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Technology for the Development of Natural Shampoo of Duku Bark Extract (*Lancium Domesticum Corr*) as a Prevention Effort Against Pediculosis

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Abstract:
Pediculosis, an infestation caused by head lice (*Pediculus humanus capitis*), is a common parasitic condition affecting the human scalp. Although synthetic chemical agents such as lindane, pyrethrin, permethrin, and malathion are widely employed to prevent and treat head lice infestations, their continuous use has led to the development of drug resistance. Consequently, the exploration of natural substances with insecticidal properties, known as pediculosides, has become increasingly necessary. This study investigates the pediculosidal activity of ethanol, ethyl acetate, and n-hexane extracts derived from duku bark (*Lansium domesticum*) against lice at different developmental stages—eggs, nymphs, and adults—at concentrations of 10%, 15%, and 20%. The results demonstrated that the mean number of inactive (non-viable) eggs was 6.72 at 10% concentration, 18.22 at 15%, and 17.06 at 20%, with a statistically significant p-value of 0.002. In contrast, mortality among nymphs averaged 10.06 individuals at 10%, 15.56 at 15%, and 16.39 at 20%, without reaching statistical significance ($p = 0.169$). For adult lice, the mean mortality was 7.83 at 10%, 13.22 at 15%, and 20.94 at 20%, yielding a highly significant p-value of 0.001.

Keywords: Pediculosis, *Pediculus humanus capitis*, Duku Bark Extract, Natural Pediculosides, Head Lice Control, Plant-Based Insecticides.

ELT 焦点：开发 Duku 树皮提取物（*Lancium domesticum corr*）天然洗发水的技术，以预防虱病

摘要：虱病是生活在人类头发上的头虱昆虫的侵扰。引起头皮刺激的虱子类型是 Pediculus Humanus capitis。一般来说，每个人都可以通过使用合成化学药物（如林丹、除虫菊酯、氯菊酯和马拉硫磷）来预防头虱感染，但如果持续使用这些药物会导致耐药性。因此，有必要对可用作天然药物的天然成分进行研究，即称为豌苷的杀虫剂。本研究旨在确定乙醇提取物、乙酸乙酯提取物和 duku 树皮的 N-己烷提取物在 10%、15% 和 20% 浓度下对鸡蛋、ninfa 和成年跳蚤死亡率的测试结果。根据检测结果，得到浓度为 10% 的 6.72 枚蛋、15% 18.22 枚蛋和 20% 17.06 枚蛋，p 值为 0.002 的平均不活性蛋的检测结果。在平均浓度为 10% 的死头 10.06 头、15% 15.56 头和 20% 16.39 头的蜱 ninfa 下进行测试，p 值为 0.169。同时，对死去的成年跳蚤的检测浓度为 10% 7.83 头、15% 13.22 头和 20% 20.94 头，p 值为 0.001。可以得出结论，杜库树皮的乙醇、乙酸盐和正己烷提取物有可能用作用杜库树皮提取物制造洗发水的虱苷

关键词：葱淀粉提取物凝血酶止血小鼠、杜库树皮提取物、预防虱病

1. Introduction

Pediculus humanus capitis is an ectoparasite on the human scalp and hair, and its infestation has spread throughout the world. This parasitic infestation has a high prevalence, especially in school-age children. It has been reported that the prevalence of pediculosis in the United States affects 6 to 12 million people every year; Malaysia and Thailand have a prevalence of 35% and 23.48%, respectively, while in Indonesia, 15% of school-age children are infested with pediculosis capitis (Rengganis et al., 2019) (Subandrate et al., 2016).

This parasite infestation will cause clinical symptoms of itching on the scalp, social stigma, shame, low self-esteem, and anemia, which can cause children to become lethargic and sleepy in class, thus affecting concentration in learning. Currently, efforts to reduce and eliminate pediculosis are being carried out by the administration of synthetic chemical drugs. The dominant drugs used in the community include lindane, pyrethrin, permethrin, and malathion. In general, treatment with synthetic drugs can cause resistance if not performed carefully, and hair becomes stiff (Bartosik et al., 2015).

Efforts are needed to minimize the negative impact of the use of synthetic pedicures, namely, by using natural pediculocides. Duku bark extract (Lansium domesticum corr) is a natural ingredient that can be used as a natural insecticide. Duku (Lansium domestica Corr.) is a typical Indonesian plant. Many studies have been conducted on this duku, ranging from agriculture to the health sector. Some research results have also shown that duku bark has various uses. In agriculture, duku extract can be used as an antifeedant and can effectively deal with rice plant locust pests (Rodríguez et al., 2020) (Rahayu et al., 2024). Additionally, duku can be used in cosmetics (Fitriana, Humaira, Trisnawaty, 2022). In 2017, researchers conducted research on the effects of duku bark extracts against fungi. Duku bark can function as a fungicide by forming a clear zone around the disc using PDA media on the growth of the fungus Candida albicans (Darmadi & Setiawan, 2018). Furthermore, testing of Pediculus humanus capitis insects showed that duku bark extract has the potential to act as a pediculous head lice (Pediculus humanus capitis) at a concentration of 15 (Darmadi & Setiawan, 2018).

