SHORT COMMUNICATION

Chemical composition and antimicrobial activity of essential oils from Acantholippia deserticola, Artemisia proceriformis, Achillea micrantha and Libanotis buchtormensis against phytopathogenic bacteria and fungi

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ABSTRACT

Essential oils from aerial parts of Acantholippia deserticola, Artemisia proceriformis, Achillea micrantha and Libanotis buchtormensis were analysed by GC–MS. The major compounds identified were β-thujone (66.5 ± 0.2%), and trans-sabinyl acetate (12.1 ± 0.2%) in A. deserticola; α-thujone (66.9 ± 0.4%) in A. proceriformis; 1,8-cineole (26.9 ± 0.5%), and camphor (17.7 ± 0.3%) in A. micrantha and cis-β-ocimene (23.3 ± 0.3%), and trans-β-ocimene (18.4 ± 0.2%) in L. buchtormensis. The oils showed a weak antimicrobial effect (MIC > 1.5 mg/ml) on most phytopathogens tested. A moderate antimicrobial activity (MIC between 0.5 and 1.5 mg/ml) was displayed by the oils of A. deserticola, A. micrantha and L. buchtormensis on Septoria tritici and by the oil of A. deserticola on Septoria glycine. The antimicrobial activity was associated to the contents of β-thujone, trans-sabinyl acetate and trans-sabinol. Our results indicate that the tested essential oils have little inhibitory potency not suitable for use as plant protection products against the phytopathogens assayed.

ARTICLE HISTORY

Received 16 April 2015
Accepted 28 August 2015

KEYWORDS

Aspergillus; Erwinia; essential oils; Fusarium; Pseudomonas; Septoria; Xanthomonas

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Supplemental data for this article can be accessed at http://dx.doi.org/10.1080/14786419.2015.1091453.
1. Introduction

Essential oils are complex natural mixtures of volatile secondary metabolites obtained from taxonomically diverse groups of plants (Juliani et al. 2002). They are generally considered as low toxicity for humans and wildlife and environmentally safe. Compared to neem and other botanical antimicrobials, the active ingredients of many essential oils are reasonably priced and are commonly used as flavours and fragrances (Tripathi et al. 2008). Several studies have shown that some essential oils possess biocidal and/or biostatic antimicrobial activities. Moreover, because of the multiple sites of action through which an essential oil can act, the development of microbial resistance is very low (Koul et al. 2008). These advantageous properties and the public concern about the impact of synthetic antimicrobials on the environment and non-target species increase the interest in the identification of new sources of essential oils able to control phytopathogenic micro-organisms.

The medicinal aromatic plants Acantholippia deserticola (Phil) Moldelke, Libanotis buchtormensis (Fisher) DC, Achillea micrantha Willd. and Artemisia proceriformis Krasch are used in folk medicine of several countries (Rojo et al. 2006; Yari et al. 2006; Liang et al. 2007; Abad et al. 2012). A. deserticola is used to treat several gastrointestinal, cardiovascular and central nervous system conditions (Villagran et al. 2003). The essential oils of its aerial parts showed pesticidal potential against mites (Brevipalpus chilensis Baker, and Tetranychus urticae Koch) and the insect pest Aleurothrixus floccosus (Maskell). L. buchtormensis is an herbal remedy against inflammation, rheumatism and the common cold (Liang et al. 2007), A. micrantha has been used against inflammation, and as a vulnerary and wound-healing remedy (Yari et al. 2006). A. proceriformis is used to treat upper airway disorders and its essential oils showed in vitro anti-candidiasis and insect repellent activities (Obistioiu et al. 2014). Some of the medicinal properties of these plants and related species are attributed to their essential oils (Küçükbay et al. 2012; Petretto et al. 2013; Rouis et al. 2013; Venditti et al. 2014; Kazemi & Rostami 2015). The aim of this research was to investigate the chemical composition and antiphytopathogenic activity of the essential oils from aerial parts of A. deserticola, L. buchtormensis, A. micrantha and A. proceriformis.

