa* Schauer (Verbenaceae)	type A: *trans*-α-bergamotene (19.3), α-alaskene (16.0), β-caryophyllene (17.3); type B: β-caryophyllene (41.2), (E)-nerolidol (23.6); type C: β-caryophyllene (59.4); type D: thymol (78.1)	211,230,234,235
185	*Lippia origanoides* HBK (Verbenaceae)	*p*-cymene (27.8), α-terpinene (22.4), thymol (20.6)	236,237
186	*Lippia schomburgkiana* Schauer (Verbenaceae)	1,8-cineole (64.1%), α-terpineol (12.0%)	238,239
187	*Mangifera indica* L. (Anacardiaceae)	variety A: terpinolene (45-66); variety B: δ-3-carene (57-71) variety C: myrcene (30-57)	46,47,91,240,241
188	*Maranta ruiziana* Körn (Marantaceae)	germacrene B (28.0), bicyclogermacrene (12.0), β-caryophyllene (10.5)	22
189	*Melampodium camphoratum* Baker (Asteraceae)	type A: α-phellandrene (20.5), camphor (15.0), β-caryophyllene (8.9); type B: terpinolene (30.3), limonene (13.8), δ-3-carene (13.2)	22,63,242,243
190	*Mentha piperita* L. (Lamiaceae)	β-phellandrene (26.0), α-pinene (12.5), β-pinene (9.6)	22
191	*Mentha rotundifolia* (L.) Huds. (Lamiaceae)	linalyl acetate (32.4), linalool (41.9)	364
192	*Miconia ciliata* (Rich.) DC. (Melastomataceae)	hexyl acetate (8.4), *p*-cymene (10.3), butyl hexanoate (7.3), (*E*,*E*)-α-farnesene (14.7)	91
193	*Miconia minutiflora* (Bonpl.) DC. (Melastomataceae)	α-copaene (22.8), β-caryophyllene (14.5), *trans*-α-bergamotene (6.5), α-humulene (12.2), β-curcumene (7.9)	91
194	*Miconia rubiginosa* (Bonpl.) DC. (Melatomataceae)	nonanal (18.5), α-copaene (32.9)	91
195	*Mikania amara* (Vahl.) Willd. (Asteraceae)	type A: tetradecanal (26.3), dodecanal (25.3), dodecanol (15.7) type B: dodecanal (53.7), tetradecanal (14.8), dodecanol (9.0)	22,244-246
196	*Mikania banisteriae* DC. (Asteraceae)	α-pinene (43.3), δ-cadinene (4.1)	22,246
197	*Mikania lindleyana* A. DC. (Asteraceae)	type A: α-phellandrene (23.5), limonene (11.9), germacrene D (10.6), α-thujene (8.2); type B: α-phellandrene (30.6), α-thujene (23.0), α-pinene (13.0); type C: myrcene (62.2), caryophyllene oxide (20.6) type D: β-caryophyllene (64.1), cedr-8(15)-en-9-α-ol (17.9)	247-248
198	*Mikania congesta* DC. (Asteraceae)	β-cubebene (19.5), β-caryophyllene (16.0), germacrene D (12.9)	22,246
199	*Monopteryx uaucu* Spruce (Fabaceae)	methyleugenol (39.0) elemicin (29.6) methylchavicol (13.7) monoterpenes (12,.9)	84,96,104,105,249

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
200	*Murraya paniculata* (L.) Jacq. (Rutaceae)	β-caryophyllene (16.0), germacrene D (7.0)	91
201	*Myrcia bracteata* (Rich.) DC. (Myrtaceae)	type A: (*E*)-β-farnesene (33.9) β-curcumene (9.8) β-bisabolol (8.2); type B: (*E*)-nerolidol (80.8) type C: spathulenol (31.0), germacrene B (8.8)	250-252
202	*Myrcia citrifolia* (Aubl.) Urb. (Myrtaceae)	α-pinene (8.9), α-cadinol (9.1), β-pinene (9.5)	187,252
203	*Myrcia cuprea* Kiaersk. (Myrtaceae)	type A: β-caryophyllene (39.1), α-pinene (15.9), myrcene (12.2); type B: β-caryophyllene (19.9), myrcene (48.6)	84,96,104,105, 138,251,252
