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Characterization of three pheromones (α-Bergamotol , β-farnesene, Isobombykol) from Saussurea costus essential oil by Gas chromatography/mass spectrometry

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Short Report

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Abstract

With the need of sustainable agroecosystem, pest management is becoming imperative. Nowadays, it is known that essential oils are potent molecules with high potential for plant protection. These advantages have encouraged scientists to intensively screen for the plants biomolecules as promising candidates for pest management to replace currently used chemical pesticides. The application of such as technology for the removal of these insects has received much attention and led to the development of effective, economic and environmentally friendly technologies. In this study, a metabolomic approach was used to investigate the characterization of three pheromones, identified by gas chromatography-mass spectrometry (GC-MS) as *α-Bergamotol*, β-farnesene, Isobombykol.

Introduction

There has been a growing interest of pheromone research face to the onslaught of various biotic factors. It has been shown that the essential oils of aromatic plants have been used in pest management strategies due to their repellent effects on target insects (Kheloul et al. 2019). Consequently, the application of these technologies depends essentially on understanding the full mechanism of their synthesis and their target action. An increased understanding of these strategies has driven a revolution that is now, more than ever, involvement of known and specific biomolecules.

It is interesting to note that hundreds of pheromones and other semiochemicals were identified and used for monitoring insect's abundance and attack (Witzgall et al. 2010). These semiochemicals compounds are able to mediate interactions either between individuals of the same species (pheromones), or across varied biological entities (allelochemicals) (Tewari et al. 2014). These natural products are increasingly efficient for a long-term reduction of insect populations. When encountering biotic and abiotic stresses, plants are able to adjust various biological activities where the synthesis of hormones is the best way. According to transduction distances and cell neignbouring, three types of signaling processes are known (1) endocrine (2) paracrine and (3) autocrine (Wang and Irving 2011).

The idea of using species-specific behavior-modifying chemicals for the management of noxious insects (insect vectors of diseases in agriculture, horticulture, forestry, and stored products) has been a driving ambition through five decades of pheromone research (Witzgall et al. 2010).

Furthermore, the pest management paradigm has undergone an intentional shift from calendar-based, broad-spectrum insecticide applications (Tewari et al. 2014). Considerable interest has been gained for the development of alternative pest management strategies. Nowadays, attentions are directed towards the use of plants biomolecules or essentials oils as novel biotools.

Essential oils are used with known therapeutic properties. Nevertheless, they have other biological activities that make them able to be used as pesticides (Burfield and Reekie 2005; El Tamer 2002). Essentials oils act as chemical cues with an elicit effect on the behavioural responses of other

organisms. Thus, the use of essential oils has steadily increased in pest management and offers an attractive alternative to replace chemical pesticides.

In this paper, we describe the presence of three pheromones in the essential oil of *Saussurea costus*. As a perennial plant of the *Asteraceae* family, the roots are used as anethnomedicine to cure indigestion, analgesic, abdominal pain, anthelmintic, dyspepsia, fever, and bronchitis (Madhuri et al. 2012). The extracted macromolecules of *S.costus* are characterized by a broad-spectrum activity, including antimicrobial (Hasson et al. 2013), anticancer (Tian et al. 2017), and anti-inflammatory activities (Tag et al. 2016). Besides, these properties, they can be used in pest management.

Finally, case studies are presented in which certain essential oils contain many molecules with pheromones properties. Furthermore, certain compound with such as properties has not been reported previously in this essential oil. In this paper, we describe the isolation and the identification by GC–MS of three pheromones from *Saussurea costus* oil.

Materials And Methods

Plant material preparation

Fresh and healthy rhizomes of 900 g g rhizome (*Costus sp.*) were purchased from the local market of Mascara, Algeria. Samples were identified by an expert in the Department of Biology, Faculty of Nature and Life Sciences (Mascara). Rhizomes were washed with deionized water, redried (55 ± 1°C) and grinded to homogenous powder for the extraction of essential oil.

Oil extraction

Essential oil was extracted by hydro-distillation process using a Clevenger's type apparatus in accordance with the method recommended by European Pharmacopoeia. Light yellow colored oil, with a pleasant odor, was obtained which was separated and dried over the minimum amount of anhydrous sodium sulfate to remove traces of moisture. The essential oil obtained was stored at a low temperature (4 ± 2°C) in the dark for further use.