2. Results and discussion

Steam distillation from aerial parts of A. deserticola yielded 2.80 ± 0.1% (w/w) of essential oil. This yield was 14 times higher than those obtained for the plant materials of A. proceriformis (0.20 ± 0.2%), A. micrantha (0.20 ± 0.1%) and L. buchtormensis (0.15 ± 0.2%). The essential oil yields of both A. deserticola and A. proceriformis were lower than those previously reported (5.5 and 0.40%, respectively). Yields were not found in the literature for the remaining plant species investigated. The chemical composition of the four essential oils is listed in Table 1. As can be seen, A. deserticola, contained mainly β-thujone (66.5 ± 0.2%), and trans-sabinyl acetate (12.1 ± 0.2%); A. proceriformis showed dominance of α-thujone (66.9 ± 0.4%); A. micrantha contained 1,8-cineole (26.9 ± 0.5%) and camphor (17.7 ± 0.3%); and L. buchtormensis showed cis-β-ocimene (23.3 ± 0.3%) and trans-β-ocimene (18.4 ± 0.2%) as major constituents. Previous studies on the essential oil of A. deserticola from Taparaca region in Chile and from San Antonio de los Cobres in Salta province (Argentina) also reported β-thujone as the main component (77.9 and 92.1% respectively) (Torres et al. 1981; Rojo et al. 2006). These oils shared 70 and 100% of their constituents, respectively, with those of the
Table 1. Composition of the essential oils from aerial parts of *A. deserticola*, *A. proceriformis*, *A. micrantha* and *L. buchtormensis*.

