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Utilization of Papaya and Pandan Leaf Extract as a Source of Vegetable Pesticides

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Abstract

In this study, the manufacture of vegetable pesticides using natural ingredients of papaya leaf extract and pandan leaf extract has been carried out as a substitute for synthetic pesticides to kill plant pest organisms (OPT). This research is an experimental study using 250 experimental organisms Larvae of Spodoptera litura which were divided into 5 groups. Each group consisted of 10 larvae of Spodoptera litura. Each group was repeated 5 times. As test materials, papaya leaf extract and pandan leaf were added to the media solution containing the test organisms. The concentration of each extract was different for each treatment in each vial, for P1 (Papaya Leaf) which was 150 ml, P2 (Pandan Leaf) 150 ml, and P3 300 ml (Mixture of Papaya Leaves and Pandan Leaves), and Control was 0ml. Data were obtained by counting the number of larvae that died on the first day after application. Based on the data, the percentage value of larval mortality was calculated using the Percentage formula, while the percentage value of larval mortality in the control treatment was calculated using the Abbott formula, the average value of mortality for each replication was calculated using the Datum formula. Based on the testing of vegetable pesticides from papaya leaf extract and pandan leaf extract, the characteristics of vegetable pesticide products from papaya leaf extract and pandan leaf extract were obtained, with the highest mortality percentage obtained in P3 treatment (a mixture of papaya leaf extract and pandan leaf extract) of 88%, while the percentage of mortality was 88%. in treatment P1 (pawpaw leaves) by 70%, and the percentage value of death in treatment P2 (pandan leaves) by 38%. From these results, papaya leaves and pandan leaves are effectively used as sources of environmentally friendly vegetable pesticides in killing plant pests of Spodoptera litura larvae.

Keywords: Papaya leaves, pandan leaves, vegetable pesticides, *spodoptera litura*

Introduction

To maintain food security, plants need to be protected from pests and diseases to ensure adequate production (Nguyen et al., 2020). Plant Pest Control (IPM) is generally carried out using the chemical insecticide method because the process is relatively easy and the results obtained are relatively fast. However, the application of insecticides using chemicals has drawbacks, namely the impacts such as symptoms of pest resistance, pest resurgence, the killing of natural enemies, increasing residues in yields, polluting the environment, and health problems for users. The utilization of botanical insecticides can reduce the use of chemical insecticides in agricultural areas (Cabral et al., 2021). According to Heryani & Rejekiningrum, (2019), the continuous use of chemical insecticides results in environmental damage, as well as an imbalance of ecosystems that exist in nature (Benu et al., 2020). In addition, the presence of synthetic insecticides on agricultural land has serious impacts such as air, soil, and water pollution and the death of non-target organisms (natural enemies), and the occurrence of pest resurgence (Tampubolon et al., 2018). An alternative solution to the existing problems is to reduce the use of chemical insecticides in controlling plant pests (Role, 2019) and replace them with insecticides derived from nature such as vegetable insecticides sourced from plants and plants to reduce environmental damage (Rahman et al., 2020).

Armyworm (*Spodoptera litura*) is an important pest that must be controlled because it can harm farmers and affect the quality of crop yields (Silalahi et al., 2021). This caterpillar attacks the leaves of the host plant. Characteristics of the damage caused by this pest are the perforated plant leaves. The young larvae damage the leaves by leaving remnants of the upper epidermis and leaf bones, while the advanced larvae damage the leaf bones and even attack the pods (Gu et al., 2015; Hou et al., 2021). The clustering nature is due to the way the moths lay their eggs in groups. Yield losses due to armyworm attacks can reach 80% if

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left unchecked (Mohamed et al., 2019). For this reason, it is necessary to control the armyworm (Spodoptera litura) plant pest by using insecticides from plants.

