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Preparation of Biopesticide Powder from Jicama (*Pachyrhizus erosus*) Leaf Extract to Eradicate Whitefly Pests (*Bemisia tabaci* G.) on Eggplant Plants (*Solanum melongena* L.)

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Abstract
Synthetic pesticides in Indonesia are increasingly widespread because they effectively kill pests. However, synthetic pesticides leave residues that can cause environmental pollution and human health problems. Therefore, another alternative is needed, namely switching to using environmentally friendly plant-derived pesticides. One of the alternatives is biopesticide powder from jicama leaf extract as a whitefly pest controller. Jicama leaf contain active compounds toxic to whiteflies, namely rotenone, a group of flavonoid compounds. The method of making this biopesticide powder consists of 2 stages. The first is the preparation of jicama leaf extract through a maceration process for two days with the ratio of leaf powder and solvent, namely 40 g, 60 g, 80, and 100 g of jicama leaf powder in 500 ml of 96% ethanol. The second stage is processing jicama leaf extract into biopesticide powder through the encapsulation process, namely mixing the extract with maltodextrin using a weight ratio of extract maltodextrin, namely 1: 2 (w: w). The analysis tests biopesticide effectiveness against whitefly by observing the number of whitefly deaths after being sprayed with biopesticide solutions. After testing, it was found that the biopesticide powder that was effective in eradicating whitefly pests was a biopesticide powder with a ratio of 100 grams of jicama leaf powder in 500 mL of 96% ethanol with a dissolution dose of 20 g/L in water, which was able to kill whitefly with a mortality percentage of 100% on day 3.

Keywords: biopesticide; encapsulation; jicama leaves; maceration; whitefly.

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Introduction
Whitefly (*Bemisia tabaci* G.) belongs to the plant-destroying pests from the insect class (1). Whiteflies attack plants through perforated leaves and limp plants, and plant growth decreases drastically to appear stunted. The same plants that host whitefly include eggplant, cucumber, guava, rose, and chili (2).

An example of the losses caused by this pest is the eggplant crop that was attacked by yellow virus caused by whitefly in three sub-districts in Magelang District, namely Mungkid, Ngluwar, and Muntilan sub-districts where the damaged eggplant crop reached 5 hectares. Whiteflies attack eggplant plants, especially on the leaves, so that necrotic spots appear, and they can transmit geminivirus disease to eggplant plants continuously (3).

Various efforts have been made to control plant pests and diseases. However, until now, it still relies on synthetic pesticides. The use of synthetic pesticides can leave residues that can cause pollution to the environment and disturbances to human health (4). According to the Brebes District Environment Office (KLH), there has been a decline in soil quality in agricultural land, especially the shallot production center of Padasugih Village, by 50% due to the extensive use of pesticides (5). In addition, as many as 19.25% of farmers in Brebes Regency experienced mild poisoning, and 4.08% experienced moderate poisoning due to excessive pesticide use, direct exposure, improper mixing of pesticides, and contaminated food and drink (6). Judging from these cases, other alternatives that have a slight negative impact are needed, such as plant-derived pesticides whose essential ingredients come from plants that are relatively easy to make and are easily decomposed (7).

Plant-based pesticides are starting to be widely used as an alternative to controlling pests and diseases in plants that do not damage the environment (8). The research results by (9) showed that jicama seed extract with a concentration of 8% reduced the number of red flour beetle pests (*Tribolium castaneum*). Jicama seeds can be used as a vegetable pesticide because they contain toxic rotenone compounds that inhibit metabolism and the nervous system in insects (10). After research, all parts of the jicama plant contain rotenone except the tuber (11). The production of jicama in Indonesia is relatively high. According to BPS data, 119 ha of jicama are planted, producing 3,101.10 tonnes (12). However, so far, the utilization of the jicama plant in Gunungkidul Regency is only on its tubers for starch flour production. The rest of the harvest is in the form of leaves, stems, and roots, which are not utilized. Therefore, there is potential to utilize the leaves of jicama, which have no use and are still rarely used as raw materials for making plant-derived pesticides.

