Essential oils for the treatment of dust mites

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Abstract. House mites, including D. pteronyssinus and D. farina, are common causes of allergic diseases, such as asthma, atopic dermatitis, eczema, conjunctivitis and perennial rhinitis in susceptible patients. Conventional acaricides, such as benzyl benzoate, bifenthrin, chlorpyrifos and pyrethroids, are effective chemicals in treating mites. However, they are usually with high drug resistance and high adverse effects on environment, human health, and non-target organisms. Recently, essential oils from different plants were found to be safe and effective alternatives for killing different types of mites. The present review summarized the essential oils from different plants. The crude essential oils from Melissa officinalis, S. lavandulifolia oil, cade oil, P. cattleianum, Patchouli oil, Horseradish oil, C. cassia, P. cablin, Manuka oil, Clove Bud oil, and the pure essential oils, such as eugenol, carvaphyllene, and camphor might be good candidates for the dust mites. Further studies on biological mechanisms of the acaricidal effects of these active essential oils, and the structure-activity relationships are needed to make the functions of these drugs more clear.

1 Introduction

Mites are tiny arthropods belonging to the class of arachnids and the subclass of acari. They are spread across a wide range of habitats. At least 45,000 different species of mites have been described. Some of these mites damage food, cause skin irritation, itchiness and severe bacterial infections.

House mites, including D. pteronyssinus and D. farina, are common causes of allergic diseases, such as asthma, atopic dermatitis, eczema, conjunctivitis and perennial rhinitis in susceptible patients [1, 2]. D. pteronyssinus and D. farina are both pyroglyph mites, made up of 60-90% domestic mites.

Conventional acaricides, such as benzyl benzoate, bifenthrin, chlorpyrifos, pirimiph-methyl and pyrethroids, are effective chemicals in treating mites [3, 4]. However, they are usually with high drug resistance and high adverse effects on environment, human health, and non-target organisms [4, 5]. Recently, essential oils from different plants were found to be safe and effective alternatives for killing different types of mites (Table 1).

Table 1: LD50 values for essential oils against dust mites

2 Crude essential oils for dust mites

Pineapple balm, patchouli, horseradish and clove are rich in essential oil. The essential oil from Melissa officinalis, a plant cultivated in France, Ireland, and Serbia, showed high activity on killing both D. farina and D. pteronyssinus. The LD50 for D. farina and D. pteronyssinus was 3.91 and 3.53 μg/cm2, respectively, representing approximately four to five folds of DEET, a negative control. The patchouli oil extracted from Pogostemon cablin killed the D. farina with the LD50 of 6.11 μg/cm2, which was 9.58 times of dibutyl phthalate (DBP) (58.52 μg/cm2) [6]. Horseradish oil extracted from Armoracia rusticana consisted of different types of isothiocyanates. In a contact plus fumigant mortality bioassay, the horseradish oil (LD50: 1.54 μg/cm2) was more potent compared to DBP (24.49 μg/cm2) on killing D. farina [7]. The Clove bud oil killed D. farina and D. pteronyssinus with the LD50 of 5.91 μg/cm2 and 7.86 μg/cm2, respectively, in the contact toxicity bioassay [8]. In addition, Melissa officinalis oil changed the colour of the mites from colorless to golden brown, indicating the acaricide potential of the oil [9].

The essential oils of P. cattleianum and Leptospermum scoparium also demonstrated strong acaricide activity. The acaricidal activity of P. cattleianum oil was significant when examined by fumigant or contact toxicity bioassays. The LD50 for P. cattleianum oil on D. farina and D. pteronyssinus was 2.44 and 2.40 μg/cm2, respectively, which was 8.79 and 12.92 times as active as DEET [10]. Manuka oil extracted from Ease Cape Manuka killed D. farina, D. pteronyssinus and T. putrescentiae at LD50 of 0.54, 0.67 and 1.12 μg/cm2, respectively [11].

Other extractions of essential oils from S. lavandulifolia, S. barbata and A. koreana were also active miticides. They were more powerful acaricides than benzyl benzoate, a traditional chemical drug [12-14]. The S. lavandulifolia oil, S. barbata oil, and A. koreana oil killed D. farina with LD50 of 3.18, 2.55, and 3.53 μg/cm2, respectively. killed D. pteronyssinus with LD50 of 3.15, 2.5, 4.15μg/cm2; killed T.putrescentiae with LD50 of 4.93,
5.00, 6.27μg/cm². Whereas Cade oil, Hiba oil, Basil oil, Asarum sieboldii Miq oil and C.obtusa Leaf oil were found without evident acracial activity [15-19].