204	*Myrcia eximia* DC. (Myrtaceae)	β-caryophyllene (45.7)	138,187,251,252
205	*Myrcia fallax* (Rich.) DC. (Myrtaceae)	type A: germacrene D (27.7), δ-cadinene (12.5) bicyclogermacrene (14.6); type B: spathulenol (42.4), β-elemene (17.4); type C: myrcene (85.0)	251,252
206	*Myrcia multiflora* (Lam.) DC. (Myrtaceae)	α-santalene (43.9), *trans*-α-bergamotene (14.6) (*E*)-β-farnesene (8.5)	251,252
207	*Myrcia poliantha* D.C. var. *coriacea* Berg. (Myrtaceae)	neral (28.0), geranial (50.2), sesquiterpenes (14.6)	138,165-167
208	*Myrcia speciosa* (Amsh.) McVaugh (Myrtaceae)	germacrene D (30.3), β-caryophyllene (13.0), bicyclogermacrene (8.2), δ-elemene (8.0)	252
209	*Myrcia sylvatica* (G. Meyer) DC. (Myrtaceae)	type A: α-cadinol (9.4), β-bisabolene (14.7), spathulenol(30.3); type B: α-calacorene (11.5), *cis*-calamenene (30.1), spathulenol(18.7); type C: selin-11-en-4-α-ol (24.7), caryophyllene oxide (16.6), spathulenol (13.8)	251,252
210	*Myrciaria glomerata* Berg. (Myrtaceae)	germacrene D (41.7), α-cadinol (10.7), β-elemene (7.6)	253
211	*Ocimum basilicum* L. (Lamiaceae)	thymol (16.7), *p*-cymene (14.2), 1,8-cineole (13.8), β-bisabolene (11.5)	22,254
212	*Ocimum gratissimum* L. (Lamiaceae)	flowers: 1,8-cineole (18.4), eugenol (14.8), β-caryophyllene (10.0), bicyclogermacrene (11.6) type A: *p*-cymene (29.7), (*E*)-β-farnesene (19.0), thymol (13.1) type B: methyleugenol (46.8), eugenol (19.3), β-caryophyllene (5.5) type C: eugenol (33.6), β-caryophyllene (12.9), 1,8-cineole (9.0)	22,25,91,213,255
213	*Ocimum micranthum* Willd. (Lamiaceae)	flowers: limonene (10.3), linalool (8.2), carvone (19,1), (*E*)-methyl cinnamate (14.5), β-elemene (23.1), β-caryophyllene (23.0), isoeugenol (15.9)	22,25,46,47,91,99, 100,213,256
214	*Ocimum minimum* L. (Lamiaceae)	type A: methylchavicol (34.7), 1,8-cineole (16.4), linalool (4.5); type B: methylchavicol (42.1), linalool (29.4), limonene (10.6); type C: (*E*)-methyl cinnamate (60.6), carvone (12.7), (*Z*)-cinnamate methyl (7.3)	22,25,46,213
215	*Ocotea cymbarum* Aubl. (Lamiaceae)	α-selinene (25.8), δ-cadinene (18.6), terpinen-4-ol (9.0)	22,111,257
216	*Ocotea fasciculata* (Nees) Mez (Lauraceae)	type A: elemol (24.0), β-elemene (18.8), β-eudesmol (11.7); type B: β-elemene (8.7), α-cadinol (17.1), elemol (16.7)	258
217	*Ocotea longifolia* H.B.K. (Lauraceae)	δ-cadinene (20.0), dillapiole (15.2), α-cubebene (6.5)	22,111,258
218	*Ocotea petalanthera* (Meissn.) Mez (Lauraceae)	β-pinene (43.9) sesquiterpenes (31.5) *p*-cymene (11.1)	84,96,105
219	*Oncidium lanceanum* Lindl. (Orchidaceae)	*m*-cresol (12.7), nonanal (12.0), methyl salicylate (9.0), hexyl benzoate (16.1), tetradecanol (17.6)	91
220	*Ormosia flava* (Ducke) Rudd. (Fabaceae)	benzyl salicylate (76.7), benzyl benzoate (19.1)	84,96,104,105
221	*Pachira aquatica* Aubl. (Bombacaceae)	β-caryophyllene (11.5), (*E*,*E*)-α-farnesene (19.2),	91,196,259