The rotenone compounds in the jicama plant belong to the flavonoid group (11). These compounds are easily oxidized at high temperatures and easily damaged by the environment. For durability in storage so as not to be contaminated by microbes, flavonoids must be encapsulated (13). Encapsulation aims to change the form of liquid to solid, protect the core from environmental influences, maintain the chemical composition, and reduce damage to the compound before application (14). Maltodextrin is one of the encapsulants that is often used in the encapsulation process. In addition to its affordable price, maltodextrin has several advantages, such as high solubility, low hygroscopicity, low possibility of browning, and binding solid power (14).

This research was intended to study the processing of jicama leaves into biopesticide powder and determine the ratio of jicama leaf powder to solvent effective against whitefly abundance on eggplant plants. The variables examined included the ratio of powder to solvent, as well as the weight of biopesticide powder for dissolution in 1 L of water.

Material and Methods

Materials and Preparation

Materials used during the experimental process include jicama leaves, eggplant plants, 96% ethanol (v: v), maltodextrin, whitefly, distilled water, 37% concentrated HCl (v: v), $HgCl_2$, KI, $FeCl_3$, Mg, synthetic pesticide (Actara 25 WG), filter paper, and plastic wrap.

Preparation of materials (14) : 3 kg of jicama leaves were washed with water and then cut to a size of ±1 cm. The leaves were dried in an oven at 50°C for 24 hours. The dried leaves were crushed with a grinder until smooth and then sieved using a 60-mesh sieve. The powdered jicama leaves were ready to be extracted.

Preparation of Jicama Leaf Extract

The preparation of jicama leaf extract is carried out by maceration process, which is the immersion of samples using organic solvents at room temperature. Powder of jicama leaves was weighed with sample weight variations of 40 grams, 60 grams, 80 grams, and 100 grams. Then, it was put into Erlenmeyer, and 500 mL of 96% ethanol was added to each sample variant. The maceration process was carried out for 48 hours, stirring every 24 hours using a glass stirrer for 5 minutes (18). The solution was then filtered using filter paper, and the filtrate of the jicama leaf extract was obtained.

After obtaining the extract, the solvent evaporation was continued to get a thicker extract. Evaporation is done by leaving the filtrate in a pan in an open space until the volume becomes 10% of the initial volume. The final result is a thicker jicama leaf extract.

Phytochemical Test

Alkaloid Test

A total of 1 mL of extract plus Mayer reagent (1.4 g $HgCl_2$ in 60 mL of distilled water plus 5 g KI in 10 mL of distilled water then diluted to 100 mL). If a white precipitate is formed, it indicates that the sample contains alkaloids (15).

Flavonoid Test

A total of 1 mL of extract was added to 100 mL of hot distilled water. Simmer for 5 minutes, then filtered with filter paper. Take 5 mL of filtrate, add 0.05 g of Mg powder and 1 mL of concentrated HCl, then shake vigorously. The formation of red, yellow, or orange indicates flavonoids' presence (15).

Saponin Test

A total of 1 mL of sample was put into a test tube, then 10 mL of distilled water was added, shaken for 1 minute, and 2 drops of HCl 1 N were added. If the foam formed remains stable or does not disappear for 7 minutes, it indicates the presence of saponins (15).

Tannin Test

An extract of 1 mL was added with ten drops of $FeCl_3$ 10%. A blue-black or green-black color indicates the presence of tannins (15).

Preparation of Jicama Leaf Biopesticide Powder

Encapsulation processes jicama leaf extract into biopesticide powder. Encapsulation is encapsulating or coating a substance with a polymer wall layer to change the liquid form into micro-sized solids or powders (14). The encapsulant used in this experiment is maltodextrin, the product of cassava starch hydrolysis with acids or enzymes (14).

The extract of jicama leaf was added with maltodextrin with the ratio of extract weight: maltodextrin weight, which is 1 2 (w: w) in each sample—then stirred using a glass stirrer until homogeneous. The mixture was dried in an oven at 50°C for 12 hours until dry. After drying, the product was crushed with a pestle and mortar until it became a fine powder. To obtain a uniform and delicate powder, it must be sieved using a 60-mesh sieve. The resulting product, a fine powder, is jicama leaf biopesticide powder.

