# Chapter 12

## Chemical composition of the essential oil of Hypenia helenoi M.T. Faria

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### ABSTRACT

*Hypenia* has been subject to taxonomic variations, from one botanical section to a genus of Hyptidinae and remaining undivided or divided up into seven infrageneric sections. Essential oils (EOs) constituents of *Hypenia* were described only recently and supported the division of the genus into two taxonomic sections. In this work, the composition of EOs of *H. helenoi* was analyzed using gas chromatography coupled with quadrupole mass spectrometry (GC/MS). Hydrodistillation of aerial parts led to 45 compounds, with emphasis on sesquiterpene hydrocarbons (78%) such as β-element (27%), germacrene D (20%), (*E*)-caryophyllene (7%) and bicyclo germacrene (6%). β-Pinene (4%) was the majority among the monoterpenes (10%), suggesting the mevalonate pathway in EO biosynthesis. Minor constituents such as globular, spathulenol, and humulene epoxide II were rarely identified in the family (Lamiaceae), while other constituents were described for the first time in the genus.

**Keywords:** *Hypenia helenoi*, essential oil, chemical composition, chemosystematics.

### 1 INTRODUCTION

In Brazil and other Cerrado areas of eastern South America, the Lamiaceae Martinov family is mainly represented by the neotropical subtribe Hyptidinae Endl., tribe Ocimeae Dumort. Hyptidinae is characterized by flowers with compressed stamens that form an explosive pollination mechanism (HARLEY, 1988). Patterns of floristic and taxonomic variation and molecular studies led to new evolutionary relationships between taxa, resulting in 19 genera with about 400 species (HARLEY et al., 2004; HARLEY & PASTORE, 2012).

The genus *Hypenia* (Mart. ex Benth.) Harley was initially attributed to about 24 species (HARLEY, 1988) and currently has 28 species (FARIA, 2014) occurring mainly in the Cerrado regions of Goiás state, which is considered the center of the genus' diversity and dispersion with 18 species. Seven of these species are endemic and mainly found in areas of rock formations, in oligotrophic and sandy soils with high levels of aluminum, and exposed to high luminosity. Some *Hypenia* species have modified flowers (ATKINSON, 1999), which seems to be an adaptation to bird pollination (HARLEY & PASTORE, 2012).

*Hypenia* species remained taxonomically indivisible (BENTHAM, 1833; HARLEY, 1988; HARLEY & PASTORE, 2012) or were distributed in two (BENTHAM, 1848; EPLING, 1949; FARIA, 2014), six (ATKINSON, 1999) or seven (BRIQUET, 1896) infrageneric sections. After being elevated to the generic level (HARLEY, 1988), this status was later maintained (FARIA, 2014; HARLEY & PASTORE, 2012) or suggested (ATKINSON, 1999) the transfer of all its species to the genus *Eriope* (Humb. & Bonpl ex Benth.). The botanical keys of *Hypenia* show that characters used for its distinction derived almost exclusively from a limited range of floral characteristics.

*Hypenia* species are aromatic and frequently mentioned in the Brazilian Cerrado for their ethnobotanical use, as an infusion or decoction of leaves in the treatment of flu, common colds, and other respiratory diseases (BRIDI, MEIRELLES & VON POSER, 2021). Essential oils of *Hypenia irregularis* (Benth.) Harley showed a superior repellent action than control (15% N, N-diethyl-m-toluamide) against exposure to *Aedes aegypti* mosquito (POSSEL et al., 2020), while *Hypenia salzmannii* (Benth.) R. Harley showed trypanocidal activity (SOUZA et al., 2017). Other studies have associated the influence of phenology and infrageneric levels on essential oil variations by multivariate analyses (FARIA et al., 2012; JESUS et al., 2022; SILVA et al., 2011).

This article presents the results of the essential oil composition of *H. helenoi* by gas chromatography coupled with mass spectrometry (GC/MS). Chemovariations in essential oils have contributed to species differentiation, in addition to conservation and perspectives of economic use in a sustainable way.

