CHEMICAL COMPOSITION AND INSECTICIDAL ACTIVITY OF THE MEDICINAL PLANT *PHJAC CHAC* IN CAO BANG PROVINCE, VIETNAM

Abstract

Phjac chac—closely related to *Neocinnamomum mekongense*—is widely used by the indigenous communities in Cao Bang province, Vietnam. This plant holds immense potential as a flavoring agent and medicinal herb due to its unique aroma. Despite its widespread use, information is scarce regarding the chemical composition of both *Phjac chac* and *Neocinnamomum mekongese*. Therefore, this research studies the *Phjac chac* plant's components and its insecticidal activity. Using gas-phase chromatography combined with a mass spectrometer, we have concluded that *Phjac chac* leaves are composed of benzyl benzoate (65.4%), followed by linalool (5.4%), E-cinnamaldehyde (4.0%), α-pinene (3.9%), β-phellandrene (3.4%), eugenol (3.4%), and benzaldehyde (2.7%). We tested its essential oil's insecticidal property on cockroach larvae and found it is 3.3 times more effective in killing cockroach larvae than benzyl benzoate, with the lethal concentration 50 (LC50) of 1.00 and 3.37 mg mL. This result indicates that the mixture of essential oil components has a synergistic or complementary effect with benzyl benzoate, contributing to a better larvicidal effect. This finding may provide useful information to further exploit and conserve this plant for the economic activity of Cao Bang province.

1. Introduction

Due to its diverse climate conditions, Vietnam's flora is also diverse with a plethora of tropical and temperate plants [1], of which 4,000 species are currently used as medicinal plants [2]. Vietnam has 54 ethnic minority groups, many of which reside in mountainous areas. Such minority groups have been practicing herbal medicine throughout history and continue to do so due to the lack of accessible modern medicine in the region.

Cao Bang province is an area where herbal medicine is widely practiced. Due to its high terrain and special climatic conditions, Cao Bang province has an abundance of flora, especially herbs. A recent survey report documented approximately 940 medicinal species, of which 577 plant species have been used to treat various ailments such as asthma, diabetes, hemorrhages, hepatitis, scrofulous, toothaches, tranquilizer, urolithiasis, vaginitis, etc [3].

The plant species called *Phjac chac* can be found in Bao Lac district, Cao Bang province. It has widely been used for thousands of years by residents of this area: the Dao, Tay, and Nung minority groups. It is a woody plant that grows on high mountains over 1,000 meters above sea level. As explained by a Dao person, the term *Phjac chac* was derived from the Dao indigenous language, in which *phjac* means vegetable and *chac* implies "aromatic when crushed." As the name implies, the leaves of the *Phjac Chac* plant have a mild fragrance, similar to the smell of lemongrass. *Phjac Chac* leaves are used by local people as a spice for dishes such as grilled meat, sour bamboo shoot soup, and blood pudding. *Phjac Chac* leaves contain about 1% essential oil, which locals extract with the steam distillation method [4]. *Phjac Chac* essential oil is used to create fragrance, deodorize, clean the air, and repel mosquitoes. It is also employed in traditional Asian medicine to relieve cold symptoms such as nasal congestion and coughing [4]. We have speculated that due to its aromatic nature, the plant has insecticidal properties.

The *Phjac chac* plant has been concluded to be closely related to the *Neocinnamomum mekongense* plant, which belongs to the Lauraceae family [4]. Though there have been studies that describe this particular species' morphology and habitat, there is a lack of scientific evidence regarding its chemical composition and the safe dosage for human consumption. Therefore, this study aims to determine the chemical composition and insecticidal activity of *Phjac chac*.

Figure 1. *Phjac Chac* plant

Figure 2. *Phjac Chac* essential oil

2. Experiment

2.1. Materials

Phjac Chac leaves were collected in June 2023 in Cao Bang, Vietnam.

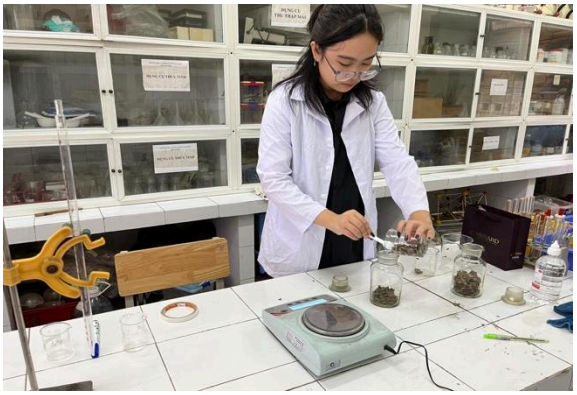

Figure 3. Soaking *Phjac Chac* leaves

2.2. Chemical composition analysis

Compounds in *Phjac Chac* essential oil samples were determined by gas-phase chromatography combined with a mass spectrometer (GC–MS; Thermo DSQ II, Thermo Scientific, TX, USA) under the following conditions: capillary column fused silica conduit DB–5 ms (30 m x 0.25 mm, film thickness 0.25 μm); programmed temperature 60–240 °C (3 °C min-1); injector temperature of 250°C; helium as a carrier gas, regulated at a linear velocity of 32 cms-1 (measured at 100 °C); undivided injection type (2 μL of 1:1000 hexane solution); the split stream adjusted to yield a ratio of 20:1; EIMS electron energy of 70 eV; and the temperature of the ion source and connecting parts of 200 °C.