Effectiveness Test

The effectiveness of biopesticides can be seen in the percentage of pest mortality. Mortality shows the ability level or the number of pest deaths caused by pesticides tested on whitefly pests. Mortality is driven by whether or not the content of active ingredients that are toxic in jicama leaf extract biopesticides.

Biopesticide Effectiveness Test of Jicama Leaf Extract

Dissolve the biopesticide powder with 10 g/L and 20 g/L as much as 250 mL. Then, put the biopesticide into a spray bottle. 20 whiteflies were placed on the eggplant plants and then adapted for one week. Spray the biopesticide onto the eggplant plants and observe the number of whitefly deaths every 24 hours. Calculate the percentage of mortality, according to (16), using the following formula:

$$\text{Percentage of pest mortality} = \frac{\text{(Number of whitefly deaths)}}{\text{(Number of whitefly tested)}} \times 100\% \quad (1)$$

Effectiveness Test of Synthetic Pesticide (Actara 25 WG)

As a comparison variable, the effectiveness test was also conducted on synthetic pesticide products on the market, using the same method, namely dissolving synthetic pesticides with the recommended dose of 0.1 g/L as much as 250 mL. Then, put the pesticide into a spray bottle. 20 whiteflies were placed on the eggplant plants and then adapted for one week. Spray the biopesticide onto the eggplant plants and observe the number of whitefly deaths every 24 hours. Calculate the percentage of mortality, according to Sinaga (16), using the following formula:

$$\text{Percentage of pest mortality} = \frac{\text{(Number of whitefly deaths)}}{\text{(Number of whitefly tested)}} \times 100\% \quad (2)$$

Results and Discussion

Preliminary Experiment on Determination of Weight Ratio of Extract with Maltodextrin for Encapsulation Process

This preliminary experiment aims to get the proper ratio of extract weight to maltodextrin weight for the biopesticide encapsulation process. In this experiment, there were three experimental variations, namely the ratio of extract weight: maltodextrin 2: 1 (w: w), the weight ratio of extract: maltodextrin 1: 1 (w: w), and the weight ratio of extract: maltodextrin 1: 2 (w: w). The results of each comparison can be seen in Table 1 below.

Table 1. Effect of Weight Ratio of Extract to Maltodextrin on Drying Time and Encapsulation Result

Comparison Weight of Extract: Maltodextrin	Drying Time (hours)	Encapsulation Result
2 : 1	96	Dry but watery powder
1 : 1	72	Dry powder but easily moistened so that it coagulates
1 : 2	12	Dry and non-clumping powder

Based on Table 1, the best ratio of extract weight to maltodextrin weight for the biopesticide encapsulation process is the ratio of extract weight to maltodextrin 1: 2 (w: w). This can be seen from the faster drying time. In addition, the dry powder produced in this ratio is more consistent and does not clump.

The faster drying time is due to the fact that maltodextrin is composed of free hydroxyl groups that can bind water in a material. The water content bound by maltodextrin is more susceptible to evaporation in the drying process than the water content in the material tissue (17).

Biopesticide Manufacturing Process

The biopesticide was made by extracting the powder of jicama leaf through a maceration process with different ratios of jicama leaf powder and 96% ethanol solvent (v: v). There are four variations of extracts produced through the maceration process, namely 40 g of jicama leaf powder in 500 mL of 96% ethanol, 60 g of jicama leaf powder in 500 mL of 96% ethanol, 80 g of jicama leaf powder in 500 mL of 96% ethanol, and 100 g of jicama leaf powder in 500 mL of 96% ethanol.

The extract was made from dried jicama leaf powder as much as 40 g, 60 g, 80 g, and 100 g, which were extracted with 96% ethanol solvent as much as 500 mL through maceration or soaking process for 48 hours. After filtering, the filtrate was obtained as much as 464 mL for the maceration process with a ratio of 40 g of jicama leaf powder in 500 mL of 96% ethanol. The filtrate is then evaporated to separate the solvent from the resulting extract to obtain a concentrate as a thicker extract. After evaporating the solvent to 10% of the initial volume, the extract with a ratio of 40 g of jicama leaf powder in 500 mL of 96% ethanol was reduced to 46 mL. The results obtained are concentrated or thicker extract. The results of making jicama leaf extract can be seen in Table 2 below.