Research conducted by Di Campli reported that the terpenoid content in the combination of tea tree oil with nerolidol has the potential to cause mortality in Pedikulus humanus capitis, which was tested for 20 min, resulting in 100% mortality. The results of the research conducted by Arrizqiyani et al. (2019) showed that some essential oils from natural ingredients have the potential to be a natural pediculosis against the mortality of head

lice (Pediculus humanus capitis), which was carried out in vitro. The treatment result compared to the positive control was 157.16 seconds for natural materials, whereas the positive control test result was 7200 s. Testing of duku bark extract on the mortality of pediculus humanus capitis has not been carried out, therefore further research is needed from this duku bark extract to see the characterization of the duku bark extract and at the same time isolate the type of active compound that functions as a natural insecticide against pediculosis infection (Arrizqiyani, 2019).

2. Methods

This study used the laboratory experimental research method (in vitro), which is a type of research conducted under controlled conditions in the laboratory, to test the effect of a treatment on the research object. In this study, duku bark extract (Lansium domesticum Corr.) was tested for its effectiveness as a natural pediculoid against the head lice (Pediculus humanus capitis). The research process involved several main stages, starting from the collection and processing of duku skin samples, which were then extracted using the maceration method with ethanol, ethyl acetate, and n-hexane solvents. The extracts obtained were phytochemically tested to identify the content of active compounds, such as flavonoids, alkaloids, saponins, triterpenoids, and tannins.

Tools and materials

The tools used included glass tools, scales, blenders, rotary evaporators, desiclators, ovens, chambers, glass plates, capillary pipes, UV-Vis spectrophotometry, IR, and GC-MS. Duku fruit peel, aquadate, methanol, ethanol, ethyl acetate, and various color reagents were used. Meanwhile, the material used in this study was duku bark obtained from a duku sales place sourced from the city of Medan, and then dried for simplification (Asworo & Widwiastuti, 2023).

Making Simplisia, macroscopic and microscopic examination of the peel of fresh duku fruit was carried out by wet sorting by washing in running water, followed by stretching and drying at room temperature for 3-5 days. The samples were then subjected to dry sorting and refinement. Macroscopic examination was performed without the use of instruments, while microscopic examination was performed using a microscope.

Research stages

Extraction

The extraction of duku bark was carried out by maceration using several solvents, namely ethanol and ethyl acetate. Next, the solvent was evaporated using a rotary evaporator until a viscous extract with a constant weight was obtained. After the liquid extract was rotated, a thick extract from the duku bark was obtained, which had different characteristics depending on the solvent used. The following are the rotary results obtained for each solvent.

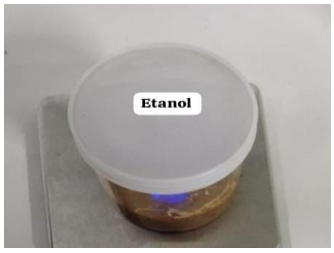


Figure 1 Ethanol extract

Figure 2 N-Hexane extract

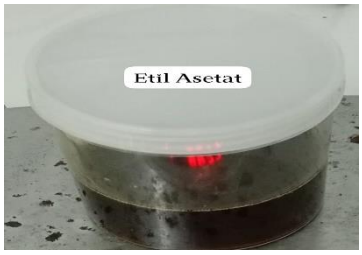


Figure 3 Ethyl Acetate

Phytochemical screening of duku bark extract

Alkaloid testing was performed using Bouchardat, Mayer, and Dragendrof reagents. 2. Flavonoid test with addition of HCl + Mg powder. Tannin test with FeCl3 and Terpenoid test with Bouchardat reagent. (Arrizqiyani, 2019)

3. Result and Discussions

Results

Phytochemical Tests

Phytochemical tests that have been carried out based on the type of solvent used obtained the results as below.

Table 1. Phytochemical test of duku bark extract

No	Types of Extracts	Test Results				
		Flavonoids	Alcolloids	Saponins	Triterpinoids	Tannins
1	Ethanol	+	-	+	+	+
2	Ethyl Acetate	+	-	+	+	-
3	N-Hexane	+	+	+	+	-

Based on table 1. The results of phytochemical tests of ethanol, ethyl acetate, and n-hexane extracts of duku bark were obtained in n-hexane; only the secondary metabolite compounds of tannins were negative (-), flavonoids, alkaloids, saponins, and triterpenoids were positive (+). In Ethanol, the results of colloidal secondary metabolite compounds were negative (-), while flavonoids, saponins, triterpenoids, and tannins tested positive (+). Meanwhile, in ethyl acetate, the secondary metabolite compounds that are negative (-) are alkaloids and tannins, while flavonoids, saponins, and triterpenoids are positive (+) (Firoozbahr et al., 2023).