## 2 MATERIALS AND METHODS

### 2.1 COLLECTION AND IDENTIFICATION OF BOTANICAL MATERIAL

Aerial parts of *H. helenoi* in the reproductive stage were collected in May 2011 in Hidrolândia (S 15°27'58.4″; W 47°30'24.7″), Goiás state, Brazil and identified by one of the authors (M. T. F.). Voucher specimens were deposited at the UFG herbarium (No. 45772 and 45773).

### 2.2 EXTRACTION AND CHEMICAL ANALYSIS OF ESSENTIAL OILS

Aerial parts (54 and 70 g) were dried at room temperature for seven days. After drying, the botanical material was pulverized in a Willey knife mill (30 mesh, Tecnal) and subjected to hydrodistillation in a modified Clevenger apparatus for 2 h. Essential oils were collected after the addition of 0.5 mL of hexane (ultra-residue grade, Baker), dried with anhydrous $Na_2SO_4$, and stored in a freezer (-18°C).

Essential oils were analyzed by gas chromatography coupled to a quadrupole mass spectrometer (GC/MS) in a QP5050A equipment (Shimadzu), using a DB-5 fused silica capillary column (30 m x 0.25 mm x 0.25 µm), maintaining a flow rate of 1.0 ml/min of Helium as carrier gas and heating with programmed temperature (60-246°C with a gradient of 3°C/min). The ionization energy was 70 eV and the sample injection volume was 0.5 µl diluted in hexane (20%, ultra-residue grade, Baker). Qualitative analysis was conducted in scan mode with a mass range of 40-400 Da; a split ratio of 1:30 and a speed of 1.0 scan/s. Injector and interface temperatures were maintained at 220°C and 240°C, respectively. A Varian CP3900 with a flame ionization detector (GC/FID) was used for compositional analysis. Chromatographic conditions were the same as those of GC/MS. The carrier gas was $N_2$ and relative percentages were determined from peak areas without the use of correction factors. Identification of oil constituents was performed by comparing mass spectra (ADAMS, 2018) and NIST (1988) libraries, as well as by comparing mass spectra and retention indices (ADAMS, 2017). Arithmetic retention indices (VAN DEN DOOL & KRATZ, 1963) were calculated by co-injection with a linear hydrocarbon ($C_8$-$C_{32}$) mixture (Sigma, St. Louis, USA).

## 3 RESULTS AND DISCUSSION

Extraction of essential oils from *H. helenoi* by hydrodistillation of aerial parts and analysis by GC/MS led to 45 compounds identified by comparison of retention indices and mass spectra with standards (Table 1). The average yield of essential oil was 0.05 ± 0.02% w/w.

