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Effect of volatile matter from wood chips on the activity of house dust mites and on the sensory evaluation of humans

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Abstract The effect of volatile matter from various wood chips on house dust mites and their influence on human comfort were measured. To investigate the effect of volatile matter on the mite species *Dermatophagoides pteronyssinus*, the activity of the mites was observed after exposure to volatile matter from six species of wood chips. The degree of activity of the mites was classified into two categories: (1) walking or moving and (2) immobilized. To measure their influence on human comfort, the smells of those wood chips were evaluated by the subjects. Among softwoods, volatile matter from *Chamaecyparis obtusa* and *Thujopsis dolabrata* var. *hondai* chips suppressed the activity of the mites highly and made the subjects feel refreshed and unexcited. *Cryptomeria japonica* showed slight suppression of the mites and was considered to be refreshing, natural, and unexciting by the subjects. Among hardwoods, *Cinnamomum camphora* highly suppressed mites activity and was considered to be non-refreshing and exciting by the subjects.

Key words House dust mite · *Dermatophagoides pteronyssinus* · Wood chip · Volatile matter · Sensory evaluation

Introduction

In 1964 Voohorst et al.[1] found that many of the allergic diseases that have become a serious health problem recently were caused by house dust mites.[2] Since then, many reports have been published on the relations between allergic diseases and house dust mites, the characteristics of the mite allergens, and controlling exposure to house dust mites. Sakamoto[3] reported that eliminating contact with the mite allergens was important for controlling the allergic diseases caused by house dust mites, and he offered specific suggestions, such as daily cleaning of rooms and minimal use of carpeting.

It has been reported that keeping a room in dry condition is effective for ridding the house of house dust mites,[4,5] but changes in life styles and house construction have made it difficult to keep room humidity low. Thus, to kill mites effectively, insecticides have been used, but they pose other health risks. Given this situation, the effects of some plant and wood oils on house dust mites have received much attention.[6–10] McDonald and Tovey[6] examined the effect of five essential plant oils (citronella, eucalyptus, spearmint, tea tree, wintergreen oils) as laundry additives for killing house dust mites. They suggested that dilute solutions of essential oils were potentially an effective, acceptable, inexpensive method of controlling house dust mites. Ottoboni et al.[7] evaluated 10 essential oils and found the most effective ones for getting rid of house dust mites were caraway, garlic, black pepper, and Peru balsam. Takaoka et al.[8] examined the effect of the wood oils on house dust mites [*Dermatophagoides pteronyssinus* (*D.p.*) and *Dermatophagoides farinae*] by keeping them in the sawdust of seven species of wood that are commonly used as construction materials. They showed that the oils of *Chamaecyparis obtusa*, *Cryptomeria Japonica*, and *Pseudotsuga menziesii* highly suppressed the activity of the mites, whereas the oils of *Picea abies* and *Tsuga heterophylla* had little effect on the mites. Miyazaki et al.[9,10] reported that exposure to essential oils had an influence on *D.p.* house dust mites, especially wood oils obtained from *Chamaecyparis obtusa*, *Pseudotsuga menziesii*, *Thuja plicata*, and *Thujopsis dolabrata* var. *hondai*, whereas wood oils from *Cryptomeria japonica* and *Thuga heterophylla* had only a slight effect on the mites. At any rate, little information is available about the effects of the volatile matter from wood on house dust mites.

To use the volatile matter from wood in our lives, their effects on mites and human comfort should be considered.

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In this study, volatile matter from wood chips were used for measuring their effects on *D.p.* and influence on the sensory evaluation of humans.

Materials and methods

Effect on mites

Adult female house dust mites, *Dermatophagoides pteronyssinus*, were used in this study. Six species of wood chips were used: hinoki (*Chamaecyparis obtusa*), hiba (*Thujopsis dolabrata* var. *hondai*), sugi (*Cryptomeria japonica*), kusunoki (*Cinnamomum camphora*), mizunara (*Quercus crispula* Blume), and keyaki (*Zelkova serrata*). The first three are softwoods, and the last three are hardwoods. The length and width of the wood chips were all less than 3 mm. These woods are widely used as materials for construction and furniture.