The use of plant extracts as a source of vegetable insecticides because in plants there is a defense mechanism (Yudiawati & Hapis, 2017). One of the vegetable plants that can be used for Plant Pest Control (IPM) is papaya leaves. Papaya leaves (Carica papaya L.) contain toxic compounds such as saponins, karpain alkaloids, papain, and flavonoids and are harmless to humans and animals. Papaya leaf pesticides have high effectiveness and have a specific impact on pest organisms (Jujuaningsih et al., 2021). Papaya plants contain a lot of papaya enzymes in their leaves, namely proteolytic enzymes that play a role in breaking down connective tissue, and when papaya enzymes enter the body of insects it causes chemical reactions in the body's metabolism which can cause inhibition of growth hormones (Prihatini & Dewi, 2021). Papaya plants contain cysteine proteinase, alkaloids, papaya enzymes, chymopapain, papaya latex extract, saponins, flavonoids, karpanes, and tannins. The mechanism of action of several substances in papaya as anthelmintics is to break down connective tissue, hydrolyze exoskeletal proteins to damage the cuticle and expel the contents of the body, suppress the central nervous system of worms, and cause muscle paralysis in worms (Oktofani & Suwandi, 2019).

Another plant that can repel insects is pandan leaves. Another plant that can repel insects is pandan leaves. The results of phytochemical tests on the content of chemical compounds in pandan leaves have been reported by Prameswari & Widjanarko (2014) that extracts of water, ethanol, and water: ethanol from fragrant pandan leaves contain positive alkaloids, tannins, flavonoids, and polyphenols. The maximum total flavonoid and total phenolic content in pandan leaf extract were obtained at 96% ethanol extract, respectively 478.7629 and 99.4086 mg/g (Agustiningsih et al., 2010). Therefore, a study was conducted using papaya leaves and pandan leaves as candidates for plant pest control (IPM), and further testing was carried out on the effectiveness of vegetable insecticides against armyworms (Spodoptera litura).

Methods

Materials and methods

Directional methode

This research was carried out at the Chemical Laboratory of FKIP UNTAD and the Laboratory of Pests and Plant Diseases, Faculty of Agriculture, Tadulako University.

Tools and materials

The materials used in this study were papaya leaves, pandan leaves, methanol, water, and S. litura larvae as experimental organisms. While the tools used are a dough mixing pan, blender, mixing spoon, test tube (vial), lighting lamp, filter, measuring cup, funnel, digital balance and scales, as well as a loupe/magnifying glass and microscope as a tool for observing whether organisms die or not. observed test.

General procedure

Making vegetable pesticides

Making papaya leaf methanol extract (Carica papaya L)

Papaya leaves that have been cleaned weighed as much as 200 grams. Then mashed using a blender that has previously been added as much as 1 liter of water. Furthermore, 50 mL of methanol was added to the extract and allowed to stand for 24 hours, and filtered to obtain a suspension.

Preparation of pandan leaf methanol extract (Pandannus Amarylifoulius roxb)

Clean pandan leaves weighed as much as 200 grams. Then mashed using a blender that has previously been added as much as 1 liter of water. Furthermore, 50 mL of methanol was added to the extract and allowed to stand for 24 hours, and filtered to obtain a suspension.

Production of combined extracts (papaya leaf extract and pandan leaf extract)

Each clean papaya and pandan leaf were weighed as much as 100 grams, then mixed. Furthermore, it is mashed using a blender that has previously added as much as 1 liter of water. Then 50 mL of methanol was added to the extract and allowed to stand for 24 hours and filtered to obtain a suspension.

Caterpillar maintenance (S.litura)

S.litura eggs were taken from the red chili plantation area in Pombove Village, Biromaru District. The eggs were kept in jars until they hatched on the 4th day and then fed with chili leaves. After becoming imago on the 24th day, Imago was released to chili plants which were planted in polybags that had been given a lid with the number of plants per polybag of 5-6 plants. Next, the eggs are taken and collected into a jar. Eggs are reared for 2-4 days (until they hatch) and develop. The hatched larvae (instar 1 to instar 5) were used as test material.

Special procedure

Pest or test organism dyeing method

The method of immersing the pests or test organisms is to dip the test pests in the form of caterpillars into a solution of vegetable pesticides for 24 hours. The caterpillars are then put into a test tube (vial) which has been filled with each concentration of vegetable pesticides in each treatment, then given a light, after 24 hours the mortality is observed, then the number of dead larvae is counted, by observing using a tool. microscope or magnifying glass.

