World Academy of Science, Engineering and Technology
International Journal of Medical and Health Sciences
Vol:5, No:12, 2011

The Acaricidal and Repellent Effect of Cinnamon Essential Oil against House Dust Mite

Je-Hoon Michael Oh

***Abstract*—**The major source of allergy in home is the house dust mite (Dematophagoides farina, Dermatophagoides pteronyssinus) causing allergic symptom include atopic dermatitis, asthma, perennial rhinitis and even infant death syndrome.

Control of this mite species is dependent on the use of chemical methods such as fumigation treatments with methylene bromide, spraying with organophosphates such as pirimiphos-methyl, or treatments with repellents such as DEET and benzyl benzoate. Although effective, their repeated use for decades has sometimes resulted in development of resistance and fostered environmental and human health concerns. Both decomposing animal parts and the protein that surrounds mite fecal pellets cause mite allergy. So it is more effective to repel than to kill them because allergen is not living house dust mite but dead body or fecal particles of house dust mite.

It is important to find out natural repellent material against house dust mite to control them and reduce the allergic reactions. Plants may be an alternative source for dust mite control because they contain a range of bioactive chemicals.

The research objectives of this paper were to verify the acaricidal and repellent effects of cinnamon essential oil and to find out it's most effective concentrations. We could find that cinnamon bark essential oil was very effective material to control the house dust mite. Furthermore, it could reduce chemical resistance and danger for human health.

***Keywords*—**house dust mite, cinnamon, repellent effect

I. Introduction

THE major source of allergy in home is the house dust mite, American house dust mite (Dematophagoides farinae) and European house dust mite (Dermatophagoides pteronyssinus), causing allergic symptom include atopic dermatitis, asthma, perennial rhinitis and even infant death syndrome[1]. As the dwelling of human can be afforded to maintain regularly both temperature and relative humidity through the year due to tighten closed window, central heating system, and air-conditioner, ideal conditions for house dust mite living have been lasted in home. These situations give a chance to human to expose the house dust mite and its allergen. Thus, people are concerned about house dust mite and allergy caused by house dust mite, and they require types of acaricide and repellent materials.

Control of this mite species is dependent on the use of chemical methods such as fumigation treatments with methylene bromide, spraying with organophosphates such as pirimiphos-methyl, or treatments with repellents such as DEET and benzyl benzoate. Although effective, their repeated use for decades has sometimes resulted in development of resistance and fostered environmental and human health concerns[2].

Je-Hoon Michael Oh is with Gyeonggi Suwon International School, Suwon 443-808, Republic of Korea (phone: +82-10-9990-7655; e-mail: naver162@naver.com)

These problems have highlighted the need for the development of new materials that is natural and have no harm to human body.

And furthermore, a house dust mite will produce approximately 2,000 fecal particles and an even larger number of partially digested enzyme-covered dust particles in whole life span. Both decomposing animal parts and the protein that surrounds mite fecal pellets cause mite allergy. So it is more effective to repel than to kill them because allergen is not living house dust mite but dead body or fecal particles of house dust mite.

It is important to find out natural repellent material against house dust mite to control them and reduce the allergic reactions. Plants may be an alternative source for dust mite control because they contain a range of bioactive chemicals. Because of this, much effort has been focused on plant extracts or essential oils as potential sources of mite-control agents. It has been known that cinnamon has insecticide effect.

This research had examined the cinnamon essential oil for acaricidal and repellent effect. it has two detailed objectives; The first was to verify the cinnamon essential oil as acaricidal effect against house dust mite, if so, which is the minimum effective concentration. And the second was to verify the cinnamon essential oil has repellent effect against house dust mite, if so which is the most effective concentration.

II. Research Background

A. House Dust Mite

The house dust mite (*Dermatophagoides farinae*) is a cosmopolitan guest in human habitation. Dust mites feed on organic detritus such as flakes of shed human skin and flourish in the stable environment of dwellings. House dust mites are a common cause of asthma and allergic symptoms worldwide. The mite's gut contains potent digestive enzymes (notably proteases) that persists in their feces and are major inducers of allergic reactions such as wheezing. The mite's exoskeleton can also contribute to allergic reactions.