| Compounds^a| Rcalc^b| RF^c| *A. deserticola*| *A. proceriformis*| *A. micrantha*| *L. buchtormensis* |
|-------------|--------|------|-----------------|-----------------|-----------------|---------------------|
| cis-salvene | 845    | 847  | 0.5 ± 0.1       | 0.4 ± 0.1       | –               | –                   |
| Tricycleyne | 921    | 921  | –               | –               | 0.3 ± 0.1       | –                   |
| α-Thuyene   | 924    | 924  | –               | 0.2 ± 0.1       | 1.3 ± 0.1       | 0.2 ± 0.0            |
| α-Pineen    | 931    | 932  | 0.7 ± 0.2       | 1.8 ± 0.2       | 5.3 ± 0.2       | 7.9 ± 0.3            |
| α-Fenchene  | 943    | 945  | –               | 0.7 ± 0.1       | –               | –                   |
| Camphene    | 946    | 946  | –               | –               | 6.2 ± 0.2       | 0.5 ± 0.1            |
| Sabinene    | 970    | 969  | 2.8 ± 0.1       | 3.8 ± 0.2       | 6.2 ± 0.3       | 5.8 ± 0.2            |
| β-Pineen    | 973    | 974  | 0.8 ± 0.2       | 0.4 ± 0.1       | 2.5 ± 0.2       | 0.9 ± 0.1            |
| Myrcene     | 989    | 988  | 0.3 ± 0.1       | 0.5 ± 0.1       | 0.7 ± 0.1       | 7.1 ± 0.3            |
| α-Terpineen | 1014   | 1014 | tr              | 0.6 ± 0.1       | 1.8 ± 0.1       | 0.3 ± 0.1            |
| p-Cimene    | 1022   | 1020 | 0.1 ± 0.0       | 1.5 ± 0.1       | 3.5 ± 0.2       | 1.6 ± 0.2            |
| Limonene    | 1024   | 1024 | 0.2 ± 0.1       | –               | –               | 9.9 ± 0.3            |
| β-Phellandrene| 1025  | 1026 | 1.1 ± 0.2       | 0.2 ± 0.0       | 0.1 ± 0.0       | 0.1 ± 0.0            |
| 1,8-Cineole | 1026   | 1026 | 0.1 ± 0.0       | 1.2 ± 0.1       | 26.9 ± 0.5      | –                   |
| cis-β-ocimene| 1034  | 1032 | –               | tr              | 0.1 ± 0.1       | 23.3 ± 0.3           |
| trans-β-ocimene| 1044 | 1044 | 0.3 ± 0.1       | 0.1 ± 0.0       | 0.5 ± 0.0       | 18.4 ± 0.2           |
| γ-Terpineen | 1056   | 1054 | 0.1 ± 0.0       | 1.1 ± 0.1       | 2.8 ± 0.2       | 3.8 ± 0.1            |
| cis-sabinene hydrate | 1065 | 1065 | tr              | –               | 0.8 ± 0.1       | 0.6 ± 0.1            |
| Terpinolene | 1085   | 1086 | 0.3 ± 0.1       | 0.7 ± 0.3       | –               | –                   |
| trans-sabinene hydrate | 1098 | 1098 | –               | 0.5 ± 0.1       | –               | –                   |
| α-Thujone   | 1103   | 1101 | 7.4 ± 0.3       | 66.9 ± 0.4      | –               | –                   |
| Menth-2-em-1-ol-<cis-p> | 1110 | 1118 | –               | 0.2 ± 0.1       | –               | –                   |
| β-Thujone   | 1114   | 1112 | 66.5 ± 0.2      | 4.0 ± 0.3       | –               | –                   |
| Chrysanthenone | 1123 | 1124 | –               | 0.2 ± 0.0       | –               | –                   |
| Thujanol-<iso-3-> | 1132 | 1134 | –               | 0.2 ± 0.1       | –               | –                   |
| trans-pino-carveol | 1134 | 1135 | –               | 0.2 ± 0.0       | –               | –                   |
| trans-sabinol | 1138 | 1137 | 5.4 ± 0.1       | 0.5 ± 0.1       | –               | –                   |
| Ocimene     | 1140   | 1140 | –               | –               | 0.2 ± 0.0       | –                   |
| Camphor     | 1141   | 1141 | –               | 17.7 ± 0.3      | –               | –                   |
| neo-iso-3-thujanol | 1151 | 1147 | 0.1 ± 0.0       | 0.7 ± 0.2       | –               | –                   |
| Sabina ketone | 1154 | 1154 | –               | 0.2 ± 0.0       | –               | –                   |
| Pinocarveol | 1160   | 1160 | –               | 0.3 ± 0.2       | –               | –                   |
| Thujanol-<3-> | 1164 | 1164 | –               | 0.2 ± 0.0       | –               | –                   |
| Borneol     | 1165   | 1165 | –               | –               | 2.7 ± 0.3       | –                   |
| Terpinen-4-ol | 1174 | 1174 | 0.2 ± 0.1       | 1.5 ± 0.2       | 2.9 ± 0.1       | 0.3 ± 0.1            |
| Thuj-3-en-10-al | 1181 | 1181 | –               | 0.2 ± 0.1       | –               | –                   |
| Myrtenal    | 1195   | 1195 | –               | 0.4 ± 0.1       | –               | –                   |
| trans-Carveol | 1215 | 1215 | –               | 0.1 ± 0.0       | –               | –                   |
| Citronellol | 1223   | 1223 | 0.1 ± 0.1       | –               | –               | –                   |
| Carvacrol methyl ether | 1240 | 1241 | –               | –               | 0.3 ± 0.0       | –                   |
| Carvotanacetone | 1247 | 1244 | 0.5 ± 0.1       | –               | –               | –                   |
| Piperitone   | 1247   | 1249 | –               | 0.4 ± 0.1       | –               | –                   |
| iso-3-thujanol acetate | 1270 | 1267 | 0.3 ± 0.1       | –               | –               | –                   |
| Bornyl acetate | 1284 | 1287 | –               | 0.3 ± 0.0       | 0.4 ± 0.1       | –                   |
| trans-sabinyl acetate | 1289 | 1289 | 12.1 ± 0.2     | –               | –               | –                   |
| trans-caryl acetate | 1342 | 1339 | tr              | –               | –               | –                   |
| α-Terpinyl acetate | 1349 | 1346 | 0.5 ± 0.1       | –               | –               | –                   |
| Eugenol     | 1356   | 1356 | –               | 0.1 ± 0.0       | –               | –                   |
| cis-caryl acetate | 1367 | 1365 | 0.2 ± 0.1       | –               | –               | –                   |
| α-Copaene   | 1374   | 1374 | 0.2 ± 0.0       | 1.9 ± 0.1       | 0.4 ± 0.2       | –                   |
| β-Bourbonene| 1387   | 1387 | 0.7 ± 0.1       | 0.3 ± 0.1       | 0.3 ± 0.1       | –                   |
| β-Elemene   | 1389   | 1389 | –               | –               | 1.2 ± 0.1       | –                   |
| Methyl eugenol | 1403 | 1403 | –               | –               | 0.1 ± 0.0       | –                   |
| β-Caryophyllene | 1417 | 1417 | 1.0 ± 0.1       | 0.4 ± 0.1       | 1.2 ± 0.2       | –                   |
| β-Copaene   | 1430   | 1430 | 0.1 ± 0.0       | –               | –               | –                   |
| Aromadendrene | 1439 | 1439 | –               | 0.2 ± 0.0       | –               | –                   |
| trans-β-farnesene | 1440 | 1454 | tr              | –               | 2.0 ± 0.1       | –                   |
| α-Amorphene | 1483   | 1483 | –               | 0.2 ± 0.1       | 0.2 ± 0.0       | –                   |
| Germacrene-D | 1484  | 1484 | 4.2 ± 0.2       | 1.2 ± 0.2       | 1.2 ± 0.2       | –                   |