Quantitative analysis of chemical components was performed by peak area normalization using GC-FID under the same conditions as described for GC–MS. The retention index was calculated for all volatile components using the n-alkane homologous series. Identification was based on mass spectrometry and retention index (RI) analysis and compared with literature data [2].

2.3. Testing the insecticidal activity of essential oils

Phjac Chac essential oils and benzyl benzoate (Sigma Aldrich) were prepared at concentrations ranging from 0.5 to 25.0 mg/mL in 3% Triton X-100 and used in biological assay treatments.

For each concentration, approximately 50 cockroach larvae were placed between two 2 × 2 cm filter papers soaked with 0.4 mL of a solution containing essential oil or benzyl benzoate to form a packet. The packet was then placed into unsoaked filter paper (72.25 cm^2) and sealed with a plastic clothespin. Packets were transferred to an incubator at 27 ± 1 °C 27 ± 1 °C with relative humidity (RH) ≥ 80% for 24 hours. After this period, live and dead larvae were counted. Cockroaches that did not move were considered dead. The experiment was performed four times for each treatment, and 3% Triton X-100 solution was used as a negative control. The lethal concentration (LC50) of each compound against larvae was calculated using GraphPad Prism 6.0. *Phjac Chac* essential oil was considered significantly ($P < 0.05$) more (or less) effective than benzyl benzoate when there was no overlap between the 95% confidence limits of the LC50 values (Roditakis et al., 2005).

3. Results and discussion

3.1. Results of chemical composition analysis of Phjac Chac essential oil

Essential oils and their terpenes are an alternative means of controlling parasites (Anthony et al., 2005). However, chemical modifications of essential oils within the same plant species cause differences in insecticidal activity (Cruz et al., 2013, Peixoto et al., 2015). I analyzed the chemical composition of essential oils of *Phjac Chac* leaves using gas chromatography-mass spectrometry (GC–MS). Research results show that 77.6% of

essential oils are terpenes (aromatic or aliphatic monoterpenes or sesquiterpenes) and 8.3% are phenylpropanoid aromatic esters. The main compounds found in *Phjac Chac* oil are benzyl benzoate (65.4%), followed by linalool (5.4%), E-cinnamaldehyde (4.0%), α-pinene (3.9%), β-phellandrene (3.4%), eugenol (3.4%), and benzaldehyde (2.7%).

Essential oils from *Phjac Chac* leaves are used in the pharmaceutical industry because of their many biological activities. Currently, the main compound of *Phjac Chac* leaf essential oil is eugenol, which has insecticidal activity; however, a rare chemical ingredient benzyl benzoate can also be found in *Phjac Chac* essential oil.

3.2. Test results of killing cockroach larvae

Phjac Chac essential oil is 3.3 times more effective in killing cockroach larvae than benzyl benzoate alone, with LC50 of 1.00 and 3.37 mg mL-1, respectively (Table 1). This result indicates that the mixture of essential oil components has a synergistic or complementary effect with benzyl benzoate, contributing to a better larvicidal effect. Synergistic effects of essential oil compounds have been shown in insects and cockroaches.

Table 1: Cockroach larvae killing concentration of *Phjac Chac* essential oil and benzyl benzoate

Compounds	**LC_{50} (mg mL^{-1})**	**CI 95%**	**R^2**
Phjac chac essential oil	1.00[a]	0.99–1.02	0.84
Benzyl Benzoate	3.37[b]	3.14–3.60	0.97

Many studies have also shown that benzyl benzoate or eugenol can kill and repel insects. These substances are all present in large concentrations in *Phjac Chac* essential oil. In addition to killing cockroaches, according to ancient practices in Vietnam, *Phjac Chac* essential oil can repel mosquitoes and mice, kill bacteria and mold, and deodorize cars.

4. Conclusion

After the research period, I have identified some chemical components of *Phjac Chac* essential oil such as terpenes (77.6%) and phenylpropanoid aromatic ester (8.3%). The main compounds found in the oil are benzyl benzoate (65.4%) followed by linalool

(5.4%), E-cinnamaldehyde (4.0%), α-pinene (3.9%).), β-phellandrene (3.4%), eugenol (3.4%), and benzaldehyde (2.7%).

Tests were conducted on the ability to kill cockroach larvae and showed that *Phjac Chac* essential oil's effectiveness in killing cockroaches is 3.3 times higher than that of benzyl benzoate.

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