Table 2. The Analogy of Jicama Leaf Extract Preparation

Weight of Jicama Leaf Powder (g) in 500 mL Solvent	Filtrate Volume (mL)	Concentrate Volume (mL)
40	464	46
60	445	45
80	428	43
100	410	41

The main problem in liquid biopesticide products is product stability. Liquid biopesticides cannot maintain product stability because the active flavonoid ingredients will be easily damaged by the environment and easily contaminated by microbes. The biopesticide produced must maintain the stability of flavonoids so that when used, the biopesticide is still effective. Therefore, one of the innovations that can be developed to preserve the stability of biopesticide products that have a direct impact on flavonoid content is the encapsulation process. Encapsulation is a technique to protect core materials that were originally in liquid form into a solid form. It aims to maintain the chemical composition and reduce damage to these compounds before application (14). The encapsulant used in this experiment was maltodextrin, added to each extract with a weight ratio of extract: maltodextrin, namely 1: 2 (w: w). In the extract with a ratio of 40 g of jicama leaf powder in 500 mL of 96% ethanol (v: v), the weight ratio of the extract was 42,36 g with the maltodextrin needed for encapsulation of 84,73 g. The encapsulation process resulted in 40 g of jicama leaf powder in 500 mL of 96% ethanol (v: v). After the encapsulation process, 62,46 g of biopesticide powder was produced. The biopesticide powder was then calculated for moisture content using the gravimetric method to determine the product's resistance to damage that might occur. Biopesticide with a ratio of 40 g of jicama leaf powder in 500 mL of 96% ethanol (v: v) has a moisture content of 8,39%. The above description presents the analogy of making biopesticide powder in Table 3 below.

Table 3. Analogy of Biopesticide Powder Preparation

Weight of Extract (g)	Maltodextrin Weight (g)	Biopesticide Powder (g)	Water Content (%)
42,36	84,73	62,46	8,39
41,45	82,89	60,86	8,23
39,60	79,21	58,92	6,71
37,76	75,52	56,21	6,09

Phytochemical Test of Jicama Leaf Extract

In this experiment, phytochemical tests were carried out to determine or analyze the chemical content contained in plant parts. This phytochemical analysis is qualitative so that the chemical content of plants can be known. In general, the chemical content of plants can be grouped into groups of alkaloid compounds, flavonoids, tannins, and saponins. To find out the content of the compound is seen from the color changes that occur and the precipitate formed. The results of the phytochemical test of the jicama (*Pachyrhizus erosus*) leaf extract can be seen in Table 4 below.

Table 4. Phytochemical Test Results of Jicama Leaf Extract

Weight of Jicama Leaf Powder (g) in 500 mL Solvent	Test	Observation Results	Result Test
40	Alkaloids	No white precipitate formed	–
	Flavonoids	The yellowish-orange color formed	+
	Saponins	It forms a stable but slight foam	+
	Tannins	It forms a blackish-green color	+
60	Alkaloids	No white precipitate formed	–
	Flavonoids	A bright orange color formed	+
	Saponins	It forms a stable but slight foam	+
	Tannins	It forms a blackish-green color	+
80	Alkaloids	No white precipitate formed	–
	Flavonoids	It forms a red-orange color	+
	Saponins	Forms a stable and considerable amount of foam	+
	Tannins	It forms a fairly intense blackish-green color	+
100	Alkaloids	No white precipitate formed	–
	Flavonoids	It forms a deep red color	+
	Saponins	Forms a stable and abundant foam	+
	Tannins	It forms an intense blackish-green color	+

Description : (+) There is an indication of compound class
(–) no indication of compound class

Based on the results of phytochemical testing on extracts with a comparison of jicama leaves with different solvents, it shows that each jicama leaf extract (*Pachyrhizus erosus*) contains flavonoid compounds, saponins, and tannins so that it is proven that jicama leaf extract can be used as a biopesticide.