(Continued)
A. deserticola oil reported here. An oil from dried aerial parts of A. proceriformis collected in the Karaganda Oblast (Kazakhstan) had the same constituents as our sample from the Akmola region, with α-thujone (66.3%) and β-thujone (22.3%) as major components (Suleimenov et al. 2010). In contrast, oils from the aerial part of A. proceriformis collected in Lublin (Poland) contained davanone (16.75%), piperitone (17.51%) and 1,8-cineole (12.54%) as major constituents, with a total of 51% of sesquiterpenes (Kowalski et al. 2007) while a sample from Cuba contained 33.4% of trans-sabinyl acetate with a total of 78.3% monoterpenes (Pino et al. 2011). These oils shared only 26 and 33.4% of their components with those present in our leaf oil of A. proceriformis. As far as we know, this is the first report of the oil composition obtained from leaves of A. micrantha and L. buchtormensis.

The antimicrobial activity of the oils was assayed against strains of A. carbonarius, A. niger, Septoria tritici, Septoria glycines, Fusarium graminearum, Fusarium verticillioides, Erwinia carotovorans, Pseudomonas corrugata, Pseudomonas syringae and Xanthomonas vesicatoria. Prothioconazole, streptomycin, potassium sorbate, calcium propionate and thyme oil were used as reference standards. The results are summarised in Table S1. MIC100 values of essential oils between 0.05 and 0.5 mg/ml indicate a strong antimicrobial activity, while MIC100 values between 0.6 and 1.5 mg/ml and over 1.5 mg/ml reveal a moderate to weak activity, respectively (Sartoratto et al. 2004). In this context, the oils of A. deserticola, A. micrantha and L. buchtormensis on S. tritici and A. deserticola oil on S. glycine showed a

Table 1. (Continued.)