Testing of duku bark extract against head lice metamorphosis.

The effectiveness of the duku bark extract on the mortality of head lice (Pediculus humanus capitis) was tested in vitro. Sieve paper and the size of a petri cup were inserted into a petri dish. Duku bark extract was dripped and evenly distributed on filter paper. Ten ticks were placed in a petri dish and closed. The samples were examined during the first five minutes, and then checked every 5 min for 2 h. Positive controls and negative controls were created for comparison (Panjaitan & Farida, 2024).

Data Analysis

The data analysis was the data analysis carried out in the test study of ethanol, ethyl acetate, and N-hexane of duku bark (Lancium domesticum corr) as a natural pediculoside against eggs, ninfa, and adult fleas, and the results were subjected to a normality test with the Kruskal-Wallis test to determine the effect of the extract and the Mann–Whitney test to determine the effect of the concentration of the extract.

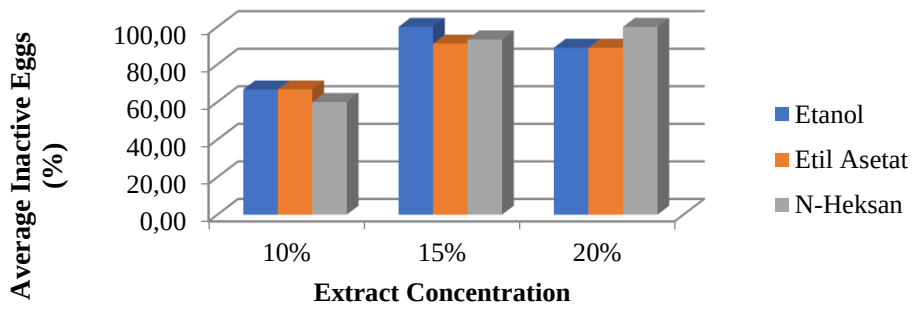
Test Results of Ethanol, Ethyl Acetate and N-Hexane extracts of Duku Bark against eggs, ninfa and adult fleas

Table 2. Testing of flea eggs

Extract	Average Inactive Eggs (Eggs)		
	10%	15%	20%
Ethanol	10	15	13.33
Ethyl Acetate	10	13.67	13.33
N-Hexane	9	14	15

From table 2. The results were obtained with the egg test object using ethanol extracts of inactive eggs with an average concentration of 10% 10 inactive, a concentration of 15% 15 inactive eggs and a concentration of 20% which was 13.33 inactive eggs. Ethyl acetate extract with a concentration of 10% for as many as 10 inactive eggs, 15% for as many as 13.67 grains and 20% for 13.33 grains. Meanwhile, n-hexane extract at an average concentration of 10% inactive 9 eggs, 14 eggs at 15% concentration, and 15 eggs at 20% inactive eggs.

Graph image 1 Average percentage of inactive eggs after being treated with ethanol, N-Hexane and Ethyl Acetate extracts at different concentration levels



Graph Figure 1. Average percentage of inactive eggs after being treated with ethanol

From graph 1 above, the test on tick eggs can be concluded that ethanol extract at 10% concentration of inactive eggs is 62%, 15% concentration of inactive eggs and 20% concentration of inactive eggs 82%. In the ethyl acetate extract, the concentration of 10% of inactive eggs were 62%, the concentration of 15% of inactive eggs was 84% and the concentration of 20% of inactive eggs was 82%, respectively. Meanwhile, by

using n-hexane extract at a concentration of 10%, the average concentration of inactive eggs was 58%, the concentration of 15% of inactive eggs was 85%, and the concentration of 20% of inactive eggs was 98%.

Determination of inactivity of flea eggs was based on testing by conducting microscopic examinations before and after testing. An egg that is active with a fat morphology, inside the egg there are still the contents of the embryo, and if pressed, it will actively sound. On the other hand, eggs that are not morphologically inactive are flat (empty), transparent, and do not make a sound when pressed. The following are the differences between active and inactive eggs (Noersyamsidar, 2022)

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Figure 4. Active egg morphology

