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Short Communication: Bioactive Materials

Acaricidal activity and chemical composition of essential oil derived from the *Albizziae julibrissin* barks

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Abstract The chemical compositions of the essential oil extracted from *Albizziae julibrissin* barks were analyzed by Gas chromatography-Mass spectrometry spectrometry. Fourteen components were identified, representing 89.23 % of the total oil composition. The analysis of the essential oil revealed that the essential oil contains 14 compounds, accounting for 89.23 % of the total oil. Hexanoic acid was the principal component (41.43 %) of the essential oil, followed by 4,4,6-trimethyl-cyclohex-2-en-1-ol (11.16 %), palmitic acid (9.00 %), 2-pentylfuran (5.66 %), 2-butyl-2-octenal (4.12 %), linoleic acid (3.10 %), amyl hexanoate (3.01 %), (*E,E*)-2,4-decadienal (2.49 %), 2-hexylthiophene (2.47 %), caprylic acid (2.13 %), δ-undecalactone (1.52 %), heptanoic acid (1.27 %), 3,5-octadien-2-ol (0.99 %), and 2-octenal (0.88 %). The acaricidal activity of the *A. julibrissin* oil was tested against *Dermatophagoides farina*, *D. pteronyssinus* and *Tyrophagus putrescentiae* by the fumigant bioassay. Based on the LD_{50} values, the essential oil exhibited strong acaricidal activities against *D. farinae* (LD_{50}, 4.88 μg/cm^3), *D. pteronyssinus* (2.44 μg/cm^3), and *T. putrescentiae* (1.22 μg/cm^3). These results indicate that *A. julibrissin* oil could be a source of acaricidal agents for mite control.

Keywords Acaricidal activity · *Albizziae julibrissin* · *Dermatophagoides farina* · *Tyrophagus putrescentiae*

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House dust mites (*Dermatophagoides farina* and *D. pteronyssinus*) have been recognized as a main cause of allergic dermatitis and rhinitis (Stewart 1995). Exposure to mite allergen, particularly in atopic children, is connected with the development of sensitization to some allergens (Arbes et al. 2003). The allergenic role of the stored food mites, *Tyrophagus putrescentiae*, is a significant inducer of allergens (allergic asthma and rhinitis) among industrial food workers and farmers (Marx et al. 1993). Current chemicals for mite control primarily use synthetic acaricides, avermectines and benzyl benzoate. However, some mite species have become resistant to these synthetic acaricides in the consequence of repeated exposure (Foil et al. 2004). Thus, there is a clear need for efficient alternatives to synthetic acaricide for the control of stored food mites and house dust mites (Erdal and Kamuran 2010). Plant oils and microbial secondary metabolites may provide potential alternative sources to acaricidal agents, because they contain a rich array of active chemicals (Cavalcanti et al. 2010).

Albizziae cortex, the stem bark of *Albizia julibrissin* Durazz (Leguminosae), is known as traditional Chinese medicine (Han et al. 2008). *Albizziae* cortex is popularly used as sedative and anti-inflammatory agents to treat injuries and remove carbuncles (Han et al. 2008). Recently, it was reported to exhibit various pharmacological activities such as antitumor and antagonic actions against PAF receptor (Kokila et al. 2013). To the best of our knowledge, the acaricidal activity of the essential oil extracted from the *A. julibrissin* barks against stored food mites and house dust mites has not been reported in literature. Therefore, the purpose of this study was to investigate the chemical composition of the essential oil of the *A. julibrissin* barks and its acaricidal activity against stored food mites and house dust mites.

Plant materials

The stem barks of *A. julibrissin* Durazz (Leguminosae) were purchased from the local market in Jeonju, Korea, in August 2015. A voucher specimen was authenticated by Prof. Jeongmoon Kim and deposited in the herbarium at Department of Landscape Architecture, Chonbuk National University, Korea. The essential

oil of the *A. julibrissin* barks was extracted from the dry stem barks by the steam distillation extraction method (Yang and Lee 2013).

Essential oil prepared

The essential oil of the *A. julibrissin* barks was isolated by hydrodistillation using a modified Clevenger-type apparatus for 8 h (Kingston and Jassie 1988). The essential oil was dried over anhydrous sodium sulfate, affording the pure essential oil. The essential oil of the *A. julibrissin* barks was then concentrated *in vacuo* at 30 °C, affording the desired oil in 0.075 % yield.