The body of a house dust mite is just visible against a dark background in normal light. A typical house dust mite measures 0.4 millimetres (0.016 in) in length and 0.25–0.32 millimetre (0.0098–0.013 in) in width. Both male and female adult house dust mites are creamy blue and have a rectangular shape. The body of the house dust mite also contains a striated cuticle. Like all acari, house dust mites have eight legs (except 3 pairs in the first instar) [3]

It takes the common dust mite species approximately 30 days to complete its lifecycle from egg, larva, 3 nymph stages, to adult. The life-span is approximately 4 months. The average life cycle for a male house dust mite is 10 to 19 days. The

common female dust mite will lay from 50 to 80 eggs in its lifetime. In houses, they feed exclusively on human dander or dead skin that an adult human sheds at the rate of one to 1½ g per day, about one pound every year. The average temperature and relative humidity for their optimum development and propagation is around 28ºC and 80% R.H.

Within a house, the dust in mattresses, carpets, corners of rooms and floor space beneath the bed provide the most favorable niches. The bed is the most intimate human environment and serves as the focus of infestation, because the common house dust mites feed on human dander which is shed mostly in the bed. Also, humans are the most important carriers of dust mites from one place to another through their bodies and clothing. The mites are also wind blown and many different species are carried through the air from building to building.[4]

In a 10-week life span, a house dust mite will produce approximately 2,000 fecal particles and an even larger number of partially digested enzyme-covered dust particles. Both decomposing animal parts and the protein that surrounds mite fecal pellets causes mite allergy.[5]

B. Cinnamon

Cinnamon is a spice obtained from the inner bark of several trees from the genus Cinnamomum that is used in both sweet and savoury foods. Cinnamon trees are native to South East Asia, and its origin was mysterious in Europe until the sixteenth century. Cinnamon is harvested by growing the tree for two years then coppicing it. The next year, about a dozen shoots will form from the roots. The branches harvested this way are processed by scraping off the outer bark, then beating the branch evenly with a hammer to loosen the inner bark. The inner bark is then prised out in long rolls. Only the thin (0.5 mm (0.020 in) inner bark is used; the outer, woody portion is discarded, leaving metre-long cinnamon strips that curl into rolls ("quills") on drying. Once dry, the bark is cut into 5–10 cm lengths for sale. The bark must be processed immediately after harvesting while still wet. Once processed, the bark will dry completely in four to six hours, provided that it is in a well-ventilated and relatively warm environment. A less than ideal drying environment encourages the proliferation of pests in the bark, which may then require treatment by fumigation. Bark treated this way is not considered to be of the same premium quality as untreated bark.

Cinnamon could have some pharmacological effects in the treatment of type 2 diabetes mellitus and insulin resistance. Recent studies in phytochemistry have indicated that cinnamtannin B1 isolated from C. Verum bears possible therapeutic effect on type 2 diabetes. Cinnamon has traditionally been used to treat toothache and fight bad breath and its regular use is believed to stave off common cold and aid digestion. In medicine it acts like other volatile oils and once had a reputation as a cure for colds. It has also been used to treat diarrhea and other problems of the digestive system. Cinnamon is high in antioxidant activity. The essential oil of cinnamon also has antimicrobial properties, which can aid in the preservation of certain foods[6].There was a research to verify the insecticide effect of cinnamon. Peter Shang-Tzen Chang, a professor in the School of Forestry and Resource Conservation at National Taiwan University, tested eleven compounds in cinnamon leaf oil for their ability to kill emerging larvae of the yellow fever mosquito, Aedes aegypti. They showed that cinnamon leaf essential oil was environmentally friendly pesticide, with the ability to kill mosquito larvae more effectively than DEET. [7]

III. MATERIALS AND METHODS

A. Materials

Cinnamon bark essential oil(5ml) was purchased from www.Herbmall.co.kr It was pure essential oil extracted by traditional steam distillation and made by La Drôme Provençale(France). Cinnamon leaf essential oil(10ml) was purchased from www.yes24.com It was also pure essential oil extracted by steam distillation and made by Aroma Care Solution(Austria). DEET (N,N-Diethyl-meta-toluamide) is slightly yellow oil. It is the most common active ingredient in insect repellents. Ethanol was used as a solvent.

B. House Dust Mite

House dust mites, *Dermatophagoides farina,* have been cultured in laboratory. (Bioactive Natural Products Lab, Department of Agricultural Biotech, College of Agriculture and Life Science, Seoul National University) To rear the mites, plastic container(12.5 x 10.5 x 5.0cm) containing 25g of sterilized food were put on the big plastic container(30.0 x 20.0 x 20.0cm) which had 100% saturated salt water in the bottom. Plastic container was placed on incubator at 27±1°C and 75% relative humidity(RH) under dark condition. Sterilized food composed of fry feed No. 1 and dried yeast, 1:1 by weight. The fry feed was purchased from Korea Special Feed Meal Co. Ltd.. Incheon, Korea, and dried yeast was purchased from Samil Co., Ansan, Korea.