The Traditional Chinese Medicine (TCM) was considered to be the source of environmentally acceptable and alternative commercial acaricides. The acaricidal activity of petroleum ether, ethyl acetate, and methanol extracts from 22 kinds of TCM were screened. The petroleum ether extract of C. cassia, E. caryophyllata, and P. cablin were with highest activities (4.6, 5.0 and 6.0 μg/cm² respectively, 24 h, LD50) than the extracts of ethyl acetate and methanol [20].

### 3 Essential oil compounds for dust mites

Besides the crude essential oils from different plants, many other active essential oil components or compounds were demonstrated to be effective on dust mites (Table 2).

#### 3.1 Eugenol and its congeners

Eugenol is an acaricidal constituents of cade oil, Asarum sieboldii Miq oil, and Clove bud oil. Eugenol and its congeners (acetyleneugenol, isoeugenol, and methyleugenol) are potent acaricides against different mite species. Previous studies indicated the order of lethal effect against D. farina was methyleugenol (LD50: 0.94-5.82 μg/cm²) > eugenol (LD50: 5.47-12.52μg/cm²) > isoeugenol (LD50: 5.17-36.10μg/cm²) > acetyleneugenol (LD50: 14.16 μg/cm²). Among eugenol and its congeners, methyleugenol was with the highest toxicity, which was similar to that of benzyl benzoate [17,18]. The lipophilicity of eugenol and its congeners may responsible for their difference of acaricidal activities [8,15].

#### 3.2 Caryophyllenes

α-caryophyllene, β-caryophyllene, and caryophyllene oxide were found in the components of many essential oils, such as Psidium cattleianum, Melissa officinalis, Basil oil, Clove oil, and Cade oil. Previous studies indicated the neuroprotective, anti-inflammation, and sedation, anti-anxiety effects. Linalool was reported to be an effective killer of dust mites. The acaricidal activities of linalool on D. farina and D. pt eronyssinus were better than benzyl benzoate (1.83 folds and 2.04 folds, respectively) [12]. But less than DEET or DBP [17,21].

#### 3.3 Linalool (+/-)

Linalool is a widely used terpene found in many plant species, such as Salvia Lavandulifolia, and basilis. Linalool is used as an important ingredient in shampoos, soaps, and detergents. Studies also demonstrated its anti-inflammation, sedation, anti-anxiety effects. Linalool was found for camphor effective killer of dust mites. The acaricidal activities of linalool on D. farina and D. pteronyssinus were better than benzyl benzoate [12]. But less than DEET or DBP [17,21].

#### 3.4 Camphor and camphene

Camphor and camphene are important aromatic ingredient of the wood and bark of the camphor tree. They are used as mild topical analgesic and insect repellent.

The acaricidal activity of camphor was detected by several studies. It killed D. farina, D. pteronyssinus, and T. putrescentiae effectively (LD50 of 3.34 μg/cm², 3.25 μg/cm², and 5.10 μg/cm², respectively, by contact bioassay), which was better than benzyl benzoate [12], similar to DEET [15,17,21,22]. No acaricidal activity was found for camphene [12].

#### 3.5 Terpinen-4-ol and terpineol

Terpinen-4-ol is the major constituent and active ingredient of tea tree oil used for demodex. Besides tea tree oil, the terpinen-4-ol also exists in other plants, such as Juniperus communis, and hiba oil. A moderate activity of terpinen-4-ol against dust mites was found in several studies. The LD50 of terpinen-4-ol on D. farina was 14.51 - 30.55 μg/cm² compared to 28.10 - 38.95 μg/cm² of DEET, and was 15.90 - 30.32 μg/cm² compared to 28.51-38.42 μg/cm² of DEET on D. pteronyssinus [15-17,21].

Terpineol is a monoterpene alcohol. It is one of the active components in tea tree essential oil, Salvia lavandulifolia oil, hiba oil, basil oil, and cinnamon oil. The LD50 value of terpineol against D. farina was between 4.33-22.05 μg/cm², which was more active than DEET (28.1-37.67 μg/cm²). Similar effects were found for D. pteronyssinus.

#### 3.6 Cineole

1,8-Cineole is the most abundant ingredient in the Eucalyptus essential oil and S. lavandulifolia leaf oil. The activity of cineole on D. farina, D. pteronyssinus,
and *T. putrescentiae* was measured by contact bioassay. The LD$_{50}$ was 12.3, 12.4, and 10.73 µg/cm$^2$ for three dust mites, respectively, which was lower than benzyl benzoate (LD$_{50}$: 7.46, 6.52, 9.70 µg/cm$^2$) [12]. Other study also demonstrated the slight acaricidal effects of cineole [17,22].