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
222	*Parkia oppositifolia* Spr. ex-Benth. (Fabaceae)	methyl salicylate (71.4)	22,46,47,165-167, 260
223	*Passiflora edulis* Sims (Passifloraceae)	benzaldehyde (82.3)	91
224	*Patinoa paraensis* (Huber) Cuatrec. (Bombacaceae)	aroma concentrate: (*Z*)-3-hexanol (51.7), cyclopentanol (29.1).	261
225	*Pectis elongata* Kunth (Asteraceae)	type A: limonene (13.5), elemicin (11.5), cubebol (9.7), myrcene (8.3); type B: perilalldehyde (64.6)	191,262,263
226	*Peperomia circinnata* Link var. *circinnata* (Piperaceae)	limonene (13.5), elemicin (11.5), cubenol (9.7), myrcene (8.3)	22,264
227	*Peperomia glabella* var. *glabella* (Sw.) A. Dietr. (Piperaceae)	β-caryophyllene (15.1), selina-3,7(11)-diene (9.6)	66
228	*Peperomia macrostachya* (Vahl) A. Dietr. (Piperaceae)	type A:limonene (38.3), spathulenol (33.7) type B: *epi*-α-bisabolol (15.9%), caryophyllene oxide (12.9%), myristicin (7.6%), limonene (5.4%)	66,67
229	*Peperomia magnoliifolia* (Vahl.) A. Dietr. (Piperaceae)	type A: myrcene (69.0) type B: selin-11-en-4-α-ol (12.9)	66
230	*Peperomia muscosa* Link (Piperaceae)	melaleucol (52.7), α-selinene (13.9), β-elemene (10.9)	66
231	*Peperomia pellucida* Kunth (Piperaceae)	dillapiole (55.3), (*E*)-caryophyllene (14.3%), carotol (8.1%)	22,265-266
232	*Peperomia rotundifolia* (L.) Kunth (Piperaceae)	decanal (43.3), dihydro-β-santalol (9.0%), (*E*)-nerolidol (7.9%), limonene (7.7%).	66,67
233	*Peperomia serpens* (Sw.) Loud. (Piperaceae)	(*Z*)-nerolidol acetate (47.6) (*E*)-nerolidol (42.6)	267,268
234	*Petiveria alliacea* L. (Phytolacaceae)	benzaldehyde (54.6), dibenzyl disulfide (18,0)	21,91,94
235	*Petrea volubilis* L. (Verbenaceae)	1-octen-3-ol (14,5), phenylacetaldehyde (8.6), linalool (16.5), methyl salicylate (13.3), heptadecane (15.5), heneicosane (10.0)	91
236	*Pilocarpus microphyllus* Stapf (Rutaceae)	type A: β-caryophyllene (23.9), 2-pentadecanone (20.8), 2-undecanone (20.4), germacrene D (6.6); type B: 2-tridecanone (25.4), β-caryophyllene (6.7), germacrene D (6.8)	22,270
237	*Piper aduncum* L. (Piperaceae)	type A: dillapiole (31.5), piperitone (15.1), terpinen-4-ol (11.0); type B: dillapiole (50.8), piperitone (13.9), terpinen-4-ol (7.3); type C: dillapiole (56.3), piperitona (7.0); type D: dillapiole (82.9); type E: dillapiole (86.9); type F: dillapiole (91.1); type G: dillapiole (97.3); type H: dillapiole (88.1)	68-73,84,96,104, 105,271-280,298
238	*Piper aduncum* L. var. *cordulatum* (Piperaceae)	dillapiole (88.4)	84,96,104,105
239	*Piper amapense* Yuncker (Piperaceae)	β-caryophyllene (25.0), caryophyllene oxide (17.0), β-selinene (15.0)	22,281-283,298
240	*Piper anonifolium* (Kunth) C. DC. (Piperaceae)	type A: α-pinene (53.1), β-pinene (22.9) type B: α-eudesmol (33.5), ishwarane (19.1), germacrene D (9.6)	284,285,298