C. Variables

- Constant: temperature(27±1°C), relative humidity(75%), no lighting, and no food
- Manipulative: concentration of DEET and essential oils
  Acaricidal test: 2.5 , 1.25, 0.625, 0.3125, 0.15625, 0.12625, 0.0125, 0.09375, 0.078125, and 0.0625 µl /100 µl
  Repellent test: 0.125, 0.094, 0.083, and 0.0625 µl/100 µl
- Responding: acaricidal rate (mortality), repellent rate

D. Hypotheses

Following hypotheses were set to verify its effectiveness and required concentration.

Hypothesis 1: cinnamon bark essential oil will show the acaricidal effect against house dust mite

Hypothesis 2: cinnamon leaf essential oil will show the acaricidal effect against house dust mite

Hypothesis 3: cinnamon bark essential oil and cinnamon leaf essential oil will show a similar acaricidal effect against house dust mite

Hypothesis 4: cinnamon bark essential oil will show the repellent effect against house dust mite

E. Methods

Fabric diffusion method was used to evaluate the acaricidal and repellent effects. Test chemicals were prepared according to the testing concentrations. Each of the circular black cotton(⌀ 45mm) was wetting evenly with 100µl of prepared chemical (predetermined concentration of DEET, ethanol, cinnamon bark essential oil, and cinnamon leaf essential oil). Ethanol was processed with 100µl itself as control and DEET was processed as positive control with 100µl of same concentration of cinnamon essential oils. After evaporating ethanol by operation of 90 seconds in the clean bench, 30 house dust mites were put on the black cotton in the petri-dish(50*10 mm). The total number of house dust mites and the number of dead house dust mites were counted after 24 hours. And the acaricidal rate(mortality) was calculated with these numbers. This process was repeated three times for each concentration.

To test the repellent effect, a quarter area of black cotton(half of diameter) was wetted with chemicals of lower than the concentration which has the minimum acaricidal effect. The number of remaining house dust mites in the processed area was counted after 3 hours. This process was also repeated three times for each concentration.

IV. RESULTS

The collected experiment data were summarized in Table I. The experiments were repeated three times for each concentration and the table contains average value.

TABLE I
MORTALITY FOR EACH CONCENTRATION

sample	Average			SD	SE
	#_dead	Total	Mort.(%)		
EtOH 100	2.0	29.7	7	6.9	4.0
DEET 2.5	22.7	22.7	100	0.0	0.0
Bark 2.5	26.3	26.3	100	0.0	0.0
Leaf 2.5	31.7	31.7	100	0.0	0.0
DEET 1.25	26.0	26.0	100	0.0	0.0
Bark 1.25	31.7	31.7	100	0.0	0.0
Leaf 1.25	29.7	29.7	100	0.0	0.0
DEET 0.625	27.0	27.0	100	0.0	0.0
Bark 0.625	32.3	32.3	100	0.0	0.0
Leaf 0.625	29.3	29.3	100	0.0	0.0
DEET 0.3125	23.7	23.7	100	0.0	0.0
Bark 0.3125	27.7	27.7	100	0.0	0.0
Leaf 0.3125	25.3	25.3	100	0.0	0.0
DEET 0.15625	29.3	29.3	100	0.0	0.0
Bark 0.15625	27.3	27.3	100	0.0	0.0
Leaf 0.15625	27.0	27.0	100	0.0	0.0
DEET 0.12625	29.3	29.3	100	0.0	0.0
Bark 0.12625	27.3	27.3	100	0.0	0.0
Leaf 0.12625	27.0	27.0	100	0.0	0.0
DEET 0.125	10.3	38.0	28	7.4	4.3
Bark 0.125	34.3	34.3	100	0.0	0.0
Leaf 0.125	26.3	32.0	83	4.9	2.8
DEET 0.09375	5.0	29.7	17	5.0	2.9
Bark 0.09375	5.0	25.0	20	2.7	1.6
Leaf 0.09375	4.0	21.3	19	2.2	1.3
DEET 0.078125	6.0	27.3	22	4.7	2.7
Bark 0.078125	6.3	27.0	24	1.9	1.1
Leaf 0.078125	6.0	29.0	22	6.7	3.9
DEET 0.0625	3.0	29.0	10	3.9	2.3
Bark 0.0625	2.3	27.3	9	5.1	2.9
Leaf 0.0625	2.3	29.0	8	2.3	1.3