The experiment was conducted in a desiccator (capacity $3.6 \times 10^{-3} m^3$) at 25°C under 85% relative humidity (RH), using a saturated KCl solution. The mites were exposed to volatile matter from wood chips in exposure chambers (Fig. 1), which were modified versions of the rearing containers of Matsumoto et al.,[11] made as follows: A filter cloth (Axtar, H306-10, 15 × 15 mm; Toray Industries) was put on an acrylic resin plate (75 × 25 mm, thickness 1 mm) having a ϕ 10 mm hole in its center. A same size acrylic plate (thickness 3 mm) was placed on the filter cloth. About 10 mites were put into the hole and on the filter cloth. The hole of the acrylic plate was covered with a same size glass plate (thickness 1 mm). Plates were held with double clips at both ends. Five exposure chambers were placed on each of six species of wood chips (about 5 g).

The degree of activity of the mites was classified into two categories: (1) walking or moving (e.g., legs, chelicerae, pedipalpi) and (2) immobilized. The activity was measured with a microscope after 3, 6, 9, 12, 24, 48, and 72 h of exposure.

Differences between the values were analyzed by Student's *t*-test. They were considered significant when the *p* value was less than 0.05.

Sensory evaluation

The test samples were six species of wood chips (5 g each) placed in paper cups. An empty cup was used as the control sample.

The subjects were nine men 20–29 years old. Each subject closed his eyes and sat on a chair in the test room that was controlled at 23°C, 60% RH. The subjects were asked to make their sensory evaluations of the smells of the samples (including the control) that were randomly given to them. No information was given to the subjects other than that the samples were wood chips.

The ranking of the sensory intensity was as follows: no smell, slight smell, weak smell, moderate smell, strong smell, and unbearably strong smell. Each rank was further divided into four subranks, and the subjects were asked to evaluate those items as well. The following three pairs of adjectives for smell were prepared for the semantic differential method: natural/artificial, refreshing/non-refreshing, and exciting/unexciting. Scores of 1 to 7 were assigned by each subject to the respective samples. To evaluate the scores for each adjective, Wilcoxon's signed rank sum test was employed and judged significant at $P < 0.05$.

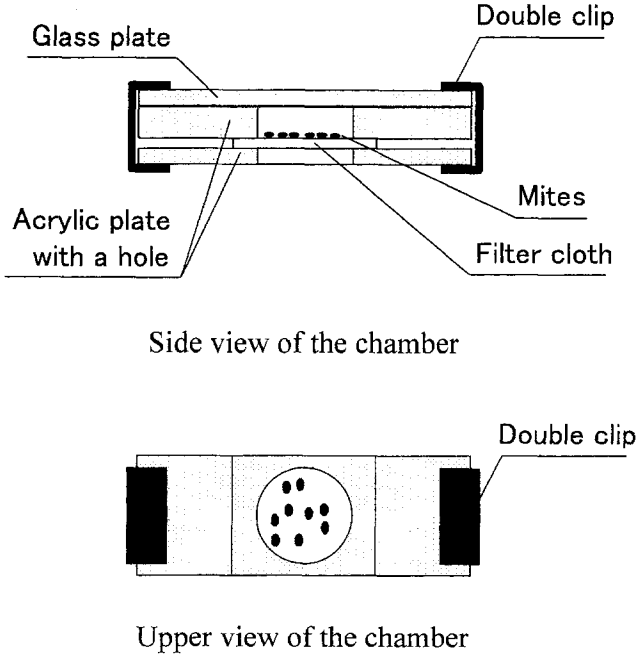

Fig. 1. Exposure chamber for testing the effect of volatile matter from wood chips on *Dermatophagoides pteronyssinus*

Results and discussion

Effect on mites

The suppressive effect of volatile matter from six wood chips on the mites of *Dermatophagoides pteronyssinus* are shown in Fig. 2. Volatile mattter from softwoods had a higher effect on the activity of the mites than the hardwoods, except *Cinnamomum camphora*.