Mite

The cultures of *D. farinae*, *T. putrescentiae*, and *D. pteronyssinus* have been maintained in the laboratory for seven years without exposure to any known mite control agent. They were reared in containers (16×13×5 cm) containing 32 g of diet (fry feed no. 1/ dried yeast, 1:1, wt/wt) at 24±1 °C and 73 % relative humidity in darkness. The fry feed was obtained from Korea Special Feed Meal Co. Ltd. (Jeonju, Korea).

Gas chromatography-Mass spectrometry (GC-MS)

Analytical GC analysis was carried out using a Hewlett-Packard HP 6890 (Agilent Technologies, Palo Alto, CA, USA) Series GC equipped with a flame ionization detection detector and a DB-5 fused silica column (30 m 0.25 mm i.d., 0.25 μm film thickness, J&W Scientific, Folsom, CA, USA); column temperature, 51–201 °C at 1.8 °C/min; injector temperature, 211 °C; split ration, 49:1; carrier gas, He at 0.75 mL/min; ionization potential, 70 eV; ion source temperature, 232 °C; mass range, 50–601 mui. The components of essential oil were identified by comparing the retention times, indices, and mass spectra in the mass spectra library (The Wiley Registry of Mass Spectral Data, 8th edition).

Acaricidal activity and statistical analysis

Fumigant bioassay was used to access the acaricidal activity of the essential oil against *D. pteronyssinus*, *D. farina* and *T. putrescentiae*. Each test sample with an amount of 40, 20, 10, 5, 2.5, 1.25, and 0.50 μg/cm^3 was applied to a paper disc (Advantec, 8 mm diameter, 1 mm thickness, Tokyo, Japan) in acetone. The same dose of acetone was used as the negative control, and benzyl benzoate was used as the positive control. After air-drying in a fume hood for 7 min, each paper disc was placed on the cap of a microtube (5 mL, Greiner bio-one GmbH, Frickenhausen, Germany). Batches of 35 adult mites (7–10-days-old) were placed in each microtube (10 mL) and exposed to a period of 24 h. Experiments were conducted at 26±1 °C and 73 % relative humidity in darkness. Mites were considered dead if they did not move when pierced with a fine pin. All treatments were replicated three times. The LD_{50} values were analyzed using the probit analysis. Mortality (%) was transformed by the analysis of variance. Treatment means were separated using Scheffe's test at $p < 0.05$.

The yield of essential oil extracted from the *A. julibrissin* barks is 0.075 % by steam distillation. The chemical compositions of the essential oil were analyzed by GC-MS. The analysis of the essential oil of the *A. julibrissin* barks revealed that the essential oil contains 14 compounds, accounting for 89.23 % of the total oil (Table 1). Hexanoic acid was the principal component (41.43 %)

Table 1 Chemical composition of the essential oil of the *Albizziae julibrissin* barks

Retention time (min)	Constituents	RI[1)]	Mass spectra (m/z)	Relative amount (%)
5.988	2-Pentylfuran	1040	46, 53, 47, 81, 95, 109, 123, 138	5.66
6.771	Hexanoic acid	974	27, 41, 60, 73, 87, 99	41.43
6.881	3,5-Octadien-2-ol	995	41, 55, 69, 97, 111, 112, 126	0.99
7.235	2-Octenal	1013	27, 29, 55, 57, 70, 84, 98	0.88
7.849	Heptanoic acid	1073	27, 41, 60, 73, 87, 101, 113, 131	1.27
9.161	δ-Undecalactone	1503	27, 41, 69, 71, 84, 99, 114, 148, 166	1.52
9.388	Caprylic acid	1173	38, 41, 60, 73, 84, 101, 115, 127, 144	2.13
10.886	2-Hexylthiophene	1292	28, 39, 58, 71, 97, 98, 112, 139, 168	2.47
11.130	Amyl hexanoate	1282	27, 41, 43, 60, 70, 87, 99, 117	3.01
11.616	*(E,E)*-2,4-Decadienal	1220	51, 55, 67, 81, 95, 152	2.49
12.068	4,4,6-Trimethyl-cyclohex-2-en-1-ol	1085	41, 69, 83, 84, 98, 125, 140	11.16
12.474	2-Butyl-2-octenal	1388	27, 41, 55, 69, 83, 95, 111, 125,, 139, 140, 182	4.12
10.835	Palmitic acid	1968	27, 41, 43, 60, 73, 85, 98, 115, 129, 157, 171, 185, 213, 227, 256	9.00
21.328	Linoleic acid	2183	27, 41, 55, 67, 81, 95, 109, 123, 136, 150	3.10
	Major Grouped			
	Fatty acyl			64.94
	Furan			5.66
	Thiophene			2.47