Experimental design or observation

In this study, a completely randomized design was used with 4 treatments, namely P1, P2, P3, and K, each of which was replicated 5 times. P1 is a treatment that uses 150 mL of papaya leaf methanol extract, P2 is a treatment that uses 150 mL of pandan leaf methanol extract, and P3 is a combination treatment between papaya leaf methanol extract and pandan leaves with a total of 300 mL. The test was carried out by inserting S. litura larvae into four treatment groups containing solutions of P1, P2, and P3, from extracts of papaya leaves and pandan leaves, as well as a control solution. Each test tube (vial) contained 10 S. litura larvae. At the same time, replication of each treatment group was carried out five times.

The percentage of molarity to larvae was calculated using the formula:

$$P = \frac{x}{y} \text{ x } 100\ \%$$

Where:

P	Percentage of death
X	Number of dead caterpillars
Y	Number of caterpillars observed

Furthermore, the mortality percentage of S. litura larvae using the Abbot formula. If there is a mortality of S. litura larvae in the Control treatment, the corrected mortality percentage value is calculated based on the Abbot formula, if the larval mortality in the Control treatment is not more than 20%:

$$\text{P} = \frac{{}'P - C}{100 - C} \text{ x } 100\%$$

Where:

P	Percentage of deaths corrected S.litura
'P	Larvae mortality at concentration treatment
C	Death on Control

While the average value of mortality in replication

$$\frac{\sum_{i=1}^{n} xi}{n}$$

Where is : $\sum_{i=1}^{n} xi$ = Total of all Datum

n = Number of datums

Results and Discussion

Papaya leaf and pandan leaf extracts have hygroscopic properties and a porous structure, so the binding power between similar molecules is relatively small and the strength of the active ingredient content is low, so it is necessary to add additional substances that function as binders. With the use of adhesives/binders, the levels of active ingredients will be much greater when compared to vegetable pesticides without using adhesives (Kardinan & Suriati, 2012).

Hendrawati (2009) states that with the presence of adhesives, the spray solution will be faster in gluing the spray solution on the plant surface, increasing the contact between pesticides, being more regular, and strong so that through the soaking process, the strength of the compound content of the active ingredients is getting better. The requirements for a good adhesive / binder are that it does not cause a bad smell when soaked, has a good binding ability, is cheap, and is easy to obtain.

Soaking and filtering botanical pesticides

Methanol is a suitable solvent for soaking papaya and pandan leaves because it has the same level of polarity as the active compounds contained in these plants. Papaya leaves and pandan leaves contain active compounds in the form of flavonoids, saponins, and tannins which are polar, so the selection of methanol as a solvent is very suitable because it has the same properties. The selection of suitable solvents is carried out to be able to bind more active compounds so that high yields are obtained (Kurniawati et al., 2016). In addition, this process is intended so that the solution of vegetable pesticides becomes a pesticide that has good usability and usability in integrated pest control (IPM). The better the stirring process, the better the vegetable pesticide solution produced so that in the immersion process, all active ingredients from papaya leaves, pandan leaves, and methanol are mixed and have a high level of active ingredient levels in killing target organisms.

Furthermore, the resulting vegetable pesticides were tested for characterization, namely the mortality test of S. litura larvae, through the contact effect method (Celup Caterpillar) in each treatment which included P1, P2, P3, K. Treatment of papaya leaf extract solution (P1), Leaf extract solution pandan (P2), and a mixture of papaya leaf extract and pandan leaf (P3) showed a difference in the mortality percentage of S. litura larvae produced. The results of the observations can be seen in **Table 1**.

Figure 1. Vegetable pesticides produced from the soaking and filtering process

The results of the analysis showed that the treatment of the caterpillar dyeing method with different types of materials showed significant differences. The lowest number of S litura larvae mortality was obtained from the caterpillar dipping method using pandan leaf extract with 19 dead S litura larvae. While the number of deaths of S litura larvae using caterpillar dipping treatment with papaya leaf extract, the number of dead S litura larvae 35 individuals.