Among the softwoods, volatile matter from *Chamaecyparis obtusa* and *Thujopsis dolabrata* var. *hondai* highly suppressed mite activity, immobilizing more than 60% and more than 40% of mites, respectively, after 12 h of exposure. After 24 h of exposure to *Chamaecyparis obtusa* and *Thujopsis dolabrata* var. *hondai*, more than 80% of mites were immobilized, and no mobilized mite was observed after 72 h of exposure to volatile matter. Miyazaki et al.[9,10] and Yamamoto et al.[12] reported that the essential oils extracted from *Chamaecyparis obtusa* and *Thujopsis dolabrata* var. *hondai* had a significant effect on immobilizing the mites, which was also seen in the present study.

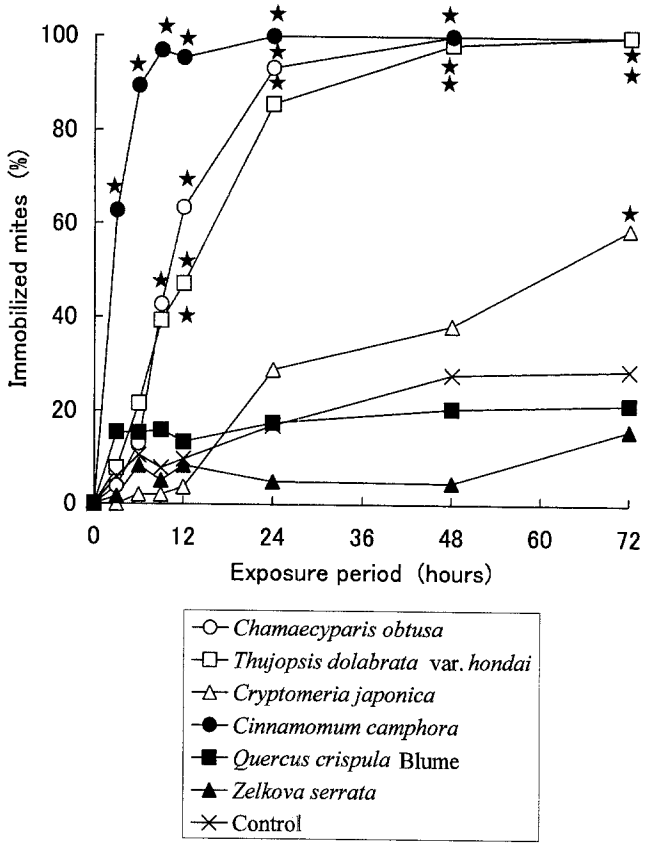

Fig. 2. Changes in the activity of *Dermatophagoides pteronyssinus* during exposure to volatile matter from wood chips. Significant differences from control values are marked with a *star* ($P < 0.05$ by Student's *t*-test)

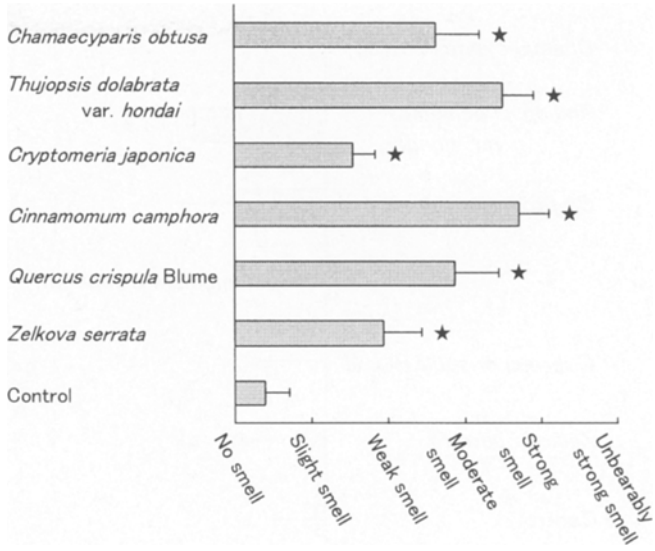

Fig. 3. Sensory intensitiy of wood chip smell as perceived by the subjects. *Lines* extending from the bars show the standard deviation. The *star* indicates a significant difference from control ($P < 0.05$ by Wilcoxon's signed rank sum test)