[1)]RI, Kovat's index of retention

Table 2 Acaricidal activities of the essential oil of the *Albizziae julibrissin* barks and commercial acaricide[1)]

Sample	Mite species	LD_{50} (μg/cm^3)	RT[2)]
Albizziae julibrissin oil	*D. farinae*	4.88±0.77	1.83
	D. pteronyssinus	2.44±0.61	2.96
	T. putrescentiae	1.22±0.53	8.60
Benzyl benzoate	*D. farinae*	8.94±0.96	1
	D. pteronyssinus	7.22±0.87	1
	T. putrescentiae	10.48±1.35	1

[1)]Exposed for 24 h
[2)]Relative toxicity = LD_{50} value of benzyl benzoate/LD_{50} value of each chemical

of the essential oil, followed by 4,4,6-trimethyl-cyclohex-2-en-1-ol (11.16 %), palmitic acid (9.00 %), 2-pentylfuran (5.66 %), 2-butyl-2-octenal (4.12 %), linoleic acid (3.10 %), amyl hexanoate (3.01 %), *(E,E)*-2,4-decadienal (2.49 %), 2-hexylthiophene (2.47 %), caprylic acid (2.13 %), δ-undecalactone (1.52 %), heptanoic acid (1.27 %), 3,5-octadien-2-ol (0.99 %), and 2-octenal (0.88 %). Significant proportions of fatty acyl group (64.94 %) were present in the sample (amyl hexanoate, caprylic acid, *(E,E)*-2,4-decadienal, hexanoic acid, heptanoic acid, linoleic acid, 3,5-octadien-2-ol, palmitic acid and δ-undecalactone). Previous studies have reported saponins, glycosides, flavonoids, lignans, and phenolic triterpenes as the phytochemical components of *A. julibrissin* barks (Chen and Zhang 1997; Kang et al. 2000; Jung et al. 2004; Won et al. 2006).

The acaricidal activity of the *A. julibrissin* oil against house dust mites (*D. farina* and *D. pteronyssinus*) and stored food mites (*T. putrescentiae*) was evaluated by the fumigant bioassay and compared to that of synthetic acaricide, benzyl benzoate (Table 2). The LD_{50} values of the essential oil obtained from the *A. julibrissin* barks were 4.88, 2.44, and 1.22 μg/cm^3 against *D. farina*, *D. pteronyssinus*, and *T. putrescentiae*, respectively. Based on the LD_{50} values against *D. farinae*, the *A. julibrissin* oil was ~1.83, times more effective than benzyl benzoate (8.94 μg/cm^3). Against *D. pteronyssinus*, the *A. julibrissin* oil was circa 2.96 times more effective than benzyl benzoate (7.22 μg/cm^3). In the case of *T. putrescentiae*, the *A. julibrissin* oil was circa 8.6 times more effective than benzyl benzoate (10.48 μg/cm^3). These results indicate that the stored food mite is more sensitive than house dust mites to the *A. julibrissin* oil. These results exhibited the differences of the acaricidal activity on the species of insects. Actually, species-specific differences have been studied for a variety of mite species (Won et al. 2006). In 2003, Jung et al. (2003) reported that the methanol extract of the *A. julibrissin* exhibited strong antioxidant activity. Furthermore, the butanol extract from the *A. julibrissin* barks exhibited significant inhibitory activity against human tumor cell lines (Zheng et al. 2006). Previous studies have reported that the main compound of *A. julibrissin*, hexanoic acid, has the fumigant activity to *Drosophila melanogaster* (Dettner et al. 1992). Moreover, Kumar et al. (2010) suggested that the palmitic acid showed antioxidant, hypocholesterolemic nematicide, and pesticide activities. This study is, to our knowledge, the first to study the acaricidal function of *A. julibrissin* oil against house dust mites and stored food mites.

The acaricidal activity may be attributed to the presence of components found in the *A. julibrissin* oil, hexanoic and palmitic acids. However, the relationship between chemical composition and acaricidal activity has not been assessed in literature. Therefore, further research is needed to understand the relationship between the acaricidal activity and isolated component. Our results indicate that the essential oil of the *A. julibrissin* barks can be potentially used as a source of natural mite control agents.

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