241	*Piper arboreum* Aubl. (Piperaceae)	carvacrol (44.0), β-caryophyllene (14.0), γ-terpinene (11.0)	22,298
242	*Piper bartlingianum* (Miq.) C.DC. (Piperaceae)	α-cadinol (11.2), β-elemene (10.5), α-muurolol (9.4), (*E*)-nerolidol (9.0)	22,281-283,298
243	*Piper callosum* Ruiz & Pav. (Piperaceae)	safrole (64.0), β-pinene (12.9), α-pinene (6.9)	22,71,74,75,76,84,96, 104,105,272,279, 286-288,299
244	*Piper cavalcantei* Yuncker (Piperaceae)	safrole (69.0) terpenes (23.0)	165-167,271

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
245	*Piper cyrtopodon* (Miq.) C. DC. (Piperaceae)	type A: β-caryophyllene (19.2), bicyclogermacrene (13.0), germacrene D (10.0); type B: curzerene (15.0), germacrene D (17.9), bicyclogermacrene (8.3); type C: β-caryophyllene (34.6), bicyclogermacrene (21.4), germacrene D (13.6); type D: elemicin (26.8), β-caryophyllene (18.8), germacrene D (14.8), bicyclogermacrene (14.0); type E: *epi*-β-bisabolol (26.3), bicyclogermacrene (8.3), germacrene D (7.3)	280,289,290,298
246	*Piper crassinervium* H.B.K. (Piperaceae)	β-caryophyllene (17.7), germacrene A (14.4), β-elemene (10.9)	22,291,298
247	*Piper dactylostigmum* Yuncker (Piperaceae)	α-cadinol (21.7), β-selinene (9.0), β-caryophyllene (8.9)	22,292,293,298
248	*Piper demeraranum* (Miq.) C. DC. (Piperaceae)	limonene (40.3), sabinene (22.7), β-pinene (14.4)	294,295,298
249	*Piper dilatatum* Rich. (Piperaceae)	(*E*)-nerolidol (10.7), spathulenol (11.8), germacrene D (12.6)	297,298
250	*Piper divaricatum* Meyer (Piperaceae)	methyleugenol (72.9), eugenol (9.3), safrole (6.7)	22,77,78,288
251	*Piper duckei* C. DC. (Piperaceae)	β-caryophyllene (23.5), caryophyllene oxide (18.4), β-eudesmol (9.4)	22,280-283
252	*Piper enckea* C. CD. (Piperaceae)	benzaldehyde (80%)	277,299
253	*Piper erectipillum* Yuncker (Piperaceae)	(*E*)-nerolidol (50.5), limonene (26.8)	298,300
254	*Piper gaudichaudianum* Kunth (Piperaceae)	type A: α-selinene (16.6), β-selinene (15.7), α-humulene (13.3) type B: α-humulene (29.2), β-caryophyllene (19.3)	301
255	*Piper grandulosissimum* Yuncker (Piperaceae)	β-cariophyllene (10.7), (E)-nerolidol (20.3), α-cadinol (7.0), α-selinene (6.7)	298,302,303
256	*Piper hispidinervum* C. DC. (Piperaceae)	safrole (76.0-95.0)	22,74,,75,84, 96,99,100,104,105, 271,286-288,298, 304-308
257	*Piper hispidum* Sw. (Piperaceae)	*p*-cymene (35.0), β-selinene (11.9), α-selinene (10.0)	288,298,309
258	*Piper hostmannianum* (Miq.) C. DC. (Piperaceae)	β-caryophyllene (23.4), β-pinene (16.8), 1,8-cineole (13.2)	22,99,100,277,298
259	*Piper manausense* Yuncker (Piperaceae)	type A: bicyclogermacrene (41.0), α-pinene (9.1); type B: spathulenol (15.0), globulol (9.4), bicyclogermacrene (7.8)	298,310,311