With *Cryptomeria japonica* (*C. japonica*), about 30% of mites were immobilized after 24h of exposure and about 40% were immobilized after 48h of exposure, but there were no significant differences from the control ($P < 0.05$). After 72h of exposure to *C. japonica*, about 60% of mites had been immobilized and a significant difference from control ($P < 0.05$) was seen. Miyazaki et al.[9] examined the effect of wood oil extracted from *C. japonica* on the mites, and found the effect of *C. japonica* oil was slight, similar to this study. On the other hand, Takaoka et al.[8] showed that the reproduction of mites was repressed as highly in the sawdust of *C. japonica* as it was in the sawdust of *Chamaecyparis obtusa*. This showed that the effect of *C. japonica* on the mites was not slight. In the studies of Miyazaki et al.[9] and the present authors, the mites were removed from contact with wood oils or chips, but in the study by Takaoka et al.[8] the mites were kept in direct contact with the sawdust. This may have caused the difference in the effect of *C. japonica* on the mites.

Among hardwoods, volatile matter from *Zelkova serrata* and *Quercus crispula* Blume had no effect on the activity of the mites, but the volatile matter of *Cinnamomum camphora* highly suppressed their activity. After 3h of exposure about 60% of mites were immobilized, and after 6h of exposure about 90% were immobilized. No mobilized mite was observed after 24h. *Cinnamomum camphora* wood contains a large amount of camphor oils that are the raw materials for insecticides, so it would be expected to have a large influence on the mites.

Sensory evaluation

The sensory intensities of the smells of six wood chips were significantly stronger ($P < 0.05$) than the control sample (Fig. 3), but they were all different from each other. The smells of *Cinnamomum camphora* and *Thujopsis dolabrata* var. *hondai* gave subjects the strongest intensities among the six wood chips, ranging between "moderate smell" and "strong smell." The sensory intensities of the smells of *Chamaecyparis obtusa* and *Quercus crispula* Blume were between "weak smell" and "moderate smell." The smells of *Cryptomeria japonica* and *Zelkova serrata* gave subjects the weakest intensities, between "slight smell" and "weak smell."

The data obtained by the semantic differential method from the nine subjects were used for the evaluation. Histograms of the scores for three pairs of adjectives – natural/artificial, refreshing/non-refreshing, exciting/unexciting – are shown in Figs. 4–6, respectively. For the first pair (Fig. 4), a natural/artificial feeling, *Thujopsis dolabrata* var. *hondai* was considered by the subjects to be significantly more natural ($P < 0.05$) than the control sample. The smell of *Thujopsis dolabrata* var. *hondai* was also considered to be natural in the essential wood oil studies of Miyazaki et al.[13] and Yamamoto et al.[12] *Cryptomeria japonica* was considered to be more natural than the control, but the difference ($P < 0.05$) was not significant. The others, like the control, were considered to be indifferent. In the studies of Miyazaki et al.[13] and

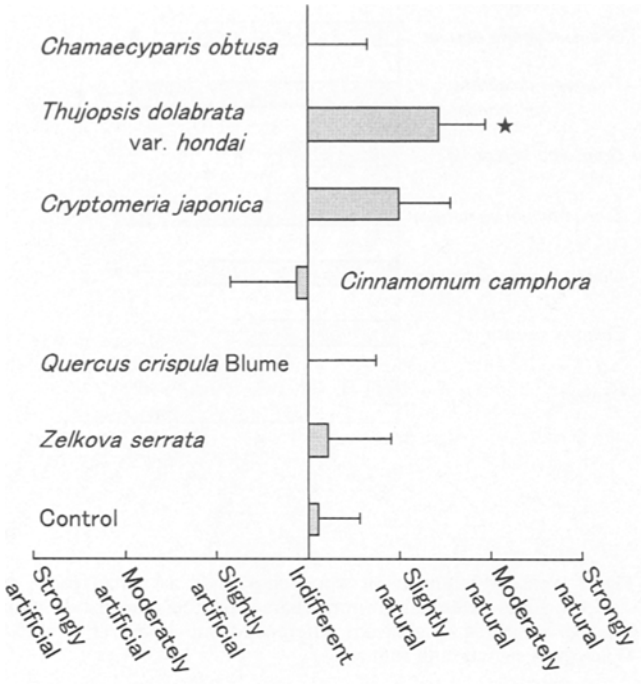

Fig. 4. Scores for natural/artificial feeling. *Lines* extending from the bars show the standard deviation. The *star* indicates a significant difference from control ($P < 0.05$ by Wilcoxon's signed rank sum test)