Table 1 – Percentage of chemical constituents of *H. helenoi* essential oils

| Code | **Constituent** | **RT**[1] | **AI**[2] | **AI**[3] | **Mean** | **SD**[4] |
|---|---|---|---|---|---|---|
| 1 | α-Thujene | 5.828 | 924 | 924 | 0.13 | 0.04 |
| 2 | α-Pinene | 6.049 | 932 | 932 | 1.75 | 0.80 |
| 3 | Camphene | 6.455 | 946 | 946 | 0.23 | 0.08 |
| 4 | β-Pinene | 7.304 | 978 | 974 | 4.18 | 0.23 |
| 5 | Myrcene | 7.634 | 987 | 988 | 0.10 | 0.01 |
| 6 | δ-3-Carene | 8.357 | 1010 | 1008 | 0.64 | 0.90 |
| 7 | ρ-Cymene | 8.794 | 1020 | 1020 | 0.36 | 0.36 |
| 8 | o-Cymene | 8.809 | 1024 | 1022 | 0.06 | 0.08 |
| 9 | Limonene | 8.989 | 1024 | 1024 | 1.47 | 0.11 |
| 10 | γ-Terpinene | 10.088 | 1054 | 1054 | 0.21 | 0.10 |
| 11 | Terpinolene | 11.226 | 1086 | 1086 | 0.05 | 0.07 |
| 12 | Linalool | 11.625 | 1096 | 1095 | 0.05 | 0.07 |
| 13 | n-Nonanal | 11.780 | 1101 | 1100 | 0.10 | 0.01 |
| 14 | Borneol | 14.443 | 1163 | 1165 | 0.57 | 0.37 |
| 15 | Isobornyl acetate | 19.782 | 1284 | 1283 | 0.50 | 0.39 |
| 16 | δ-Elemene | 22.132 | 1337 | 1335 | 0.41 | 0.01 |
| 17 | α-Cubebene | 22.668 | 1349 | 1345 | 0.28 | 0.06 |
| 18 | α-Copaene | 23.868 | 1374 | 1374 | 2.53 | 0.50 |
| 19 | (*E*)-β-Damascenone | 24.135 | 1383 | 1383 | 0.09 | 0.13 |
| 20 | β-Bourbonene | 24.271 | 1387 | 1387 | 2.89 | 0.45 |
| 21 | β-Elemene | 24.752 | 1389 | 1389 | 26.62 | 0.54 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 22 | (*E*)-Caryophyllene | 25.836 | 1417 | 1417 | 6.62 | 0.05 |
| 23 | β-Copaene | 26.160 | 1427 | 1430 | 0.57 | 0.03 |
| 24 | α-*trans*-Bergamotene | 26.412 | 1434 | 1432 | 0.36 | 0.07 |
| 25 | α-Humulene | 27.212 | 1451 | 1452 | 1.64 | 0.08 |
| 26 | g-Muurolene | 28.183 | 1479 | 1478 | 0.66 | 0.93 |
| 27 | Germacrene D | 28.534 | 1484 | 1484 | 19.86 | 1.21 |
| 28 | β-Selinene | 28.687 | 1489 | 1489 | 3.31 | 0.57 |
| 29 | Bicyclogermacrene | 29.080 | 1500 | 1500 | 6.36 | 0.78 |
| 30 | α-Muurolene | 29.233 | 1501 | 1500 | 0.37 | 0.16 |
| 31 | α-Bulnesene | 29.461 | 1507 | 1509 | 2.63 | 0.35 |
| 32 | γ-Cadinene | 29.742 | 1511 | 1513 | 0.49 | 0.04 |
| 33 | δ-Cadinene | 30.108 | 1521 | 1522 | 1.44 | 0.35 |
| 34 | Germacrene B | 31.508 | 1560 | 1559 | 1.09 | 0.15 |
| 35 | Spathulenol | 32.339 | 1578 | 1577 | 1.55 | 0.25 |
| 36 | Caryophyllene oxide | 32.573 | 1583 | 1582 | 2.15 | 0.83 |
| 37 | β-Copaen-4α-ol | 32.750 | 1586 | 1590 | 0.21 | 0.16 |
| 38 | Globulol | 32.903 | 1589 | 1590 | 0.95 | 0.23 |
| 39 | Humulene epoxide II | 33.579 | 1608 | 1608 | 0.21 | 0.16 |
| 40 | Muurola-4,10(14)-dien-1β-ol | 34.307 | 1631 | 1630 | 0.28 | 0.04 |
| 41 | α-Muurolol (Torreyol) | 34.838 | 1645 | 1644 | 0.60 | 0.03 |
| 42 | Cubenol | 35.017 | 1645 | 1645 | 0.14 | 0.19 |
| 43 | α-Eudesmol | 35.167 | 1655 | 1652 | 0.69 | 0.44 |
| 44 | α-Cadinol | 35.350 | 1656 | 1652 | 2.07 | 0.04 |
| 45 | Eudesma-4(15),7-dien-1β-ol | 36.531 | 1689 | 1687 | 0.33 | 0.08 |
| | Monoterpene hydrocarbons | | | | 9.04 | 0.85 |
| | Oxygenated monoterpenes | | | | 1.14 | 0.13 |
| | Sesquiterpene hydrocarbons | | | | 78.16 | 3.12 |
| | Oxygenated sesquiterpenes | | | | 8.93 | 2.01 |
| | Others | | | | 0.14 | 0.06 |
| | Identified (%) | | | | 97.41 | 0.19 |