The highest number of S litura larvae mortality was obtained from caterpillar dyeing using a mixture of papaya leaf extract and pandan leaf extract. This is because papaya leaves and pandan leaves contain chemical compounds of saponins, flavonoids, and tannins that have high effectiveness and a specific impact on pest organisms, so the caterpillar dyeing method using a mixture of extracts between the two vegetable ingredients can work optimally in eradicating S litura (Jujuaningsih et al., 2021).

Table 1. Percentage of mortality of S. litura larvae in various treatments

Treatment Group	The volume of solution for each treatment	Number of deaths S. litura larva in each replication (tail)					Number of deaths	Mortality Rate	Percentage of Mortality
		R1	R2	R3	R4	R5			
P1	150 mL	7	5	6	8	9	35	7	70
P2	150 mL	4	2	6	4	3	19	3.8	38
P3	300 mL	9	8	7	10	10	35	8.8	88
K	0	0	0	0	0	0	0	0	0

Note: P1, 2, 3 : Treatment group 1, 2, 3
K : Control Group
R1, 2, 3, 4, 5 : Replication to 1, 2, 3, 4, 5

Saponin compounds are terpenoid compounds that have free sterol binding activity in the digestive system so that they can affect the skin turnover process in insects (Monica et al., 2017), flavonoids are compounds that can inhibit insect eating. And tannins are compounds that can interfere with the physical activity of insects so that they lose a lot of fluid which can result in corrosive digestive tract walls (Ramadhona et al, 2018).

The caterpillar dyeing method treatment with a mixture of papaya leaf extract and pandan leaf extracts contained the most chemical compounds of saponins, flavonoids, and tannins compared to other treatments so that the number of S. using pandan leaf extract solution. The percentage of mortality of S. litura larvae in the dye treatment method with papaya leaf extract solution (P1), pandan leaf extract solution (P2), and a mixture of papaya leaf extract solution with pandan leaves (P3) is shown in Figure 3.

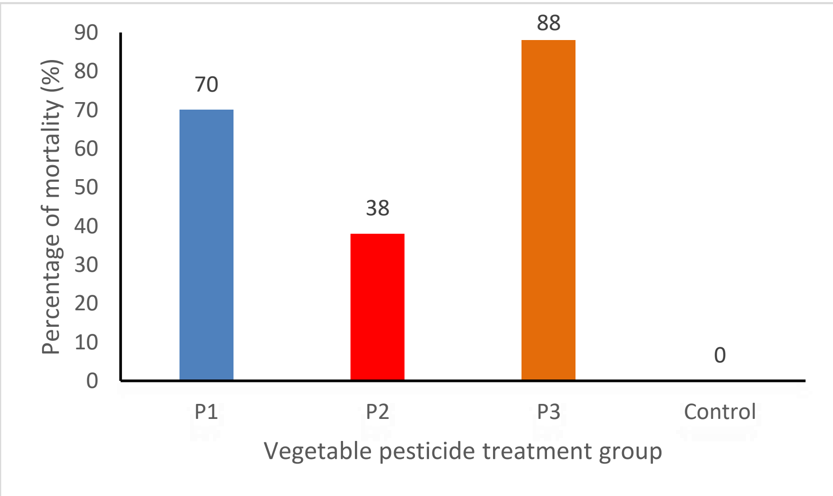

Figure 2. Graph of mortality percentage of slitura larvae

The results of the analysis showed that the treatment of the caterpillar dyeing method with different types of materials showed a significant difference in the mortality percentage of S.litura larvae. Treatment of papaya leaf extract solution (P1), pandan leaf extract solution (P2), and a mixture of papaya leaf extract solution with pandan leaves (P3) were obtained. The differences in these values are caused because the content of each compound in the vegetable pesticide solution has a different way of working both in terms of its killing power, as well as its speed in killing the target organism.

The highest percentage of mortality of S. litura larvae was obtained from the P3 treatment, namely, the dip test using a combined solution of papaya leaf extract with pandan leaves with a mortality percentage of 88%. This is because the active ingredients contained in pandan leaves and papaya leaves work together to affect the physiology of Spodoptera litura so that they can optimally eradicate Spodoptera litura larvae with a maximum working mechanism compared to the other two treatments. Papaya leaves and pandan leaves have active compounds contained in them. Papaya leaves contain active compounds in the form of flavonoids, karpain alkaloids, and tocopherols which can inhibit bacterial activity (Cahyani, 2020). While pandan leaves are plants that contain natural larvicides containing active compounds of alkaloids, saponins, tannins and flavonoids, polyphenols, and essential oils (Wardani et al., 2020).

