Jurnal Pembelajaran Dan Biologi Nukleus p-ISSN: 2442-9481
Vol 10 (1): 304-316, March 2024 e-ISSN: 2685-7332

The Effectiveness Assay of Vegetable Pesticides Papaya and Mahogany Leaf Extracts in Pest Control of *Spodoptera exigua* (Lepidoptera: Noctuidae) on Onion (*Allium ascalonicum* L) Cultivation

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Submitted December 09th 2023 and Accepted February 28th 2024

Abstract

Spodoptera exigua is the main pest that attacks the onion crop. S. exigua attack can cause crop failure reaching 57%-100%. The use of natural ingredients from plants for vegetable pesticides such as papaya leaves and mahogany leaves containing secondary metabolite compounds: alkaloids, papain, saponins, tannins, terpenoids, flavonoids and steroids that can damage the feeding activity system and damage the pest growth system which eventually the pest will die. This study uses a non-factorial RAL (Completely Randomized Rack) method with 7 treatments M0= Control, M1= Papaya leaf extract 30%, M2= Papaya leaf extract 60%, M3= Mahogany leaf extract 30%, M4= Mahogany leaf extract 60%, M5 = Papaya leaf extract 15% + mahogany leaf extract 15%, M6= Papaya leaf extract 30% + mahogany leaf extract 30%. The highest mortality result is 72.50% with the treatment of 60% papaya extract vegetable pesticide and the lowest is 27.50% with the treatment of 30% mahogany extract vegetable pesticide. The initial symptoms of death of S. exigua caterpillars are characterized by larvae that are less active in moving, moving to the surface of the container, moving away from the feed, convulsing and finally dying. The mortality of S. exigua larvae at 24 JSA killed a total of 14 larvae and increased with each subsequent treatment. The results of the vegetable pesticide test on natural enemies using extracts that produce the highest percentage of mortality on S. exigua is 100%. This indicates that the extract is safe for the survival of natural enemies. Plant-based pesticides papaya leaf extract, mahogany leaves and a combination of papaya and mahogany leaves have an effect on the mortality of S. exigua caterpillars

Keywords: *Spodoptera exigua, Plant-based Pesticides, Papaya Leaf, Mahogany Leaf, Natural Enemies*

https://doi.org/10.36987/jpbn.v10i1.5394

INTRODUCTION

Farmers generally use synthetic pesticides in controlling pests continuously with high concentrations. The synthetic pesticide ingredients used include pyrethroids, carbamates, and organophosphates (Uge et al., 2021)The use of synthetic pesticides can quickly kill pests, but excessive use can result in pest resistance, is toxic to non-target insects, leaves residues on plants, and disrupts the balance of the environment so that it endangers human health. Synthetic pesticides have a higher content of toxic compounds and are lethal to non-target insects more quickly such as ants (Nukmal, 2019). The use of synthetic pesticides made from chemicals is more effective in suppressing pest growth and the way to apply it is easier (Ginting, 2020).

Vegetable pesticides made from plants are one way to reduce the use of synthetic pesticides. Plants that have potential as pesticides generally have bitter taste characteristics (containing alkaloids and terpenes), and a slightly spicy taste (Gafur & Anshary, 2022). Natural plants that contain pesticide ingredients that can be used to control pests, including containing antifeedant substances Hasyim *et al.*, (2019), killing pests or inhibiting insect growth Jeyasankar *et al.*, (2014), there are deterrents,, there are substances that repel insect attacks, damage eggs so that they do not develop (Hasyim et al., 2019), prevent insect activity to lay their eggs (Radha R & Susheela P, 2014) and inhibit the insect reproductive system (Gafur & Anshary, 2022).

Vegetable pesticides have properties, namely easily decomposed naturally (bioegradable), do not cause side effects to natural enemies of pests (selectivity), can coexist with other pest pesticide ingredients (Compatibility), inhibit the development of resistance, and ensure sustainability in farming (sustainability). Plants that produce various types of secondary metabolites such as alkaloids, flavonoids, terpenoids, tannins, and others are useful as plant protective agents (Saputri *et al.*, 2021). Secondary metabolite compounds if applied to plants attacked by pests, do not affect the photosynthesis process or other physiological aspects of the plant, but will affect the nervous muscle system, hormonal balance, reproduction, behavior, anti-feeding and breathing of pests (Rahmad, 2020).