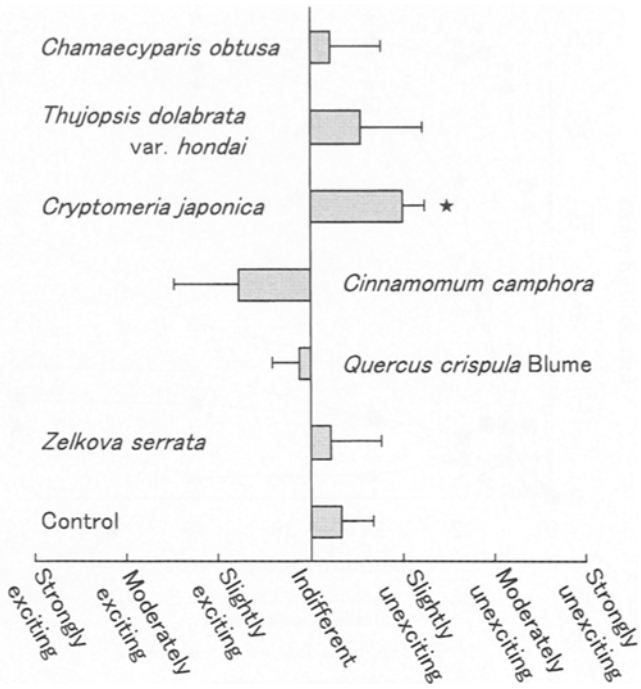

Fig. 6. Scores for exciting/unexciting feeling. *Lines* extending from the bars show the standard deviation. The *star* indicates a significant difference from control ($P < 0.05$ by Wilcoxon's signed rank sum test)

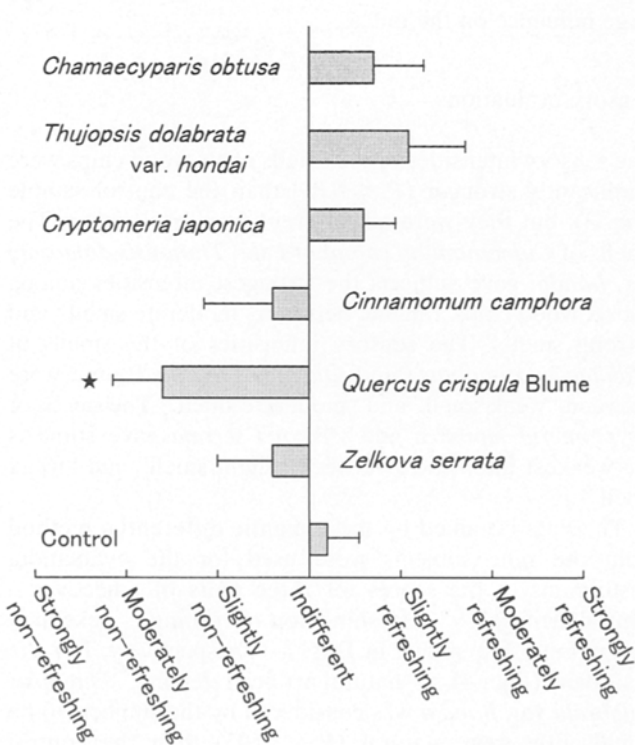

Fig. 5. Scores for refreshing/non-refreshing feeling. *Lines* extending from the bars show the standard deviation. The *star* indicates a significant difference from control ($P < 0.05$ by Wilcoxon's signed rank sum test)

Yamamoto et al.[12] the smell of *Chamaecyparis obtusa* was considered to be natural, but in the present study it was considered to be indifferent. The difference in results may be due to the use of essential oils versus wood chips.

For the second adjective pair (Fig. 5), a refreshing/non-refreshing feeling, the smells of softwoods were more refreshing than the control, but the difference ($P < 0.05$) was not significant. The smells of hardwoods were more non-refreshing than the control, but the difference ($P < 0.05$) was not significant. The smell of *Quercus crispula* Blume was considered to be significantly more non-refreshing than the control owing to the former's smell. *Cinnamomum camphora*, which suppressed the activity of the mites strongly and gave the strongest intensity, was more non-refreshing than the control, but the difference ($P < 0.05$) was not significant.