The alkaloid test did not show the presence of this group of compounds, indicated by the non-formation of a typical white precipitate from the alkaloid group. The study by (10) states that phytochemical tests with Mayer reagent prove that jicama leaves contain many alkaloids marked by the formation of white precipitate while betel leaves are not formed. This difference is due to the process of raw materials used having a somewhat different type, so active compounds are also other, and maceration is less effective in extracting all active compounds. The time needed to remove the alkaloid compounds is shorter (18).

Biopesticide Powder Effectiveness Test

In this experiment, the effectiveness of biopesticides in killing whitefly was tested. Effectiveness is a parameter that can determine the optimum concentration of jicama leaf extract in killing whitefly pests. Tests were carried out on ten eggplant plants covered with clear plastic, and then each plant was given 20 whitefly ticks that would be adapted to the plant for one week. The test was conducted with three repetitions, each for seven days at ambient temperature. The effect of interaction time on the number of whitefly deaths can be seen in Table 5 and Table 6.

Table 5. Effect of Time of Interaction with Biopesticide Treatments on the Number of Whitefly Deaths

Sample Type	Weight of Jicama Leaf Powder (g) in 500 mL Solvent	Dissolving Dose (g/L)	Average Number of Whitefly Deaths in Three Repetition (Mean±Standard Deviation)						
			24 hours	48 hours	72 hours	96 hours	120 hours	144 hours	168 hours
Biopesticides	40	10	0 ±0	0 ±0	2.33 ±0.58	5.33 ±2.52	11.33 ±3.51	16.00 ±3.46	20.00 ±0.00
		20	0 ±0	2.33 ±0.58	5.33 ±3.21	13.67 ±1.53	17.00 ±1.00	20.00 ±000	-
	60	10	0 ±0	3.00 ±1.00	6.67 ±1.53	12.00 ±0.00	15.33 ±2.31	20.00 ±0.00	-
		20	0 ±0	4.33 ±0.58	11.33 ±2.08	17.67 ±2.31	20.00 ±0.00	-	-
	80	10	0 ±0	5.00 ±0.00	9.33 ±1.53	16.33 ±1.53	20.00 ±0.00	-	-
		20	0 ±0	8.00 ±1.00	17.33 ±0.58	20.00 ±0.00	-	-	-
	100	10	0 ±0	7.33 ±0.58	13.00 ±2.65	18.33 ±0.58	20.00 ±0.00	-	-
		20	0 ±0	12.33 ±1.53	20.00 ±0.00	-	-	-	-

Table 6. Effect of Time of Interaction with Comparator Variable Treatments on the Number of Whitefly Deaths

Sample Type	Dissolving Dose (g/L)	Average Number of Whitefly Deaths in Three Repetition (Mean±Standard Deviation)						
		24 hours	48 hours	72 hours	96 hours	120 hours	144 hours	168 hours
Synthetic Pesticides	0.1	0 ±0	6.00 ±1.00	13.33 ±3.06	18.00 ±2.90	20.00 ±0.00	-	-
Blank	-	0 ±0	0.67 ±0.58	0.67 ±0.58	1.33 ±0.58	1.67 ±0.58	1.67 ±0.58	1.67 ±0.58

The mortality percentage can be calculated from the whitefly mortality data to obtain the calculation analogy presented in Figure 1 below.

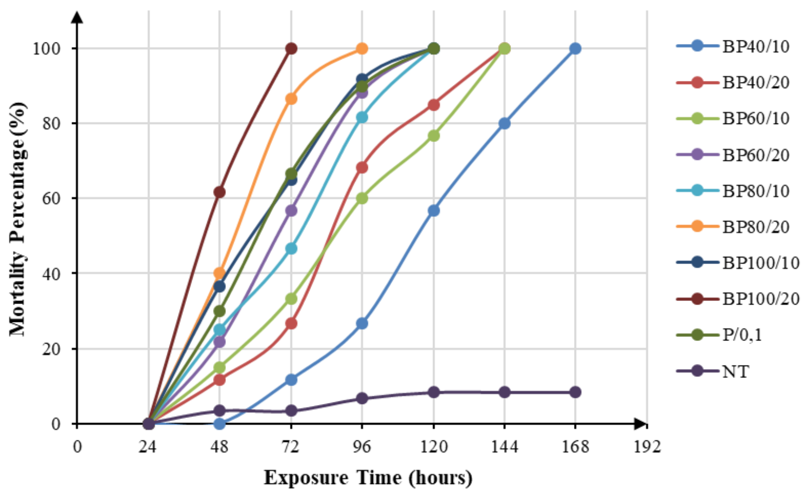

Figure 1. Graph of Exposure Time (hours) *vs* Mortality Percentage (%)