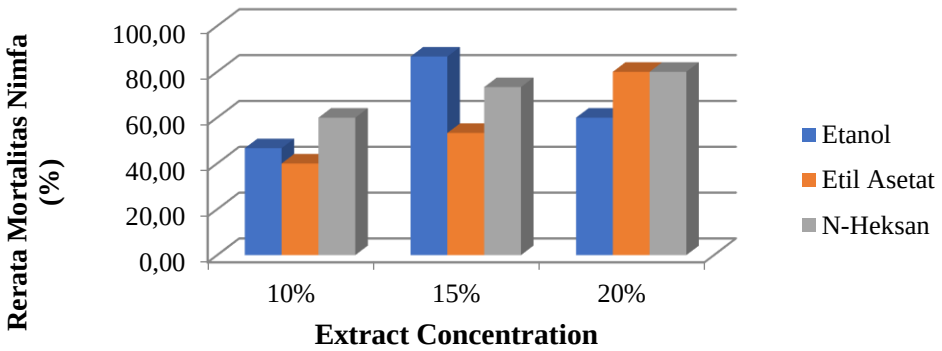
Figure 5. Morphology of inactive eggs

Table 3. Testing of Tick Ninfa

Extract	Average Mortality of Nymphs (Tails)		
	10%	15%	20%
Ethanol	2.33	4.33	3
Ethyl Acetate	2	2.67	4
N-Hexane	3	3.67	4

From table 3. above, the results were obtained with ninfa testing objects using ethanol, ethyl acetate and N-hexane extracts at a concentration of 10%, the average concentration of dead ninfa was 2.33%, the concentration of 15% was 4.33 fish, and the concentration of 20% was 3 fish. In the Ethyl Acetate extract, the average concentration of 10% dead ninfa was 2.67 heads of 15%, and 20% concentration of 4 heads, while N-hexane at a concentration of 10% was 3 heads, 15% concentration was 3.67 heads and 20% concentration was 4.

Graph figure 2. Average mortality percentage of tick nymphs after treatment with ethanol, N-Hexean and Ethyl Acetate extracts based on concentration series



Graph Figure 2. Average mortality percentage of tick nymphs after treatment with ethanol

From graph 2 above, it can be concluded that ethanol extract at an average concentration of 10% ninfa had a mortality of 42%, a concentration of 15% ninfa had a mortality of 82%, and a concentration of 20% ninfa had a mortality of 52%. In the ethyl acetate extract, 10% ninfa resulted in 38% mortality, 15% ninfa resulted

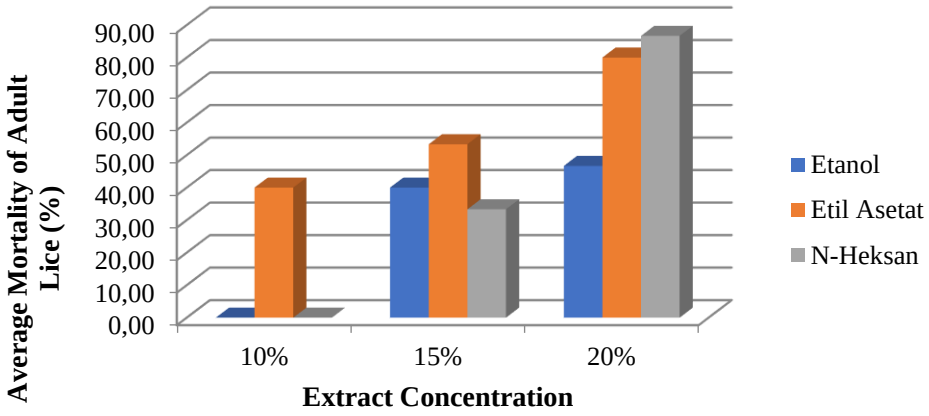
in 50% mortality, and 20% ninfa resulted in 78% fatality. Meanwhile, using n-hexane extract at a concentration of 10% with an average mortality of 58%, a concentration of 15%, an average mortality of 70%, and a concentration of 20%, with an average mortality of 78%.

Table 4. Adult Tick Testing

Extract	Average Adult Flea Mortality		
	10%	15%	20%
Ethanol	0	2	2
Ethyl Acetate	0.33	0.33	3.33
N-Hexane	0	1.67	4

From Table 4, the results were obtained with the best adult flea test objects using ethanol, ethyl acetate, and n-hexane extracts, namely with n-hexane starting from a concentration of 10% of the average dead ticks as much as 0%, a concentration of 15% 1.67 heads and an average concentration of 20% for four dead ticks.

Graph image 3. Average mortality percentage of ticks after treatment with ethanol, ethyl acetate and N-Hexan extracts based on concentration series



Graph Figure 3 Average mortality percentage of ticks after treatment with ethanol

From graph 3 above, the test on adult fleas can be concluded that ethanol extract at a concentration of 10% on average fleas with a mortality of 0%, a concentration of 15% on average fleas with a mortality of 38% and an average concentration of 20% on ticks with a mortality of 42%. In the ethyl acetate extract, a concentration of 10% on average ticks had a mortality of 38%, a concentration of 15% on average ticks had a mortality of 50%, and a concentration of 20% on average ticks had a mortality rate of 78%. Meanwhile, by using n-hexane extract at a concentration of 10% on average ticks with a mortality of 0%, a concentration of 15% on average ticks with a mortality of 30%, and a concentration of 20% on average ticks, with a mortality rate of 82%.