260	*Piper marginatum* Jacq. (Piperaceae)	type A: safrole (63.9); B: *p*-mentha-1(7),8-diene (22.9), 3,4-methylenedioxypropiophenone (40.7); type C: β-caryophyllene (10,6), 3,4-methylenedioxypropiophenone (22.9); type D: α-copaene (11.4), β-caryophyllene (10.2), 3,4-methylenodioxypropiophenone (10.4); type E: (*E*)-anethole (13,6), isoosmorhizole (24.5), (*E*)-isoosmorhizole (46.8); type F: 2-methoxy-4,5-methylenedioxi propriophenone (26.3), methoxy-4,5-methylenedioxypropiophenone isomer (21.9), (*E*)-isoosmorhizole (15.8); type G: β-caryophyllene (13.6), (*E*)-asarone (10.8), bicyclogermacrene (11.7), (*Z*)-asarone (8.8)	70,79-81,224,277,298,312
261	*Piper mastersianum* C. DC. (Piperaceae)	β-caryophyllene (26.6), caryophyllene oxide (19.9), α-cadinol (5.7)	298,313
262	*Piper millegranum* Yuncker (Piperaceae)	type A: α-selinene (11.5), β-selinene (8.7), limonene (7.3), spathulenol (6.7); type B: β-pinene (16.3), α-pinene (10.4), spathulenol (6.3); type C: bicyclogermacrene (22.3), dillapiole (14.8), spathulenol (14.6), germacrene D (10.5)	298,313

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
263	*Piper nigrispicum* C. DC. (Piperaceae)	spathulenol (35.5), bicyclogermacrene (15.1), α-copaene (7.0), β-caryophyllene (4.9)	298,315
264	*Piper ottonoides* (Wendl.) Schum. (Piperaceae)	bicyclogermacrene (38.0), β-caryophyllene (10.9), limonene (1.9) β-pinene (1.7)	84,96,104,105, 298,315
265	*Piper piresii* Yuncker (Piperaceae)	(*E*)-nerolidol (29.3), α-humulene (8.9), selin-11-en-4-α-ol (4.3), β-elemene (15.8)	298,313
266	*Piper plurinervosum* Yuncker (Piperaceae)	1,8-cineole (31.6), α-cadinol (8.5), β-caryophyllene (6.6)	22,94,292,293,298
267	*Piper regnellii* (Miq.) C. DC. (Piperaceae)	β-caryophyllene (23.4), spathulenol (11.1), (*E*)-nerolidol (13.7)	298,301
268	*Piper reticulatum* L. (Piperaceae)	β-elemene (24.6), β-caryophyllene (16.7), β-pinene (7.5)	22,291,298,316
269	*Piper schwackei* C. DC. (Piperaceae)	type A: β-caryophyllene (37.1), germacrene D (21.6), bicyclogermacrene (13.8); type B: α-cadinol (21.4), δ-cadinene (20.0), *epi*-α-muurolol (10.2); type C: α-copaene (21.1), spathulenol (16.3), α-cubebene (10.7)	277,298,317,318
270	*Piper tuberculatum* L. var. *tuberculatum* Jacq. (Piperaceae)	type A: limonene (36.1), α-pinene (19.1) β-caryophyllene (10.7), β-pinene (13.9); type B: limonene (42.2), α-pinene (8.8), (*E*)-β-ocimene (9.6); type C: (*E*)-β-farnesene (12.4) β-pinene (8.2), spathulenol (7.6); type D: β-caryophyllene (45.4) caryophyllene oxide (39.3)	298,319
271	*Piper vitaceum* Yuncker (Piperaceae)	limonene (33.2), (*E*)-nerolidol (20.6), *p*-cymene (12.8)	22,288,292,293,298
272	*Platymiscium trinitatis* Benth. (Fabaceae)	linalool (15.5), phenylethyl alcohol (6.2), heptadecane (10.7), methyl tetradecanoate (11.9)	91
273	*Pluchea sagittalis* (Lam.) Cabrera (Asteraceae)	spathulenol (13.8) β-selinene (11.2) bicyclogermacrene (9.8)	246,320,321
274	*Poecilanthe parviflora* (Fabaceae)		165-167
275	*Pogostemon heyneanum* (Lamiaceae)	patchoulyl alcohol (67.2), α-guaiene (11.5) aromadendrene (22.1), δ-guaiene (18.0)	22