Description :

BP40/10	= Biopesticide with 40 g jicama leaf powder weight in 500 mL solvent, dissolving dose 10 g/L
BP40/20	= Biopesticide with 40 g jicama leaf powder weight in 500 mL solvent, dissolving dose 20 g/L
BP60/10	= Biopesticide with 60 g jicama leaf powder weight in 500 ml solvent, dissolving dose 10 g/L
BP60/20	= Biopesticide with 60 g jicama leaf powder weight in 500 mL solvent, dissolving dose 20 g/L
BP80/10	= Biopesticide with 80 g jicama leaf powder weight in 500 ml solvent, dissolving dose 10 g/L
BP80/20	= Biopesticide with 80 g jicama leaf powder weight in 500 mL solvent, dissolving dose 20 g/L
BP100/10	= Biopesticide with 100 g jicama leaf powder weight in 500 mL solvent, dissolving dose 10 g/L
BP100/20	= Biopesticide with 100 g jicama leaf powder weight in 500 mL solvent, dissolving dose 20 g/L
P/0,1	= Actara 25 WG synthetic pesticide, dissolving dose 0.1 g/L
NT	= No treatment

From the results of the mortality test, Figure 1 shows that in the first 24 hours in all experimental samples, whitefly pests have not died, or the mortality percentage is still 0%. In the next 24 hours, the mortality percentage in some samples increased. From the experiments that have been carried out, it is evident that the greater the amount of jicama leaf powder in the solvent and the greater the dissolving dose used, the faster the time needed to reach 100% mortality percentage is.

The application of biopesticides with a ratio of 100 g of jicama leaf powder in 500 mL of 96% ethanol (v: v) with a dissolution dose of 20 g of biopesticide powder in 1 L of water proved to be the most effective in eradicating whitefly pests and faster to reach 100% mortality on day 3 compared to other samples. This is because the greater the amount of jicama leaf powder in the solvent used, the more active compounds such as flavonoids, tannins, and saponins are extracted from jicama leaves, so the time needed to kill pests is faster (19).

Several studies have been conducted, such as the study by Sari (20), which stated that the most effective dilution dose of babadotan flour powder was 10 g/L. In addition, the research by Hakiki (21) also stated that the minimum dose of plant-derived pesticides that effectively controlled Spodoptera litura larvae was 10 g/L. Based on the mortality test, biopesticide powder from jicama leaves has not achieved the effectiveness of mortality at a dose of 10 g/L as in previous studies. However, it attained the effectiveness of mortality by dissolving 20 g of biopesticide powder in 1 L of water. The dissolution dose has an effect because it is according to the opinion of Harborne (15) in Pasaribu (22), which states that giving a low dose will cause the death of pests that are getting longer.

Conclusion

The processing of jicama (*Pachyrhizus erosus*) leaves into biopesticide powder is done through two stages, namely maceration and encapsulation. Maceration aims to obtain jicama leaf extract, which is then encapsulated using maltodextrin to get biopesticide powder.

Biopesticide powder that is effective against whitefly (*Bemisia tabaci* G.) population abundance on eggplant plants (*Solanum melongena* L.) is biopesticide powder with a ratio of 100 g of jicama leaf powder in 500 mL of 96% ethanol (v: v) with a dissolution dose of 20 g of biopesticide powder in 1 L of water which can reach 100% mortality percentage on day 3.

Conflict of Interest

The authors listed below certify that they have no affiliations or involvements with any organizations or entities with financial interests, such as educational grants, related to the subject matter or materials discussed in this article.

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