| Compoundsa | Rcalc b | RI c | A. deserticola | A. proceriformis | A. micrantha | L. buchtormensis |
|------------|---------|------|----------------|-----------------|--------------|-----------------|
| β-Selinene | 1489    | 1489 | –              | –               | 0.2 ± 0.0    | 0.2 ± 0.0       |
| α-Zingiberene | 1493  | 1493 | –              | –               | –            | 1.0 ± 0.2       |
| Bicyclogermacrene | 1498 | 1500 | –              | 0.4 ± 0.1      | –            | –               |
| α-Muurolene | 1502    | 1500 | –              | 0.1 ± 0.1      | 0.2 ± 0.1    | 0.2 ± 0.0       |
| β-Bisabolene | 1505   | 1505 | –              | –               | –            | 0.7 ± 0.1       |
| δ-amarphone | 1511    | 1511 | 0.2 ± 0.1      | 0.2 ± 0.0      | –            | –               |
| γ-Cadinene | 1513    | 1513 | –              | –               | –            | 0.2 ± 0.1       |
| β-Sesquiphellandrene | 1521  | 1521 | –              | –               | –            | 2.3 ± 0.1       |
| δ-Cadinene | 1522    | 1522 | –              | 0.4 ± 0.1      | 0.7 ± 0.2    | –               |
| Elemol     | 1548    | 1548 | –              | 0.3 ± 0.1      | –            | –               |
| Germacrene B | 1559   | 1559 | –              | –               | –            | 0.2 ± 0.0       |
| Spathulenol | 1577   | 1577 | –              | –               | 0.2 ± 0.2    | 0.5 ± 0.1       |
| Neryl isovalerate | 1580 | 1582 | –              | –               | –            | –               |
| Caryophyllene oxide | 1582 | 1582 | –              | 0.1 ± 0.0      | 0.4 ± 0.1    | –               |
| β-Eudesmol | 1649    | 1649 | –              | 0.2 ± 0.0      | –            | –               |
| Selin-11-en-4α-ol | 1658  | 1658 | –              | 0.5 ± 0.1      | –            | –               |
| Hydrocarbonated monoterpenes | 5.8 ± 0.1 | 12.5 ± 0.1 | 53.3 ± 0.2 | 80.0 ± 0.1 |
| Oxygenated monoterpenes | 93.3 ± 0.1 | 76.5 ± 0.1 | 32.1 ± 0.1 | 1.6 ± 0.1 |
| Hydrocarbonated sesquiterpenes | 0.2 ± 0.1 | 7.3 ± 0.1 | 5.3 ± 0.2 | 10.2 ± 0.2 |
| Oxygenated sesquiterpenes | – | 1.1 ± 0.1 | 0.6 ± 0.1 | 0.6 ± 0.1 |
| Total | 99.3 ± 0.3 | 97.4 ± 0.2 | 91.3 ± 0.2 | 92.4 ± 0.2 |

aCompounds listed based on elution from a non-polar DB-5 column.
bRetention Index calculated from retention times in relation to those of a series of n-alkanes on a 30 m DB-5 capillary column.
cRetention Index taken from Adams (2007).
dPercentage of total area; tr = traces; – not detected.
moderate antimicrobial effect. The remaining MIC\textsubscript{100} values of the oils indicated a weak inhibitory activity. The \textit{T. vulgaris} oil, known for its high antimicrobial activity, showed a strong inhibitory effect on \textit{Septoria}, a moderate effect on \textit{Fusarium} and \textit{Pseudomonas}, and a weak antimicrobial effect on the other microbial strains tested. The MIC\textsubscript{100} values of streptomycin, prothioconazole and food preservatives were one or more orders of magnitude lower (i.e. more active) than those of the essential oils of the four medicinal plants tested. The Pearson correlation matrix of a principal component analysis based on relative participation of main constituents and MIC\textsubscript{100} values of the essential oils, shows that the increase in contents of β-thujone, \textit{trans}-sabinyl acetate and \textit{trans}-sabinol were inversely correlated ($r^2 > 0.60$, $p = 0.05$) with the increase in the MIC\textsubscript{100} values. This is visualised in the bidimensional graph of component 1 (PC1) and 2 (PC2) of Figure S1 by the obtuse angles between vectors of the mentioned oxygenated monoterpenes and the MIC\textsubscript{100} of the microbial species.

3. Conclusion

The essential oils from aerial parts of \textit{A. deserticola}, \textit{A. micrantha}, \textit{A. proceriformis} and \textit{L. buchtormensis} showed a significant variation in the composition and quantity of their chemical constituents. They displayed moderate or weak antimicrobial activity on the tested phytopathogens.

Disclosure statement

No potential conflict of interest was reported by the authors.

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