**Table 1.** The acaricidal effects of crude essential oils from different plants

| Essential oil                  | Mite species (LD$_{50}$, 95%CI) | Negative control (DEET, LD$_{50}$, 95%CI) | Reference |
|-------------------------------|---------------------------------|---------------------------------------------|-----------|
|                               | *D. farina*                     | *D. pteronyssinus*                         |           |
| Melissa officinalis (France)  | 3.91 (3.23–4.64)                | 3.53 (2.90–4.11)                           | [9]       |
| Melissa officinalis (Ireland) | 5.29 (4.44–6.27)                | 4.97 (3.67–6.41)                           |           |
| Melissa officinalis (Serbia)  | 5.50 (4.64–6.51)                | 5.85 (4.45–7.36)                           |           |
| S.lavandulifolia oil          | 3.18 (2.64–4.33)                | 3.15 (2.03–4.22)                           | [9]       |
| Cade oil                      | 2.55 (2.45–2.65)                | 2.50 (2.40–2.60)                           | [9]       |
| Hiba oil                      | 126.26 (106.08–150.79)          | 174.76 (148.37–211.83)                     | [12]      |
| Basil oil                     | 127.20 (109.33–145.39)          | -                                           | [15]      |
| P. cattleianum                | 2.44 (2.35–2.55)                | 2.4 (2.30–2.50)                            | [16]      |
| S. barbata oil                | 2.55 (2.45–2.65)                | 2.50 (2.40–2.60)                           | [17]      |
| A. sieboldii Miq oil          | 37.7 (33.1–42.7)                | -                                           | [10]      |
| A. koreana oil                | 3.53 (3.40–4.69)                | 4.15 (3.43–5.10)                           | [13]      |
| Patchouli oil                 | 6.11 (5.59–6.63)                | -                                           | [18]      |
| Horseradish oil               | 1.54 (1.09–2.13)                | -                                           | [14]      |
| C. cassia                    | 4.6 (3.9–5.4)                   | -                                           | [7]       |
| P. cablin                    | 6.0 (5.6–6.5)                   | -                                           | [20]      |
| A. sieboldii                 | 37.0 (33.1–42.7)                | -                                           | [20]      |
| E. caryophyllata (petroleum ether) | 5.0 (4.4–5.5)              | -                                           | [20]      |
| Manuka oil                    | 0.54 (0.49–0.57)                | 0.67 (0.65–0.70)                           | [11]      |
| C. obtusa Leaf               | 23.1 (22.52-23.64)              | 20.9 (20.51–21.43)                         | [19]      |
| Clove Bud Oil                | 5.91 (5.47-6.40)                | 7.86 (7.48–8.25)                           | [8]       |
Table 2. Activities of essential oil on dust mites

| Essential oil   | Mite species (LD50 range) | Reference |
|-----------------|---------------------------|-----------|
|                 | D. farina                 | D. pteronyssinus |   |
| Methyleugenol   | 0.94-5.82                 | 0.67      | [8,15,18] |
| Eugenol         | 5.47-12.52                | 3.71      | [8,15,17] |
| Isoeugenol      | 5.17-36.10                | 1.55      | [8,17]   |
| Acetyleugenol   | 14.16                     | 5.41      | [8]       |
| α-caryophyllene | 0.67-25.91                | 0.62-32.08 | [10,21] |
| β-caryophyllene | 0.91-156.24               | 1.11-37.51 | [9,10,12,17,21] |
| Caryophyllene oxide | 0.44-36.07       | 0.47-6.35 | [9,10,15,17] |
| Linalool        | 5.15-49.40                | 5.06-44.64 | [12,17,21] |
| Camphor         | 3.81-61.93                | 3.67-60.77 | [12,15,17,21] |
| Camphene        | >78                       | >78       | [12]      |
| Terpinen-4-ol   | 14.51-30.55 2             | 15.90-30.3 | [15-17,21] |
| Terpineol       | 4.33-22.05                | 4.67-25.69 | [12,16,17,21] |
| Cineole         | 12.30-164.8               | 12.4      | [12,17]   |

4 Conclusion

Dust mites induced diseases have led to a lot of sufferings for humans. Many drugs have been used for the treatment of the skin infections and allergies diseases caused by the dust mites. However, the problem of resistance, environmental issues linked to chemical treatment urged us to seek for new approaches. Recently, essential oils from different plants were found to be safe and effective alternatives for killing different types of mites. The crude essential oils from Melissa officinalis, S.lavandulifolia oil, cade oil, P. cattleanum, Patchouli oil, Horseradish oil, C. cassia, P. cablin, Manuka oil, Clove Bud oil, and the pure essential oils, such as eugenol, caryophyllene, and camphor might be good candidates for the dust mites.

Further studies on biological mechanisms of the acaricidal effects of these active essential oils, and the structure-activity relationships are needed to make the functions of these drugs more clear.

The present study was supported by the Hunan Provincial Key Laboratory of Fundamental and Clinical Research on Functional Nucleic Acid; the Application Characteristic Discipline of Hunan Province; Hunan Provincial Natural Science Foundation (No. 2019JJ40330); the Foundation of Hunan Educational Committee (Grant No. 19A060, 19A055).

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