276	*Porophyullum ruderale* Cass. (Asteraceae)	type A: camphor (32.5) 1,8-cineole (24.9) α-pinene (9.0) type B: β-caryophyllene (18.6), germacrene D (14.6) bicyclogermacrene (12.6); type C: octyl-cyclopropane (14.0), spathulenol(10.1)	246,320,321
277	*Pothomorphe peltata* (L.) Miq. (Piperaceae)	β-caryophyllene (37.5), germacrene D (11.9), heneicosane (10.2), (*E*)-nerolidol (9.1)	22,322,323
278	*Pothomorphe umbellata* (L.) Miq. (Piperaceae)	germacrene D (27.4), β-caryophyllene (14.8), δ-cadinene (13.3), bicyclogermacrene (11.5)	22,323
279	*Pouteria caimito* (Ruiz & Pavon) Radk. (Sapotaceae)	type A: 3-metoxy-acetophenone (48.6), 2-methyl butenoate (12.8), palmitic acid (15.5); type B: α-copaene (27.7), hexadecyl acetate (19.0), palmitic acid (12.4)	324
280	*Pouteria pariry* (Ducke) Baehni (Sapotaceae)	methyl-2-methyl butanoate (50.5), 2-methylpropanoate (26.8)	324,325
281	*Protium heptaphyllum* (Aubl.) March. (Burseraceae)	β-elemene (22.1), α-terpinolene (15.5), β-caryophyllene (11.1)	22,326-328
282	*Protium guianense* (Aubl.) Marchand (Burseraceae)	spathulenol (28.1), β-selinene (27.5), caryophyllene oxide (7.9), α-copaene (6.3), β-gurjunene (5.3), bicyclogermacrene (5.0)	328
283	*Protium paraense* Cuatrec. (Burseraceae)	α-pinene (50.5) sesquiterpenes (26.5)	84,96,104,105
284	*Protium spruceanum* (Benth.) Engl. (Burseraceae	leaves and fine stems: sabinene (33.9), β-caryophyllene (10.8), terpinen-4-ol (10.3) bark: sabinene (33.8), limonene (19.4), terpinen-4-ol (7.5) oil-resin: *epi*-α-cadinol (20.4), camphor (14.5), limonene (7.9) fruits: sabinene (56.1), limonene (22.1)	22,329
285	*Protium subserratum* Engl. (Burseraceae)	β-phellandrene (56.3), α-phellandrene (20.8), α-pinene (8.5)	22,330,331

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
286	*Prunus myrtifolia* (L.) Urban (Rosaceae)	Benzaldehyde (87.0)	332-334
287	*Psidium acutangulum* DC. (Myrtaceae)	α-pinene (14.8), β-pinene (10.1), 1,8-cineole (12.9)	335
288	*Psidum guajava* L. (Myrtaceae)	α-pinene (23.9), β-bisabolol (9.2)	335
289	*Psidium guineense* Sw. (Myrtaceae)	β-bisabolol (17.4), epi-α-bisabolol (6.7)	335
290	*Psidium striatulum* DC. (Myrtaceae)	β-caryophyllene (28.6)	335
291	*Quassia amara* L. (Simaroubaceae)	(*Z*)-3-hexenol (44.8), hexanol (7.1), nonane (13.8), heptacosane (15.7)	91
292	*Quisqualis indica* L. (Combretaceae)	methyl nicotinate (7.0), (*E,E*)-α-farnesene (20.0), methyl linolate (6.5)	91
293	*Renealmia alpinia* (Rottb.) Maas (Zingiberaceae)	leaves: β-caryophyllene (22.9), β-pinene (12.0), spathulenol (10.0), alloaromadendrene (8.3); fine stems: aloaromadendrene (15.7), spathulenol (12.1), germacrene D (9.9), β-pinene (9.5), γ-cadinene (9.1); fruits: β-phellandrene (60.4), β-pinene (19.8)	361
294	*Renealmia floribunda* Schum. (Zingiberaceae)	β-pinene (28.0), myrtenal (5.7), *trans*-pinocarveol (5.1)	97,98
295	*Sagotia racemosa* Baill. (Euphorbiaceae)	α-himachalene (7.9), oxygenated sesquiterpenes (35.0)	336