Tabel 5. Statistical test of differences in ethanol, ethyl acetate and N-hexane extracts of Duku bark on mortality of eggs, nymphs and adult ticks with the Kruskal Wallis Ranks test

Variable	Extract	N	Mean Rank	Asymp. Sig.
Inactive Flea Eggs	Ethanol	9	15.78	0.946
	Ethyl Acetate	9	11.61	
	N-Hexane	9	14.61	
Tick Nymphs	Ethanol	9	14.61	0.535
	Ethyl Acetate	9	11.72	
	N-Hexane	9	15.67	
Adult Ticks	Ethanol	9	13.22	0.775
	Ethyl Acetate	9	13.33	
	N-Hexane	9	15.44	

Remarks: Sig >0.05 shows no difference

Based on table 5. of the test of the difference between ethanol, ethyl acetate and N-hexane extracts,

the results of the Kruskal Wallis test for inactive egg variables p-value 0.046, ninfa variable p-value 0.535 and adult flea variable p-value 0.775 were obtained. This means that the three extracts did not have significant effects on the egg, ninfa, and adult flea variables.

Table 6. Effect of Ethanol, Ethyl Acetate and N-Hexean Extracts of Duku Skin on Mortality of Eggs, Nymphs and Adult Fleas Using the Mann Witney Test

Variable	Extract	N	Mean Rank	Asymp. Sig.
Inactive Flea Eggs	10%	9	6.72a	0.002
	15%	9	18.22BC	
	20%	9	17.06c	
Tick Nymphs	10%	9	10.06a	0.169
	15%	9	15.56a	
	20%	9	16.39a	
Adult Ticks	10%	9	7.83a	0.001
	15%	9	13.22a	
	20%	9	20.94b	

Remarks: Sig< 0.05, indicating a significant difference. The number followed by the same *superscript* letter in one column indicates that there was no significant difference between treatments (P>0.05).

Based on Table 6, the results of the effect of ethanol, ethyl acetate, and n-hexane extract concentrations were obtained by the Mann-Whitney test on the inactive egg variable p-value 0.002, on the ninfa variable p-value 0.169, and on the adult flea variable p-value 0.001 at the extract concentrations of 10%, 15%, and 20%. This means that there is a significant difference in testing on the variable of flea eggs and adult fleas with a p-alpha result of <5%, whereas the ninfa variable with a p-alpha result of >5% indicates that there is no significant difference.

Testing for mortality of ninfa ticks and adult ticks is based on the movement of the ticks and is assisted with a spatula to ensure that the ninfa and adult ticks are completely dead. The following are the forms and morphologies of ninfa and adult ticks that have experienced mortality:

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Figure 6. Surviving Adult Ninfa or Fleas

The morphology of the ninfa of the living tick is that with the characteristics of actively moving, the legs open indicates that the tick is actively moving.

Figure 7. Dead Ninfa or Adult Fleas

The morphology of dead ticks with characteristics of tick legs leads to the inside of the tick or shrinking (Tomia & Tuharea, 2022).

Determination of Standardized Parameters of N-hexane Extract of Duku Bark

Specific Parameter Testing

a. Identity Checks

The description of the nomenclature is the name of the extract, Latin name of the plant, part of the plant used, and Indonesian name of the plant (Maryam et al., 2020).

b. Organoleptic examination is performed by physical recognition using the five senses of shape, smell, color, taste, and size.

c. Levels of Compounds Soluble in Water

An extract of 2.5 g (W1) extract was weighed and extracted for 24 h with 50 mL of LP chloroform water using a measuring flask. Shake occasionally for the first 6 h, let it stand for 18 h, and strain. The obtained filtrate was evaporated to dryness in a shallow flat-bottomed dish that was diluted (W0) by letting it sit until the solvent evaporated and the residue remained. The residue was heated at a temperature of 105^{0C} to a fixed weight (W2), calculating the content in % of water-soluble juice.

d. Levels of Compounds Soluble in Ethanol

An extract of 2.5 g (W1) was weighed and macerated with 50 mL of 95% ethanol for 24 h in a stuffed flask. Shake occasionally for the first 6 h, let stand for 18 h, and filter quickly to avoid the evaporation of ethanol. The obtained filtrate was evaporated to dryness in a shallow flat-bottomed dish that was diluted (W0) by letting it sit until the solvent evaporated and the residue remained. The residue was heated at a temperature of 105^{0C} to a fixed weight (W2), calculated the content in % of ethanol-soluble juice was calculated.