The mechanism of action of the active compounds contained in these vegetable pesticides has different ways of working on organisms. Phenolic compounds can break the peptidoglycan bonds in the cell wall by damaging the hydrophobic bonds of cell membrane components, namely proteins and phospholipids, and dissolving the hydrophobic components that bind to increase membrane permeability resulting in leakage and release of cell contents. Carpain alkaloids have basic groups that can react with bacterial DNA. This reaction will damage the bacterial DNA destroying the cell nucleus. Cell damage results in bacteria not being able to metabolize so they undergo decomposition and thus the bacteria will become inactive and destroyed. Flavonoids have a mechanism of action by inhibiting the duplication and transcription of bacterial DNA. This is because flavonoids can bind to extracellular bacterial proteins and can dissolve cell walls, thereby damaging cell walls and cell membranes. Inhibition and destruction of cell walls are carried out by the formation of hydrogen and covalent bonds between active ingredients that are hydrophobic so that they interfere with the unification of cell walls and bacterial cell membranes (Tuntun, 2016).

The second highest percentage of mortality of S. litura larvae was obtained from P1, namely the dip test using a solution of papaya leaf extract with a percentage of 77% this was caused because the papaya leaf extract solution contained the enzyme papain, papain is a proteolytic enzyme that has been known as a tough meat tenderizer. which can relax the caterpillar by damaging the body's protein in the caterpillar (Prihatini & Dewi, 2021). it shows that papain works as Vermifuge. In addition, the papain enzyme causes physiological effects on insects, namely influencing the synthesis of excisteroids. The target of the papain enzyme is not on the prothoracic gland (the site of excidon synthesis) but the neurosecretory cells of the brain. Neurosecretory cells function to activate the function of the prothoracic gland which stimulates protein synthesis, prevents water loss, and increases or decreases activity and regulation, especially in metamorphosis, ecdysis, and diapauses. Because neurosecretory cells do not function perfectly and optimally, all activities are disrupted. Severe disturbances will cause the caterpillars not to eat and subsequently caterpillar mortality will occur. Minor disturbances will cause stunted caterpillar growth.

The lowest percentage of mortality of S.litura larvae was obtained from the P2 treatment, namely the caterpillar dyeing method using pandan leaf extract with a percentage of 38%. This is because the active compound content in fragrant pandan leaves has a small concentration so the performance of the active compound in eradicating S Litura larvae is less than optimal. Pandan leaves contain chemical active compounds in the form of polyphenols (9.7%), flavonoids (17.18%), saponin (16.14%), and alkaloids (16.6%) (Ansar & Khaer, 2019).

Although the chemical compounds contained in pandan leaves are strong enough to kill target organisms, this is because pandan leaves contain polyphenolic compounds and saponins that function as larvicides and insecticides (Sudarmo, 2005). According to Atika et al. (2016), these compounds are also able to inhibit the growth of larvae, especially the three main hormones in insects, namely brain hormones (Brain hormone), edikson hormone, and growth hormone (juvenile hormone). The lack of development of these hormones can prevent the movement of the larvae. Based on the research results of Cahyadi et al. (2014) it is known that saponins and polyphenols can inhibit and even kill the growth of insect larvae, mosquitoes, and other pests that disturb plants. Saponins can damage cell membranes and interfere with insect metabolism, while polyphenols act as insect digestive inhibitors.

Conclusions

The combination of papaya leaf extract and pandan leaf extract was effective in controlling Spodoptera litura pests with the highest mortality obtained in a mixture of papaya leaf extract with pandan leaves (P3) which was 88%, while the percentage value of mortality in P1 treatment (Papaya leaves) was 70%, and the lowest mortality percentage value in the P2 (Pandan leaf) treatment was 38%. From the results obtained, it can be concluded that papaya leaves and pandan leaves can be used as candidates for vegetable pesticides to control environmentally friendly plant-disturbing insects.