[1]Retention time (min). [2]Calculated Arithmetic Index. [3]Arithmetic Index (ADAMS, 2017). [4]Standard Deviation.
Source: Authors (2023)

Essential oils of *H. helenoi*-predominated terpenoid compounds whose biosynthetic pathway is well understood (DUDAREVA et al., 2005; KULHEIM et al., 2011; LICHTENTHALER, 1999; PADOVAN et al., 2014). Briefly, the mevalonate (MVA) and deoxy-xylulose phosphate (DXP) pathways result in the production of isopentenyl pyrophosphate (IPP), the universal precursor of all terpenes (DUDAREVA et al., 2005, LICHTENTHALER, 1999). IPP is isomerized to dimethylallyl pyrophosphate (DMAPP). Subsequently, DMAPP and IPP combine to form a small number of prenyl pyrophosphates (geranyl-PP, neryl-PP, and linalyl-PP).

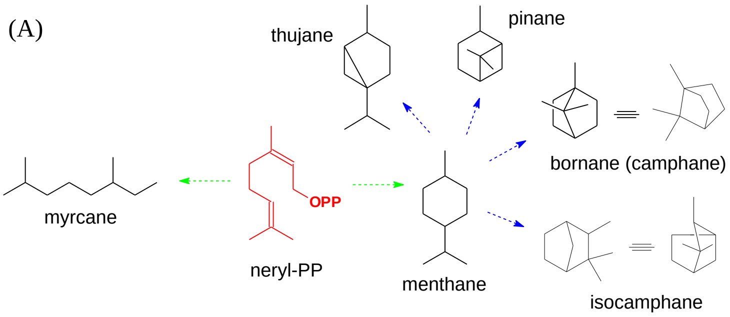
The MVA pathway produces IPP which is the precursor in the synthesis of farnesyl pyrophosphate, used by sesquiterpene and triterpene synthases and is located in the cytosol (DUDAREVA et al., 2005). The DXP pathway produces IPP which is the precursor in the synthesis of geranyl and geranylgeranyl pyrophosphate, used by mono-, di- and tetraterpene synthases, respectively, and is located in the chloroplast (LICHTENTHALER, 1999). Prenyl pyrophosphates, formed by the connection of DMAPP and IPP, are the substrates of terpene synthase enzymes, which make up a large family and catalyze the conversion of a small set of substrates into thousands of terpenes (WISE et al., 1998).