Non-specific parameters

a. Determination of Drying Shrinkage

One gram of the extract was weighed and placed into a closed porcelain crux that had been heated at 105^{0C} for 30 min and measured. Before weighing, the extract was flattened in porcelain cruces by shaking the cruss until it formed a layer 5 – 10 mm thick, placed in the oven, opened the lid, dry at 105^{0C} until the weight was fixed. Cool in the Desik. Replicate three times, and then calculate the percentage (Maryam et al., 2020).

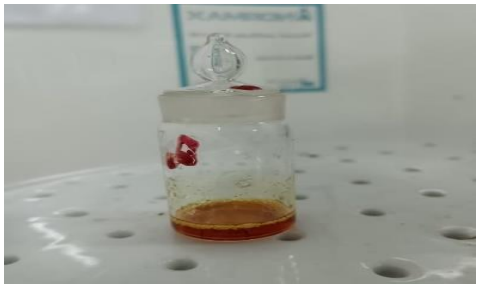

Figure 8. Drying shrinkage

b. Determination of Total Ash Levels

A total of 1 g of the carefully weighed extract (W1) was placed in a pre-incandescent and weighed porcelain cup. Glow in the oven slowly (with the temperature gradually increasing to 600 ± until the charcoal ran out. After that, it was cooled in an accelerator and weighed to a constant weight (W2). The experiment was carried out 3 times and the ash content was calculated

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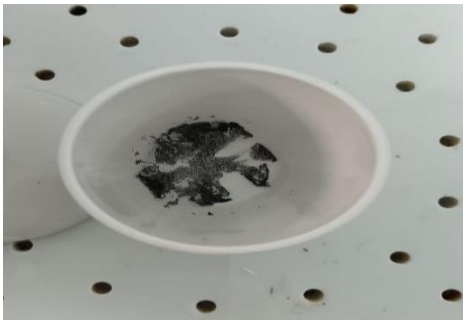

Figure 9. Determination of total ash levels

c. Determination of moisture content

The toluene used was first saturated with water, after which it was shaken and allowed to sit, the two layers of water and toluene were separated, and the water layer was discarded. Then, 10 g of the extract was weighed, placed in a round base pumpkin, and toluene was added, which was saturated with water.

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The pumpkin was carefully heated for 100 min, and after the toluene started to boil, the distillation was set at 2 drops/s, then 4 drops/s. After all the toluene boiled, heating was continued for 5 min. The tube was then allowed to cool to room temperature. The volume of water was read after toluene and water were completely separated. Replicate three times and then calculate the percentage (Ulfah et al., 2020)

Figure 10. Determination of Moisture Content

Specific and non-specific parameter test results

a. Specific parameter testing
   1. Identity
      Latin names: *Lancium domesticum corr*
   2. Organoleptic examination
      Extract color: cream
      Shape: semi-solid
      Smell: typical
   3. Water soluble compound content : **0.2%**
   4. Ethanol soluble compound content: **44.75%**

b. Non-specific parameter testing
   1. Drying Shrinkage : **10%**
   2. Ash content = **0.95%**
   3. Moisture content = **10%**

Phytochemical Test Results

Thick extracts from each solvent of ethyl acetate, ethanol and N-hexane were tested for phytochemicals, so the results were obtained including ethyl acetate extract, namely flavonoid (+) alkaloid (-) compounds, saponins (+), triterpenoids (+) and tannins (-). Ethanol extracts were obtained from the secondary metabolite compounds, flavonoids (+), alkaloids (-), saponins (+), triterpenoids (+), and tannins (+). Meanwhile, the n-hexane extract obtained its secondary metabolite compounds, namely flavonoids (+), alkaloids (+), saponins (+), triterpenoids (+), and tannins (-) (Hakim et al., 2021).

Testing of Flea Eggs using duku bark extract

Based on the results of testing flea eggs using three types of extracts, including ethanol, ethyl acetate, and N-hexane extracts, the best results were obtained using the n-hexane extract. The eggs of the ticks that were tested underwent morphological changes that were observed microscopically, namely, the transfaran shape as drawn in the research results, and did not make a sound after being pressed. If viewed based on the concentration sequence of 10%, 15%, and 20%, that is, the higher the concentration of the extract used, the more eggs will be damaged. This statement is in accordance with the results of research conducted by Hidayah, N and Sari, R, 2023 N-Hexan extract of duku bark has highly toxic properties because it contains secondary metabolites of the terpenoid or steroid group. . Fidiana et al. (2013) added that the higher the test concentration carried out on mosquito larvae, the higher the mortality rate of mosquito larvae. N-hexane is a type of non-polar solvent, which is a non-polar compound with highly toxic properties. If you look at the test using ethanol extract and ethyl acetate extract, the test results at a concentration of 15% more eggs are spoiled than at a concentration of 20%. Based on the results of research conducted by Dwijayanti and Pamungkas (2016), lower concentrations are sometimes more effective than higher concentrations, which is influenced by the number of

solvents and solutes. At low concentrations, the amount of solvent is higher (Putri et al., 2023).