Plants can be used as vegetable pesticide ingredients to control pests, namely papaya plants (Carica papaya L). Papaya can be used as a pesticide because it has sap. This sap contains compounds of alkaloid, flavonoid, terpenoid, and non-protein amino acids that are toxic to insects (Saputri *et al.*, 2023). In addition, papaya leaves contain papain compounds. The content of papain has toxic properties for caterpillars and sucking pests (Saputri *et al.*, 2021). According to (Wahyuni & Yuliani, 2023) papaya leaf extract at a concentration of 15% has an effect on Spodoptera litura mortality, namely 66.67%. Mahogany plants (Swietenia mahogani) contain alkaloid, saponin, flavonoid, tannin and tirpenoid compounds (Suprapti *et al.*, 2020). The content of alkaloids and flavonoids can interfere with the appetite of pests (Fathoni *et al.*, 2013)

The content of saponin and flavonoid compounds is known to play a role in thwarting the taste stimulus in larvae so that the larvae do not recognize food Hidayati & Suprihatini, (2020) Based on research (N. N. Hidayati et al., 2013) mahogany leaf extract at a concentration of 10% has an effect on S. exigua mortality, which is 64.17%. In 2022 onion (Allium ascalonicum) became the number one vegetable commodity with the largest production of 1,982,360 tons (BPS). Shallots are needed and have high economic value, fulfillment of national consumption, a source of income for farmers, and an increase in foreign exchange earnings (Nursam *et al*., 2018). Shallots are used by Indonesian people as a spice in cooking and there are also as treatments (Lubis et al., 2022). Data from the Central Statistics Agency (BPS) shows that shallots in Indonesia in 2022 decreased by 1.01% compared to 2021. The Central Bureau of Statistics states that the cause of the decline in shallot production is due to unfavorable weather factors that invite various attacks of plant pest organisms (OPT). Proper shallot cultivation techniques are needed to increase production both in terms of quantity and quality in order to avoid pest attacks.

Spodoptera exigua is the primary pest in attacking shallot plants. This pest has the ability to spread quickly in low and highland areas, besides that this pest attacks throughout the year in the dry season and rainy season (Marsadi & Sunari, 2017). Symptoms of S. exigua attack are transparent spots on the leaves caused by the consumption of the inner skin of the leaves, while the outer epidermis is left behind. If no control is done, it will have an impact on reducing the productivity of onion farmers' crops. Pest attacks occur at the age of 7-42 days after planting until the tuber maturation phase (Suharti, 2018). This can result in crop failure because the damage caused can reach 57%-100% (Prasetyo, 2016).

METHOD

The research was conducted in the laboratory of Universitas Pembangunan Panca Budi Medan in October-December 2023. The research design used was a non-factorial completely randomized design (CRD). There were 4 replicates and 7 levels of concentration treatment as follows: M0: Without Application (Control), M1: 30% Papaya leaf extract, M2: 60% Papaya leaf extract, M3: 30% Mahogany leaf extract, M4: 60% Mahogany leaf extract, M5: combination of 15% Papaya leaf extract and 15% Mahogany, M6: combination of 30% Papaya leaf extract and 30% Mahogany. There were 28 experimental units in total. Each experimental unit contained 10 3rd instar S. exigua larvae, with one larva in each container.

The materials used were papaya leaves, mahogany leaves, distilled water, shallot leaves, S.exigua larvae, Trichogramma sp, Cheilomenes sexmaculata beetle imago, Phenacoccus solenopsi, label paper, honey, tape, cardboard paper, filter paper, gauze and cotton. The tools used were plastic cups, tweezers, scissors, oven, beaker, erlenmeyer, test tube, sieve, stirrer, blender, black/brown glass boto, plastic bottle, rubber band, marker, camera and stationery.

Preparation of Vegetable Pesticide Extract

Papaya and mahogany leaves are cleaned with running water to remove dirt. The leaves were cut into small pieces and dried for ± 14 days, then blended and sieved. Then the leaf powder was macerated with solvent (distilled water) in a ratio of 1:10 for 3 days with occasional stirring. After the yield is produced, filtering is carried out. The filtered yield is stored in an erlenmeyer and tightly closed. While the leaf powder returns to be remacerated until the color of the solution becomes clear. The collected maceration results were stirred evenly and evaporated using an oven at 50°c.

Phytochemical Screening Test

Secondary metabolite screening tests on vegetable pesticide extracts are carried out to obtain information on the content of secondary metabolite compounds contained therein. Plant-based pesticide extracts that have been made before, then carried out phytochemical screening at the Biochemistry Laboratory of the University of North Sumatra.

Propagation of *S. exigua*

Larvae were collected directly from shallot plants at the Kutagadung Berastagi Horticultural Seed Unit (BIH). Larvae were put into plastic cups containing fresh shallot leaf feed. After becoming prepupae moved in a container and covered using gauze, the prepupal phase is 1-2 days with characteristics including shortened body shape, shrunken and slightly curved. The pupa stage ranges from 8-10 days, before turning into an imago, the pupa is moved to a larger container that has been modified. Imago is fed with a honey solution that is impregnated on cotton rolls and then hung. Cotton rolls are replaced every other day. After the imago lays eggs, the S. exigua eggs are transferred to another container and covered with gauze. The egg phase occurs for 3-5 days and by the time the eggs hatch, the eggs will turn blackish. After 12-14 days the eggs hatch and are reared, the larvae that have entered the 3rd instar phase are ready for testing.