In the studies of Miyazaki et al.[13] and Yamamoto et al.[12] the smell of *Chamaecyparis obtusa* was considered to be refreshing, as it was in the present study, but *Thujopsis dolabrata* var. *hondai* was considered to be refreshing in this study but non-refreshing in the other studies. The cause of this difference is unknown.

For the third adjective pair (Fig. 6), an exciting/unexciting feeling, *Thujopsis dolabrata* var. *hondai* was thought to be more unexciting than the control, but the difference ($P < 0.05$) was not significant. *Cryptomeria japonica* gave the subjects a significantly more unexciting feeling ($P < 0.05$) than the control. On the other hand, *Cinnamomum camphora* was considered to be more exciting than the control, but the difference ($P < 0.05$) was

not significant. The smell of camphor oils, which are the raw materials for insecticides, may have made the subjects excited. The others, like the control, were considered to be indifferent.

Conclusions

This study evaluated the effects of volatile matter from wood chips on the activity of *Dermatophagoides pteronyssinus* and on the sensory evaluation of humans. The results obtained can be summarized as follows. Among softwoods, volatile matter from *Chamaecyparis obtusa* and *Thujopsis dolabrata* var. *hondai* chips strongly suppressed the activity of the mites and gave subjects refreshing and unexciting feelings. *Cryptomeria japonica* caused slight suppression of the mites and was considered to be refreshing, natural, and unexciting. Among hardwoods, only *Cinnamomum camphora* strongly suppressed mite activity, and its smell was considered to be non-refreshing and exciting. This study suggests that using volatile matter from wood is a potentially effective method for controlling house dust mites and increasing human comfort.

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References

1. Voohorst R, Spieksma-Boezeman MIA, Spieksma FTM (1964) Is a mite (*Dermatophagoides* sp.) the producer of the house-dust allergen? Allerg Asthma 10:329–334
2. Wharton G (1976) House dust mites. J Med Entomol 12:577–621
3. Sakamoto Y (1988) Allergy caused by living environment. 1. Mite allergens (in Japanese). Chem Living creatures 26:131–134
4. Oribe Y, Sueyoshi S, Takaoka M, Miyazaki Y (1993) Effect of humidity on the activity of *Dermatophagoides pteronyssinus* (in Japanese). In: Abstracts of the 43rd annual meeting of the Japan Wood Research Society, p 53
5. Shober G, Verstappen I, Snijders MCL, Van Bronswijk JEMH (1995) Prevailing indoor climate classification to predict house dust mite abundance in Dutch homes. Belg J Zool 125:193–198
6. McDonald LG, Tovey E (1993) The effectiveness of benzyl benzoate and some essential plant oils as laundry additives for killing house dust mites. J Allergy Clin Immunol 92:771–772
7. Ottoboni F, Rigamonti IE, Lozzia GC (1992) House dust mites prevention in Italy. Boll Zool Agric Bachic 24:113–120
8. Takaoka M, Takano T, Miyazaki Y (1987) Dwelling environment of wooden construction and the reproduction of mites 2 (in Japanese). Jpn J Hyg 42:224
9. Miyazaki Y, Yatagai M, Takaoka M (1989) Effect of essential oils on the activity of house dust mites. Jpn J Biometeor 26:105–108
10. Miyazaki Y (1996) Effect of hiba wood oil on the house dust mite. Mokuzai Gakkaishi 42:624–626
11. Matsumoto K, Okamoto M, Wada Y (1986) Effect of relative humidity on life cycle of the house dust mites, *Dermatophagoides farinae* and *D. pteronyssinus*. Jpn J Sanit Zool 37:79–90
12. Yamamoto N, Miyazaki Y, Sakuda K (1998) Sensory evaluation of carpet cleaner containing essential oil and the effect on mites. J Wood Sci 44:90–97
13. Miyazaki Y, Yatagai M, Kobayashi S (1993) Sensory evaluation of essential oils and their components. Mokuzai Gakkaishi 39:843–848