In the test using head lice ninfa objects, the higher the concentration of the extract used, the higher the mortality rate of the ticks by using ethyl acetate and n-hexane extracts, but by using ethanol extract at a concentration of 15% better killing power compared to a concentration of 20%. At 15% concentration, the average mortality was 4.33 heads, while the concentration of 20% mortality was only 3 heads. Compared to this concentration, the concentration was better at 15% than at 20%. The results of the test are in accordance with research conducted (Agung Permadi et al., 2020) by Dwijayanti and Pamungkas 2016, namely there is an influence of the speed of transfer of substances between high concentration and low concentration. The influencing factor was the comparison of the solute and number of solvents. Sometimes, a low concentration is better than a high one. At low concentrations, the number of solvents is higher than that of solutes, whereas at high concentrations, the density of compounds between molecules is high, so the diffusion process is longer (Alhijrah et al., 2024).

There are several differences between testing ninfa and adult ticks. Testing with ninfa using ethanol extract at a concentration of 15% is better when compared to a concentration of 20%; however, testing using ethyl acetate and n-hexane extracts in adult ticks can be seen based on a concentration sequence. Of all the types of extracts, the mortality of adult ticks increased in number, based on the highest concentration. This statement is in accordance with the research conducted by Juniarti et al., which showed that the higher the concentration used, the better the killing power (Nur et al., 2022).

The results of research conducted by Virgianti, DP, and Rahmah LA, using eucalyptus oil, explained that the content of secondary metabolite compounds, namely the terpenoid group, has potential as an insecticide. This compound has a working system as a contact poison that can cause water balance in insects to be disturbed Minarwaty et al., 2012 added that the presence of secondary metabolite compounds from the triterpenoid group, flavonoids and saponins have a function as a bioinsecticide. The test was performed using Langsat skin with an object of the Aedes mosquito (Candy et al., 2018).

Eka and Endah explained that saponins and alkaloids act as stomach poisons and inhibit the action of the cholinesterase enzyme in the larvae, while flavonoids act as respiratory toxins causing death. Nadila added that the tannin content is a polyphenol compound that causes a stingy taste in plant parts that can enter through the body wall and cause disorders in larval muscles.

Based on the comparison of the three extracts, namely duku bark ethanol extract, ethyl acetate extract, and n-hexane extract, it can be concluded that the n-hexane extract has better properties than the ethanol extract and ethyl acetate extract. The n-hexane extract is a non-polar compound, whereas the ethanol and ethyl acetate extracts are polar compounds. Andasari and Hartanti N said that non-polar compounds from n-hexane, which are used as solvents during maceration of duku bark simplicia, have toxic compounds. Compounds that are toxic to secondary metabolites are terpenoid and steroid groups, which can be used as plant-based insecticides (Putri et al., 2023).

Standardized Parameters of N-hexane Extract

The testing of extract standardization parameters was divided into two categories: specific and non-specific parameters. The specific parameter tests included identity testing, organoleptics, water-soluble compound levels, and ethanol-soluble compound levels. Identity checks aim to provide an objective identity to the name of the plant used in the research. The organoleption test of the extract included checking for color, odor, and shape. The extract obtained had a creamy color with a distinctive odor and a semi-dense shape. Furthermore, the parameters of the dissolved compounds in water and ethanol were used to determine the number of compounds dissolved in water and ethanol (polar). In the water-soluble compound content test, a result of 0.2% was obtained, and the level of ethanol arut compounds was obtained a result of 44.75%. The sum of the results of water-soluble juice and ethanol content was also eligible, which did not exceed 100%. The sum of the water- and ethanol-soluble contents of the extract should not exceed 100%. It can also be seen that the extract is more soluble in ethanol than in water, which shows that the active compounds in the extract are more likely to be absorbed in ethanol than in water because ethanol solvents are universal solvents; therefore, they are able to attract polar and non-polar compounds, while water is only able to attract polar compounds (Ulfah et al., 2020).

The nonspecific parameters tested were drying loss, moisture content, and ash content. Drying shrinkage is the measurement of residual substance after drying at 105°C for 30 min or until a constant weight is expressed as a percentage. Knowing the drying shrinkage can provide a maximum limit for the amount of compounds lost during the drying process. The drying shrinkage value obtained from the n-hexane extract of the duku bark was 10%. This indicates that the moisture content and compounds lost during the drying process were 10%. A good requirement for drying shrinkage is no more than 10%. Thus, the n-hexane extract of duku bark still met the requirements.