GC-MS analysis

The *Costus* oil was subjected to GC-MS analysis using a Hewlett-Packard GC-MS system (GC: 5890 séries II, MSD 5972).The ion source temperature used was 230 ◦C and the initial column oven temperature was programmed at 40 ◦ C for 1 min followed by an increase of 5 ◦C/min per min until it reached 220◦C. A 1µLof essential oil M. in hexane was injected in a split less flow using helium as a carrier gas (1 ml/min flow rate). Interpretation of mass spectrum from GC-MS was conducted using the database of National Institute Standard and Technology (NIST) library.

Results And Discussion

GC-MS Analysis

A total of 45 different compounds were identified. The identified compounds with their name, % peak area (%) and retention time (RT) area were categorized to five chemical groups. The identified chemical groups are phenylpropene (30.92%), terpene (24.34%), fatty acids ((25.03%), hydrocarbons (6.4%), phenolics (2, 49%) and others.

Surprisingly, certain compounds have not been reported anywhere in the essential oil *S. costus.* The separation of oil into fractions led to identification of other important components with a pheromone properties such 10, 12-Hexadecadien-1-Ol (Isobombykol) (2.3%) and 1,4,8-Dodecatriene, (E,E,E)- (β-farnesene (0.97%). Their chromatograms are shown in Fig. 1.

Bombykol is sex pheromone for the silkworm moth, Bombyx mori (Butenandt et al. 1959). A previous study by Xu et al. (2012) found that sex pheromone reception in male moths, is highly selective with a panel of bombykol analogs.

The β-farnesene is an alarm pheromone (Marianne and Gerhard Buchbauer 2011) in many aphid species (Hemiptera: Aphididae) (Francis et al. 2005) used extensively by both plants and insects for communication (Crock et al. 1997). As an acyclic sesquiterpenes alkene, β-farnesene was common to green apple and some higher animals (Hazekamp et al. 2016). Furthermore, this pheromone is released by plants when damaged by a predator which warns other individuals that there is a danger. The alarm response of aphids to (E)-β-farnesene has been investigated in Jing-Gong et al. (2002) study, where forty-one aphid species responded to (E)-β-farnesene doses. It has been concluded that the response of aphids to (E)-β-farnesene was related to host-plant species. Present in many essential oils (*Torreya taxifolia*, *Larix leptolepis*, *Robinia pseudoacacia*, *Medicago sativa*, *Chamomilla recutita*,*Vitis vinifera* ,*Cannabis sativa*, and *Menthax piperita* (Crock et al. 1997), (E)-b-Farnesene is produced by socially dominant male mice, by bees (Fernandes et al. 1981), by several genera of ants (Ollet et al. 2014) and other reported insects.

Noteworthy, Terpenes like Bergamotol<(Z)-, alpha-trans-> (α-trans-Bergamotenol) was detected in the essential oil of *Saussurea costus* (0.51%). The presence of this molecule has not been discussed widely in the chemotype of *Saussurea costus*. The Bergamotenes, are important bioactive compounds derived from the EOs of various plant species. Bergamotenes attract predators; as a result plants are able to defend themselves against attack by herbivorous insects.

Based on previous reports, sesquiterpene derivatives are common and characteristic constituents of many *Saussurea* species (Duan et al. 2010). The results of Kheloul et al. (2019) indicate a dose-dependent trade-off between attractive and plant-derived repellent volatiles.

The utility of pheromones in enhancing the propagation of entomopathogenic control agents have received considerable attention (Kreutz et al. 2004; Tinzaara et al. 2007). Furthermore, pheromone baited traps are used for monitoring insecticide resistance in pest populations (Sauphanor et al. 2000).

Based on our study, it may be concluded that *Saussurea costus* is rich in such as pheromones. As described above, the valorization of such volatiles molecules may influence in their potential use in alternative pest management strategies.

Conclusion

There is still a great deal to be learnt about the uses of essential oils of aromatic plants in pest management. When we know more about each specific action on the target insect for example, the actions of some essential oils will probably be better understood. Pheromones produced by plants may exert beneficial effects on pest management, leading to a substitution of the conventional insecticides. These futuristic green insecticides present cost-effective technical solutions for sustainable insect management.