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References

Atika., Kahtan, M. I & Effiana. (2016). Aktivitas ekstrak etanol daun kesum(polygonum minus) sebagai larvasida aedes aegypti. *Jurnal Cerebellum, 2*(4), 667-678.

Agustiningsih., Wildan, A., & Mindaningsih. (2010). Optimasi cairan penyari pada pembuatan ekstrak daun pandan wangi (pandanus amaryllifous roxb) secara maserasi terhadap kadar fenolik dan flavonoid total. *Momentum, 6*(2), 36-41.

Ansar, D. A., & Khaer, A. (2019). Kemampuan ekstrak daun pepaya dan daun pandan sebagai larvasida nabati dalam mematikan jentik aedes aegypti. *Jurnal Sulolipu: Media Komunikasi Sivitas Akademi Masyarakat, 19*(2). 152-156.

Benu, M. M. M., Adutae, A. S. J., & Mukkun, L. (2020). Dampak residu insektisida terhadap keanekaragaman jamur tanah pada lahan sayuran. *Jurnal Ilmu Tanah dan Lingkungan, 22*(2), 80-88.

Cabral, J. P., Faria, D., & Morante-Filho, J. C. (2021). Landscape composition is more important than local vegetation structure for understory birds in cocoa agroforestry systems. *Forest Ecology and Management, 481*(February), 1-9.

Cahyadi, A., Wahdaningsih, S., & Natalia, D. (2014). Daya tolak infusa daun pandan wangi (pandanaus amaryllifolius roxb) tehadap peletakkan telur nyamuk aedes spp. *Jurnal Fitofarmaka Indonesia (JFFI), 1*(2), 65-71.

Cahyani, I. (2020). *Uji efektivitas ekstrak daun pepaya (carica papaya l.) dalam menghambat pertumbuhan bakteri streptococcus mutans rongga mulut secara in vitro.* Unpublished undergraduated's thesis. Sumatera Utara: Universitas Sumatera Utara.

Gu, S., Zhou, J., Gao, S., Wang, D., Li, X., Guo, Y. & Zhang, Y. (2015). Identification and comparative expression analysis of odorant binding protein genes in the tobacco cutworm Spodoptera litura. *Scientific Reports, 5*(13800), 1-17.

Hendrawati, A. R. E. (2009). *Uji toksisitas ekstrak etanol daun kemangi (ocimum sanctum linn.) terhadap larva artemia salina leach dengan metode brine shrimp lethality test (BST).* Unpublished undergraduate thesis. Semarang: Fakultas Kedokteran Universitas Diponegoro.

Heryani, N., & Rejekiningrum, P. (2019). Pengembangan pertanian lahan kering iklim kering melalui implementasi panca kelola lahan. *Jurnal Sumberdaya Lahan, 13*(2), 63-71.

Hou, W., Staehelin, C., Elzaki, M. E. A., Hafeez, M., Luo, Y., & Wang, R. (2021). Functional analysis of CYP6AE68, a cytochrome P450 gene associated with indoxacarb resistance in spodoptera litura (lepidoptera: noctuidae). *Pesticide Biochemistry and Physiology, 178*(October), *1-10.*

Jujuaningsih., Rizal, K., Triyanto, Y., Lestari, W., & Harahap, D. A. (2021). Penggunaan pestisida nabati ekstrak daun pepaya (carica papaya l.) pada tanaman kacang panjang (vigna sinensis l.) untuk mengurangi dampak pencemaran lingkungan di desa Gunung Selamat, kec. Bilah Hulu, kab. Labuhanbatu. *Jurnal Pengabdian Magister Pendidikan IPA, 4*(3), 1-4.

Kardinan, A., & Suriati, S. (2012). Efektivitas pestisida nabati terhadap serangan hama pada teh (camellia sinensis l.). *Balai Penelitian Tanaman Rempah dan Obat, 23*(2), 148-152.

Kurniawati, I., Maftuch., & Hariati, A. M. (2016). Penentuan pelarut dan lama ekstraksi terbaik pada teknik maserasi gracilaria sp serta pengaruhnya terhadap kadar air dan rendemen. *Samakia: Jurnal Ilmu Peikanan, 7*(2), 72-77.