296	*Scleria hirtella* Swartz Cyperaceae)	n-nonanal (43.6) geranial (26.3) neral (16.0)	337
297	*Senna multijuga* H.S. Irwin & Barneby (Caesalpinaceae)	1,4-dimethoxybenzene (12.3), benzyl tiglate (25.8), benzyl benzoate(7.3), pentacosane (8.2)	91
298	*Senna siamea* H.S. Irwin & Barneby (Caesalpinaceae)	unidentified sesquiterpenes (68)	91
299	*Sesamum indicum* L. (Pedaliaceae)	β-caryophyllene (31.6), α-humulene (18.6), germacrene D (12.8), palmitic acid (7.3)	91
300	*Siparuna amazonica* Mart. ex A. DC. (Monimiaceae)	type A: spathulenol (20.7), β-bourbonene (3,4), β-elemene (3,7) type B: spathulenol (9.9), germacrene D (4.7), germacrene B (4.5)	99,100,338
301	*Siparuna cuspidata* (Tul.) A. DC. (Monimiaceae)	β-caryophyllene (19.3)	99,100,338
302	*Siparuna guianensis* Aubl. (Monimiaceae)	type A: *epi*-α-bisabolol (25.1), spathulenol(15.7), α-pinene (6.3); type B: spathulenol (22.0), selin-11-en-4-α-ol (19.4), elemol (10.0), β-eudesmol (10.0); type C: atractilone (31,4), germacrone (23,2), germacrene D (10.9), bicyclogermacrene (8.6)	22,338-340
303	*Solanum sessiliflorum* Dun. (Solanaceae)	safrole (40.3), palmitic acid (18.2)	341
304	*Spondias dulcis* Parkinson (Anacardiaceae)	α-pinene (62.9), β-pinene (13.8)	22,342
305	*Spondias mombin* L. (Anacardiaceae)	aroma concentrate: 3,7-dimethyl-1,5,7-octatrien-3-ol (8.4), dendrolasin (5.0) α-copaene (27.5), δ-cadinene (11.9), α-selinene (9.4), β-selinene (7.2)	22,46,47,342
306	*Spondias purpurea* L. (Anacardiaceae)	limonene (60.8)	342
307	*Stachytarpheta cayennensis* (Rich.) Vahl. (Verbenaceae)	1-octen-3-ol (49.8)	91
308	*Stenocalyx michelii* (Lam.) O. Berrg. (Myrtaceae)	myrcene, limonene, *cis*-β-ocimene, linalool, β-caryophyllene, germacrene B, α-cubebene, germacrene C (15), oxygenated sesquiterpenes (60%).	99,100,138,345

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
309	*Tagetes erecta* L. (Asteraceae)	(*E*)-myroxide (5.8), terpinen-4-ol (12.3), piperitone (18.2), β-caryophyllene (5.8)	91
310	*Tanaecium nocturnum* (Barb. Rodr.) Bur. Er K. Sh. (Bignoniaceae)	benzaldehyde (96.0)	84,96,104,105
311	*Tetragastris panamensis* (Engl.) Kuntz (Burseraceae)	β-caryophyllene (27.5), α-pinene (6.7)	22,330,331
312	*Tetrameranthus duckei* R.E. Fr. (Annonaceae)	α-pinene (13.1), β-pinene (13.8)	99,100
313	*Theobroma grandiflorum* Schum. (Sterculiaceae)	octanol (43.0), dodecanol (9.9), palmitic acid (12.5)	91
314	*Theobroma speciosum* Willd. (Sterculiaceae)	geranial (13.6), neral (9.9)	346
315	*Theobroma speciosum* Willd. ex Spreng. (Sterculiceae)	neral (9.9), geraniol (5.7), geranial (13.6)	91
316	*Thevetia peruviana* (Pers.) K.Schum. (Apocynaceae)	heptanal (38.5), nonanal (48.2)	91,95
317	*Tibouchina stenocarpa* (DC.) Cogn. (Melastomataceae)	type A: terpinen-4-ol (11.2), germacrene D (7.9), palmitic acid (22.9); type B: (*E*)-β-ionone (17.2), palmitic acid (22.9)	91