MINITAB® 15 was used to test statistical hypotheses. For hypothesis 1, there was 100% acaricidal rate on the concentration of 2.5µl, 1.25µl, 0.625µl, 0.3125µl, 0.15625µl, and 0.12625µl in total 100µl with cinnamon bark essential oil as same as DEET(positive control). It was trivial that cinnamon bark essential oil has as same acaricidal effect as DEET because it was exactly same with 100% (P-value = 1.0). However, in the concentration of 0.125µl, there was a difference in the acaricidal rate. The null hypothesis (H_0: $P_1 = P_2$) can be rejected because p-value (=0.000) is less than α (= 0.05). Hence, the acaricidal rate of the cinnamon bark essential oil was higher than the DEET in the concentration of 0.125µl. The hypothesis was tested on the concentration of 0.09375µl, 0.078125µl, and 0.0625µl. The p-value was 0.064, 0.819, and 0.688 respectively. Because the p-value of these three concentrations was greater than α (= 0.05), the null hypothesis (H_0: $P_1 = P_2$) can be accepted and there was no acaricidal effect on these concentrations. This meant that the minimum effective concentration to acaricide was 0.125 µl/100 µl of cinnamon bark essential oil. It could also be seen in Fig 1.

Similarly, hypothesis 2 could be shown that cinnamon leaf essential oil had acaricidal effect as DEET and the minimum effective concentration was 0.125 µl/100 µl.

For hypothesis 3, there was 100% acaricidal rate on the concentration of 2.5µl, 1.25µl, 0.625µl, 0.3125µl, 0.15625 µl, and 0.12625µl in total 100µl with cinnamon bark essential oil as same as cinnamon leaf essential oil. It was trivial that cinnamon bark essential oil has as same acaricidal effect as cinnamon leaf essential oil because it was exactly same with 100% (P-value = 1.0). However, in the concentration of 0.125µl, there was a difference in the acaricidal rate. The null hypothesis (H_0: $P_1 = P_2$) can be rejected because p-value (=0.000) is less than α (= 0.05). Hence, the acaricidal rate of the cinnamon bark essential oil was higher than the cinnamon leaf essential oil in the concentration of 0.125µl. The hypothesis was tested on the concentration of 0.09375µl, 0.078125µl, and 0.0625µl. Their p-value were 0.835, 0.665 and 0.908 respectively. Because the p-value of these three concentrations was greater than α (= 0.05), the null hypothesis (H_0: $P_1 = P_2$) can be accepted. Therefore, the cinnamon bark and leaf essential has no acaricidal effect on these concentrations.

Because the minimum concentration of acaricidal effect was 0.125 µl, the test concentrations for repellent effect were below it. And there was little difference between cinnamon bark essential oil and leaf oil, the experiment for repellent effect was done with cinnamon bark essential oil. The test concentrations were 0.125, 0.094, 0.083, and 0.0625 µl/100 µl and their collected experiment data was shown in Table II.

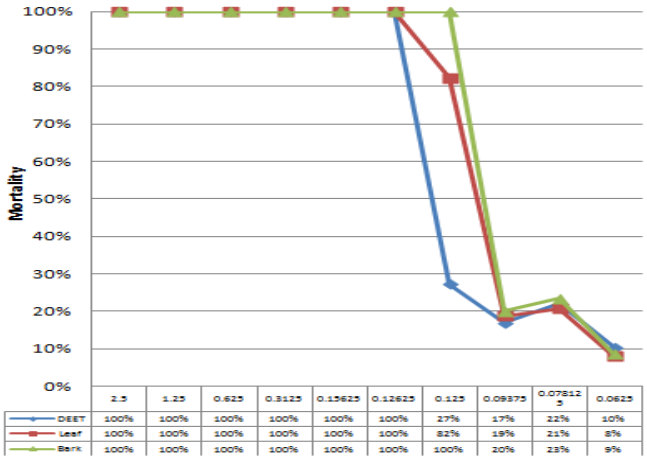

Fig. 1 Results for acaricidal effects

TABLE II
REPELLENT RATE FOR EACH CONCENTRATION

sample	Average			SD	SE
	#_Rep.	Total	Rep.(%)		
EtOH 100	17.7	34.0	51.5	9.4	5.4
Bark 0.125μl	19.0	34.0	56.9	9.6	5.5
Bark 0.094μl	23.3	26.3	88.7	3.3	1.9
Bark 0.083μl	24.7	31.7	78.4	5.9	3.4
Bark 0.0625μl	18.3	33.7	54.9	4.3	2.5

To compare the repellent effect with ethanol(control), two-proportion z-test was used on the concentration of 0.125μl, 0.094μl, 0.083μl, and 0.0625μl.The p-value were 0.574, 0.000, 0.000 and 0.722 respectively. These results showed that cinnamon bark essential oil had repellent effect on the concentration of 0.094μl and 0.083μl. And the most effective concentration for repellent effect was 0.094μl. These results could also be found in Fig 2.