Mohamed, I., Eid, K. E., Abbas, M. H. H., Salem, A. A., Ahmed, N., Ali, M., Shah, G. M., & Fang, C. (2019). Use of plant growth promoting rhizobacteria (PGPR) and mycorrhizae to improve the growth and nutrient utilization of common bean in a soil infected with white rot fungi. *Ecotoxicology and Environmental Safety, 171*(April), 539-548.

Monica, M., Wardiyanto., & Susanti, O. (2017). Kajian potensi ekstrak daun pepaya (carica papaya l) terhadap immunitas non spesifik udang vaname (litopenaeus vannamei). *Jurnal Ilmiah Perikanan dan Kelautan, 9*(2), 127-133.

Nguyen, T. T., Rosello, C., Belanger, R., & Ratti, C. (2020). Fate of residual pesticides in fruit and vegetable waste (FVW) processing. *Foods, 9*(10), 1-38.

Oktofani, L. A., & Suwandi, J. F. (2019). Potensi tanaman pepaya (carica papaya) sebagai antihelmintik. *Jurnal Majority, 8*(1), 246-250.

Prameswari, O. M., & Widjanarko, S. B. (2014). Uji efek esktrak air daun pandan wangi terhadap penurunan kadar glukosa darah dan histopatologi tikus diabetes melitus. *Jurnal Pangan dan Agroindustri, 2*(2), 16-27.

Prihatini, I., & Dewi, R. K. (2021). Kandungan enzim papain pada pepaya (carica papaya l.) terhadap metabolisme tubuh. *Jurnal Tadris IPA Indonesia, 1*(3), 449-558.

Rahman, A. S., Soedijo, S., & Salamiah. (2020). Mortalitas ulat grayak (spodoptera litura f.) yang diaplikasi dengan berbagai pestisida nabati. *Proteksi Tanaman Tropika, 3*(3), 238-243.

Ramadhona, R., Djamilah., & Mukhtasar. (2018). Efektivitas ekstrak daun pepaya dalam pengendalian kutu daun pada fase vegetatif tanaman terung. *Jurnal Ilmu-Ilmu Pertanian Indonesia, JIPI*, *20*(1), 1-7.

Role, R. M. (2019). *Uji efektivitas kombinasi estrak brotowali, tembakau, dan daun sirsak dalam pengendalian hama belalang kayu (valanga nigricornis).* Unpublished undergraduated's thesis. Yogyakarta: Program Studi Pendidikan Biologi Universitas Sanata Dharma.

Silalahi, A. S. H., Supriyatdi, D., & Sudirman, A. (2021). Respons ulat grayak (spodoptera litura) terhadap lama perendaman tembakau rajang (nicotiana tabacum l.) sebagai insektisida nabati. *Jurnal Penelitian Agronomi*, *23*(2), 84-88.

Sudarmo, S. (2005). *Pestisida nabati*: *Pembuatan dan pemanfaatannya*. Yogyakarta: Kanisius.

Tampubolon, K., Sihombing, F. N., Purba, Z., Samosir, S. T. S., & Karim, S. (2018). Potensi metabolit sekunder gulma sebagai pestisida nabati di Indonesia. *Jurnal Kultivasi*, *17*(3), 683-693.

Tuntun, M. (2016). Uji efektivitas ekstrak daun pepaya (carica papaya l.) terhadap pertumbuhan bakteri escherichia coli dan staphylococcus aureus. *Jurnal Kesehatan*, *VII*(3), 497-502.

Wardani, N. P. I. P P., Adiputra, I. G. K., & Suardana, A. A. K. (2020). Efektivitas repelensi serbuk daun pandan wangi (pandanus amaryllifolius roxb) terhadap kutu beras (sitophilus oryzae l) pada beras merah (oryza nivara). *Widya Biologi*, *11*(1), 30-40.

Yudiawati, E., & Hapis, S. (2017). Efektifitas ekstrak daun pepaya sebagai pestisida nabati terhadap intensitas serangan aphid (homoptera: aphididae) pada tanaman cabe merah (capsicum annum). *Jurnal Sains Agro*, *2*(1), 1-8.