Declarations

Conflict of Interest

No conflict.

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Figures

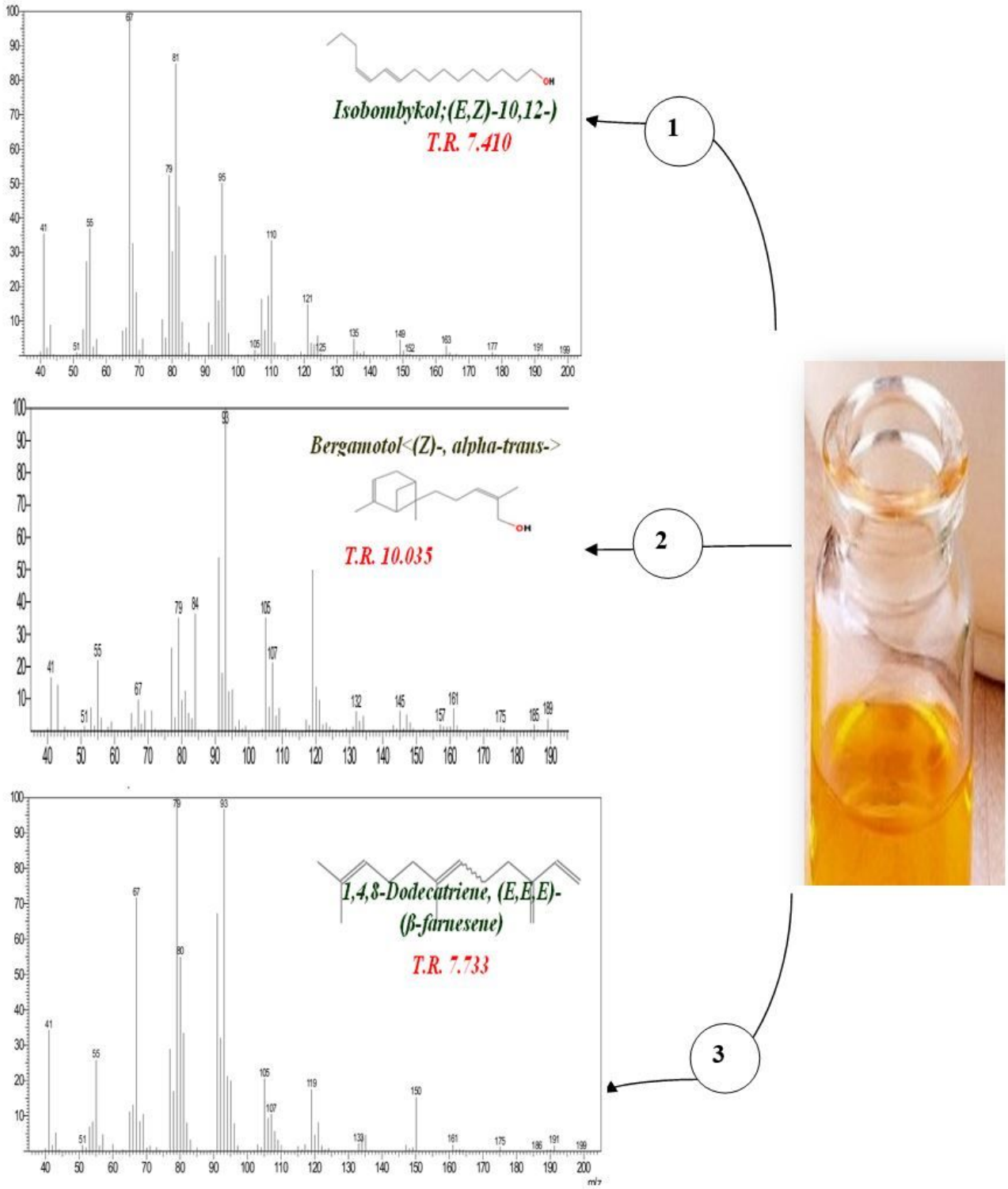


Figure 1

Schematic representation of the extraction of essential oil from Saussurea costus and the identification of the active molecules: as α-Bergamotol , β-farnesene, Isobombykol. Their mass spectrums are also presented with a peak area percent of 0.51%, 0.97 % and 2.3%, respectively.

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