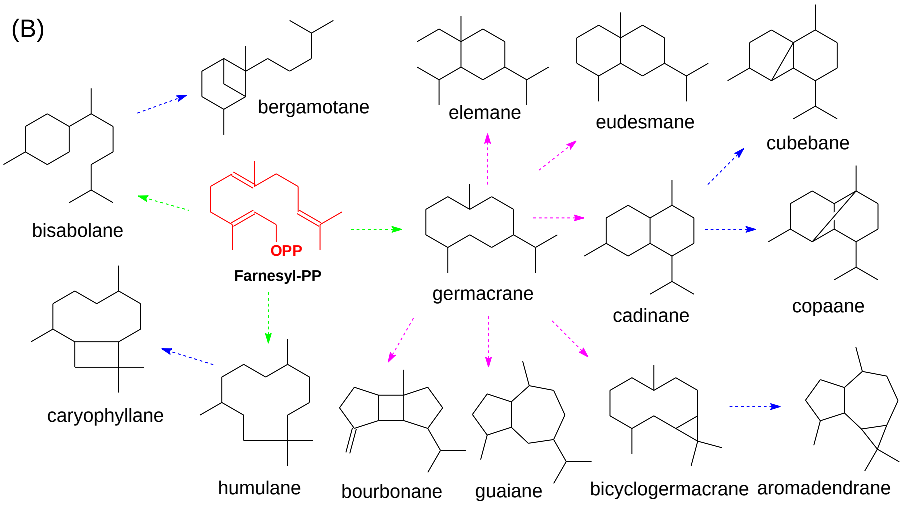
Two points in the biosynthetic pathway influence the qualitative profile of terpenes. First, the ratio of monoterpenes to sesquiterpenes is influenced by the synthesis of geranyl pyrophosphate (GPP) and farnesyl pyrophosphate (FPP), the precursors of monoterpene and sesquiterpenes, respectively. Both are synthesized from the same precursors, but by unique enzymes in different cellular compartments (DUDAREVA et al., 2005; KULHEIM et al., 2011; LICHTENTHALER, 1999). Variations in the efficiency of these enzymes can influence the monoterpene/sesquiterpene ratio (DEGENHARDT, KOLLNER & GERSHENZON, 2009; MCCASKILL & CROTEAU, 1995). Second, terpene profiles can be influenced by the action of terpene synthases with different catalytic regions for the production of a series of terpene skeletons and some enzymes have two areas involved in different steps in the reaction (KOLLNER et al., 2006), which depend on divalent metals as enzymatic cofactors (CROTEAU et al., 2005).

Although they are direct products of terpene synthases, some terpenes are formed by the action of one or more cytochrome P450 enzymes (BOHLMANN & KEELING, 2008; BOUWMEESTER et al., 1999; CROTEAU et al., 2005), acting on the product of the catalyzed reaction by terpene synthases.

Sesquiterpenes were the majority (87.09 ± 1.11%) in the essential oil of *H. helenoi*, with emphasis on sesquiterpene hydrocarbons (78.16 ± 3.12%) such as β-elemene (26.62 ± 0.54%), germacrene D (19.86 ± 1.21%), (*E*)-caryophyllene (6.62 ± 0.05%) and bicyclo germacrene (6.36 ± 0.78%). β-Pinene (4.18 ± 0.23%) was the majority among monoterpenes (10.18 ± 0.98%), suggesting the mevalonate pathway in essential oil biosynthesis with a preponderance of cytosolic terpene synthases (Figure 1).

Figure 1 - Monoterpenes (A) and sesquiterpenes (B) of essential oil from *H. helenoi*





Source: Authors (2023)

Comparative analysis (JESUS et al., 2022) indicated a significant correlation between essential oils from *H. helenoi* and species of *Hypenia* section (FARIA, 2014), such as *H. aristulata*, *H. crispata*, *H. durifolia*, *H. glauca*, *H. macranta*, *H. macrosiphon*, *H. niquelandiensis*, *H. pulchra*, *H. reticulata*, *H. rupestre*, *H. subrosea* and, mainly, *H. calycina*. *H. calycina* is morphologically similar to *H. helenoi*, differing in the shape and size of leaf blade and sizes of petiole, flower calyx and calyx teeth (FARIA, 2014).

Among the major constituents of *H. helenoi* essential oils β-elemene is known for its antitumor and anti-inflammatory effect in clinical trials (XIE et al, 2020), while (*E*)-caryophyllene has wide use in cosmetics (ANDERSEN et al., 2010). Minor compounds such as globulol, spathulenol and humulene epoxide II were rarely identified in species of Lamiaceae family, while another 10 chemical constituents were described for the first time in *Hypenia* genus.

## 4 CONCLUSION

Essential oil of *H. helenoi* is similar to that of species from *Hypenia* section proposed by Faria (2014). Minor oil constituents such as globulol, spathulenol and humulene epoxide II are rare in the family and another ten constituents were described for the first time in the genus.

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