V. Conclusion

The body's immune system is equipped to fight substances that can harm the body, such as viruses or bacteria. Allergens-such as pollen, house dust mites, mold, and animal dander- are harmless substances, but they can cause allergic reactions in some people.

Majority of asthma and a topic dermatitis are known to be spontaneously sensitive to house dust mite allergen. House dust mites are microscopic, insect-like creatures related to the tick and spider family. They feed primarily on scales from human skin and are found in most areas commonly inhabited by people.

Both decomposing animal parts and the protein that surrounds mite fecal pellets causes mite allergy. In homes, high levels of mites can be found in mattresses, pillows, bed linens, carpets, draperies, upholstered furniture and stuffed toys.

Control of house dust mite populations has been principally achieved by using chemical insecticides. Although effective, their repeated use for decades has sometimes resulted in development of resistance and fostered environmental and the risk to human health would be a potential problem. Moreover, house dust mite remain as allergens even after death.

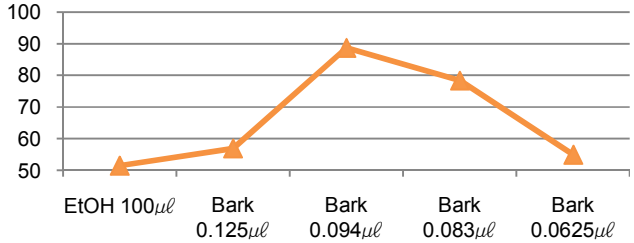

Fig. 2 Results for repellent effects

It is more effective method keeping the house dust mites away than killing them because allergen is not living house dust mite but dead body or fecal particles of house dust mite.

So, it is important to find out natural repellent material against house dust mite to control them and reduce the allergic reactions.

In this study, the research objectives were to verify the essential oil of cinnamon has acaricidal effect against house dust mite, if so, which is the minimum effective concentration and to verify the essential oil of cinnamon has repellent effect against house dust mite, if so which is the most effective concentration.

To test the acaricidal effect of cinnamon essential oil, black cotton was wetted with prepared chemicals (Ethanol, DEET, cinnamon bark and leaf essential oil) according to predetermined concentrations (2.5μl, 1.25μl, 0.625μl, 0.3125μl, 0.15625μl, 0.12625μl, 0.125μl, 0.09375μl, 0.078125μl, and 0.0625μl in total 100 μl). Fixed number of house dust mites was put on the processed black cotton in the petridiah and dead house dust mites were counted after 24 hours.

To test the repellent effect, half area of black cotton was wetted with chemicals of lower than the concentration which has the minimum acaricidal effect (0.125μl, 0.094μl, 0.083μl, and 0.0625μl in total 100 μl). The number of remaining house dust mites in the processed area was counted after 3 hours.

Cinnamon bark and leaf essential oil had acaricidal effect on the concentration of 2.5μl, 1.25μl, 0.625μl, 0.3125μl, 0.15625μl, 0.12625μl, 0.125μl. And there was no difference in these range.($p>0.065$) On the concentration 0.125μl, cinnamon bark essential oil was most effective($p=0.000$) and this was the minimum effective concentration to acaricide. Cinnamon bark essential oil had repellent effect on the concentration of 0.094μl and 0.083μl ($p=0.000$). And the most effective concentration for repellent effect was 0.094μl. We could find that cinnamon bark essential oil was very effective material to control the house dust mite. Furthermore, it could reduce chemical resistance and danger for human health

References

[1] L. G Arlian, "Arthropod Allergens and human health", Ann. Rev. Entomol. Vol 47, 2002, pp. 395-433.
[2] W. J. Jr. Hayes., and E. R. Laws. Jr., "Handbook of pesticide Toxicology", Academic press, 1991
[3] http://en.wikipedia.org/wiki/House_dust_mite
[4] M. Nadchatram. "House dust mites, our intimate associates", Tropical Biomedicine 22(1), 2005, pp. 23–37.

[5] The Patient Education Institute, Inc, " X-Plain Dust Mite Allergy Reference Summary", 2008
[6] http://en.wikipedia.org/wiki/Cinnamon
[7] Sen-Sung Cheng, Ju-Yun Liu, Kun-Hsien Tsai, Wei-June Chen, and Shang-Tzen Chang, "Chemical Composition and Mosquito Larvicidal Activity of Essential Oils from Leaves of Different Cinnamomum osmophloeum Provenances", J. Agric. Food Chem., 52 (14), 2004,pp 4395–4400