The moisture content was determined to determine

the water residue after thickening or drying. The result of determining The moisture content of the extracts was 10%. According to the literature, good moisture content is no more than 10%. When the moisture content exceeds 10%, the water content in the extract remains high, which can cause the extract to be easily contaminated by microorganisms. The ash content was determined to provide an overview of the internal and external mineral contents that came from the initial process until the formation of the extract. At this stage, the extract was heated until the organic compounds and their derivatives were destroyed and evaporated until only the mineral and inorganic elements remained. The total ash content of the extract was 0.95%. This meets the requirement that the ash content must not exceed 2%. The ash content should be small because this parameter indicates the presence of heavy metal contamination that can withstand high temperatures (Ratnani, 2015).

4. Conclusion

This study found that duku bark extract (Lansium domesticum Corr.) has the potential to be a natural pediculoid that can overcome head lice infestations (Pediculus humanus capitis). Of the three types of extracts tested, ethanol, ethyl acetate, and n-hexane—n-hexane extracts showed the highest effectiveness in killing eggs, nymphs, and adult ticks, especially at a 20% concentration. The results of the phytochemical tests showed that duku bark extract contains flavonoids, saponins, triterpenoids, and alkaloids, which contribute to its insecticidal activity. Statistical testing using Kruskal-Wallis and Mann-Whitney tests showed significant differences in flea mortality rates between different concentrations of extracts, especially for eggs and adult fleas.

The results of this study are in line with previous research showing that plant extracts containing terpenoids, flavonoids, and saponins have insecticidal activity against head lice and other insects. For example, Arrizqiyani (2019) found that essential oils from certain plants can cause head lice death within a short period of time. In addition, Candy et al. (2018) showed that some essential oils were highly effective against Pediculus humanus capitis. However, this study makes a new contribution by showing that duku bark extract, specifically n-hexane, has strong potential as a natural pediculicide, which has not been widely studied.

These findings have important implications for the development of natural alternatives to head lice treatment, especially since the use of synthetic insecticides such as lindane, pyrethrin, permethrin, and malathion can lead to resistance if used in excess. With evidence that duku bark extract can effectively kill head lice, this study opens up opportunities for the development of herbal products, such as shampoos or anti-flea lotions, which are safer and more environmentally friendly. In addition, this research supports further exploration of the use of local plants as pharmaceutical solutions based on natural ingredients.

The strength of this study lies in the use of controlled laboratory experimental (in vitro) methods, allowing accurate measurements of the effectiveness of duru bark extract. In addition, the study used a phytochemical approach to identify the active compounds in the extract, which strengthens the validity of the findings regarding the mechanism of action of pediculosides.

However, this study has some limitations. First, this study was only conducted on a laboratory scale (in vitro); therefore, the effectiveness of duku bark extract in real conditions (in vivo) or in humans has not been tested. Second, this study did not evaluate the potential side effects of the extract on the human scalp, which is an important factor in the development of commercial products. In addition, the study only focused on the flea mortality test, without examining the possible mechanisms of resistance or the long-term effects of the extract.

Future Recommendations and Research

Several further research steps are recommended to strengthen the results of this study.

1. In vivo test: Testing the effectiveness and safety of duku bark extract in human or animal models to ensure that the active compound remains effective outside laboratory conditions.
2. Development of shampoos or lotions based on duku bark extract and testing their effectiveness against head lice in daily use.
3. Evaluation of side effects: Identify possible allergic reactions or skin irritation due to the use of duku bark extract in the formulation of hair care products.
4. Mechanism of action study: Investigate more deeply how the compounds in duku bark extract work in killing head lice, as well as whether there is a potential for lice to develop resistance to these compounds.
5. Comparative analysis: The effectiveness of duku bark extract with anti-flea products already on the market was assessed to determine its advantages and disadvantages.

With further research, duku bark extract has the potential to become an effective natural solution for the treatment of pediculosis, providing a safer and more environmentally friendly alternative to the synthetic chemical insecticides currently used.

Declarations

Author's Contributions

This research was the result of the collaboration of several authors with different contributions. Darmadi, as the lead author, is responsible for the research concepts, methodology design, and data analysis. Asiska Permata Dewi and Eli Yusrita played a role in sample processing, extraction processes, and laboratory testing of the head lice. Suharti and Lucida contributed to the phytochemical tests and the analysis of active compounds in duru bark extract. All authors participated in the preparation of the manuscript and the discussion of the research results. The combination of expertise from these different fields allows this study to provide comprehensive findings and can be the basis for further research on the development of herbal anti-flea products.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this manuscript. In addition, all ethical issues, including plagiarism, informed consent, research misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies, were fully observed by the authors.

Ethical Approval

Not applicable. This study did not involve human participants, animals, or sensitive data, which required ethical approval.

Data Availability Statement

No new data were created or analyzed in this study. Data sharing was not applicable in this study.

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