318	*Turnera ulmifolia* L. (Turneraceae)	methyl octadecanoate (8.5), tricosane (8.8), pentacosane (23,.5), heptacosane (28.7)	91
319	*Unxia kubitzki* H. Rob. (Asteraceae)	β-caryophyllene (56.7), germacrene D (13.6)	91
320	*Vernonia condensata* Baker(Asteraceae)	nonane (9.0), cis-linalool oxide (11.0), linalool (17.4), nonanal (6.7)	91
321	*Victoria amazonica* (Poepp.) J.E. Sowerby (Nymphaeaceae)	palmitic acid (18.5), tricosane (23.5), pentacosane (5.9)	91
322	*Viguiera nervosa* Gardn. (Asteraceae)	α-pinene (32.2), β-pinene (21.8), bicyclogermacrene (17.6), spathulenol (10.3)	246,320,321
323	*Virola michelii* Heckel (Myristicaceae)	(*E*,*E*)-α-farnesene (53.3), elemol (7.1)	91,336
324	*Virola sebifera* Aubl. (Myristicaceae)	α-pinene (17.0), (*E*,*E*)-α-farnesene (38.5), (*E*)-nerolidol (8.0)	91,346
325	*Virola surinamensis* (Rol.) Warb. Myristicaceae)	type A: β-caryophyllene (18.7), (*Z*)-β-guaiene (15.8), limonene (11.6), α-pinene (10.5), elemicin (7.8); type B: α-pinene (49.7), myrcene (16.2), terpinolene (9.9); type C: (*E*)-β-ocimene (42.1), α-pinene (13.0), β-pinene (5.6)	22,89,347-348
326	*Vismia cavalcantei* vd Berg (Clusiaceae)	(*Z*)-β-ocimene (42.4)	345
327	*Vismia guianensis* (Aubl.) Pers. (Clusiaceae)	α-pinene (18.8), β-pinene (9.4) β-caryophyllene (16.6)	345
328	*Vitex agnus-castus* L. (Verbenaceae)	aroma concentrate: sabinene (5.7), 1,8-cineole (13.5), α-terpinyl acetate (6.0), (*E*)-β-farnesene (15.3), bicyclogermacrene (6.7); leaf oil: 1,8-cineole (16.2), (*E*)-β-farnesene (11.8), 1,8-cineole (33.5), sabinene (18.5), α-pinene (8.9)	22,91,218,349,350
329	*Voucapoua pallidor* Ducke (Fabaceae)	methyl vouacapenate	351
330	*Xylopia aromatica* (Lam.) Mart. (Annonaceae)	type A: limonene (44.6) α-pinene (24.8), β-pinene (16.7); type B: bicyclogermacrene (36.5), spathulenol(20.5)	352-355
331	*Xylopia cayennensis* Maas (Annonaceae)	α-pinene (29.2), β-pinene (16.5) , bicyclogermacrene (12.5) caryophyllene oxide (14.5)	354,355
332	*Xylopia emarginata* Mart. (Annonaceae)	spathulenol (73.0)	173,354,355
333	*Xylopia nítida* (Annonaceae)	limonene (11.3), γ-terpinene (44.1), *p*-cimene (13.7), α-terpinolene (12.6)	205,354,355

Table 4. continuation

No.	Species	Main constituents (%)	Ref.
334	*Xylopia polyantha* R.E. Fries (Annonaceae)	Monoterpenes (60.9), sesquiterpenes (20.2)	84,96,104,105
335	*Wedelia paludosa* DC. (Asteraceae)	α-pinene (39.1), α-phellandrene (11.8), α-curcumene (9.0)	22,25
336	*Wulffia baccata* (L. f.) Kuntze (Asteraceae)	myrcene (11.8), limonene (13.6), (E)-β-ocimene (17.3), β-caryophyllene (8.8)	91,356,357
337	*Zanthoxylum monogynum* St.-Hil. (Rutaceae)	Citronellal (57.1), limonene (13.8), citronelyl acetate (13.1), citronellol (6.2)	362
338	*Zornia curvata* Mart. (Fabaceae)	β-caryophyllene (30.7), germacrene B (14.3)	358
339	*Zinnia elegans* Jacq. (Asteraceae)	α-phellandrene (5.8), β-caryophyllene (6.0), germacrene D (12.4)	91,356

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