Propagation of Natural Enemies (Predators and Parasitoids)

C. sexmaculata imago were collected from the field, then reared and propagated in the laboratory. A total of 10 pairs of imago were put into rearing containers. Imago are fed with mealybugs, and feed is changed once a day. After the imago laid eggs, C. sexmaculata eggs were transferred to another container and covered with gauze. The egg stage lasts for 2-4 days, the larval phase takes 6-10 days during which the larvae are fed with mealybugs and reared. The duration of the pupa stage is 2-4 days, after the pupa process takes place the newly emerged Imago with orange and pale red body color is ready to be tested.

Eggs of the parasitoid *Trichogramma* sp from IPB were propagated using Crocidolomia pavonana eggs collected in paper plates. The paper containing the parasitized eggs were put into test tubes. After 1 week the parasitoid *Trichogramma* sp emerged was transferred into a test tube as many as 10 individuals in each test treatment. Application to *S. exigua*. Before application, the *S. exigua* larvae were exposed for 6 hours. The application was carried out using the dipping method by dipping the feed in each treatment solution for 15 minutes and drying it. Then the feed was given to the test larvae.

Application to Natural Enemies

Tests on natural enemies (parasitoids and predators) used extracts with the best previous test results on *S. exigua* larvae. The application was carried out using the Residue method, namely spraying and applying the vegetable pesticide extract in a test tube with a repetition of 4 replicates, then dried in the wind for ± 15 minutes. Then the natural enemy is put into a test tube, observed for mortality and survival for 24 hours.

Testing Parameters

Mortality of S. exigua

Mortality observations were made for 96 JSA with the following formula (Dewi et al., 2017).

$$M = \frac{a}{b} X100\%$$

Description:
M = Percentage of S. exigua mortality
a = Number of S. exigua that die
b = Number of S. exigua tested

In determining the effectiveness of a vegetable pesticide in larval pest mortality is: 0-30% = ineffective, 31-50% = less effective, 51-70 = effective, and 71-100% = very effective (Aisyah, 2016).

Symptoms of attack and behavior after application of vegetable pesticides

Symptoms of attack and behavior were observed for 4 days until the test larvae died.

Duration of Death

The length of death was observed starting from the larvae being fed with vegetable pesticides, at 24 hours the dead larvae were counted and so on up to 96 hours.

Biosafety Test

The application of vegetable pesticide extracts on predators and parasitoids is obtained from the dose of the highest larval mortality results. Observations were made for 24 hours. According to Supono et al., 2022 states that the survival of natural enemies can be calculated using the formula:

$$\text{TKH} = \frac{\text{Na}}{\text{Nw}} 100\%$$

Description:
TKH = Survival rate (%); Na = number of predators/parasitoids at the end (tail); Nw = number of predators/parasitoids at the beginning (tail)

Phytochemical Screening

Papaya and mahogany leaf extracts that have been evaporated are then carried out phytochemical screening at the Biochemistry Laboratory of the University of North Sumatra.

Data Analysis

Data on the percentage of death of S. exigua were analyzed by variance analysis (Anova), then continued with Duncan's Multiple Range Test (DMRT) at a real level of 5%.

RESULTS AND DISCUSSION
Results

The results of phytochemical screening tests from papaya leaf extract in (Table 1) show the results of secondary metabolites, namely alkaloids, flavonoids, terpenoids, steroids, saponins, and tannins. This is also in accordance with the research of Salim *et al.*, (2018) the highest compound content is tannins 0.7231%, phenol 0.6799%, saponins 0.2468%, and flavanoids 0.124%.

The screening test results of mahogany leaf extract in (Table 1) showed the results of secondary metabolites, namely alkaloids, flavonoids, terpenoids, saponins and tannins. The results of this test are in accordance with research (Amelia, 2017) and (Koneri & Pontororing, 2016) states that the highest content is, flavonoids 0.394%, alkaloids 0.178%, saponins 0.033%, and terpenoids 0.02%.

Table 1. Papaya and Mahogany Extract Screening Test Results

Compound	Reagent	Papaya Leaves	Mahogany Leaves	Color Change
Alkaloid	Bouchardart	+	+	Brick Red Deposition
	Maeyer	-	-	Yellowish White Precipitate
Flavonoid	Fecl3	+	+	Black Colloid
	Mg.Hcl	-	+	Pink Solution
	H2So4	-	+	Yellowish Orange Solution
Terpenoid	Liebermann-Bouchard	+	-	Bluish Green Solution
	Salkowsky	-	+	Red solution
Steroid	Liebermann-Bouchard	+	-	Bluish Green Solution
	Salkowsky	+	-	Red Solution
Saponin	Aquadest + Pengocokan	+	+	Foaming
Tanin	Fecl3	+	+	Black Colloid

Mortality of *S. exigua*

Based on the results of variance investigations obtained that vegetable pesticides papaya leaf extract, mahogany and a combination of papaya leaves and mahogany have an effect on the mortality of *S. exigua* larvae. Mortality of the test pests in the control treatment (M0) no deaths were found (Table 2). In the treatment of papaya leaf vegetable pesticides, mahogany and the combination of both had no effect at 24 JSA, while at 48 JSA, 72 JSA and 96 JSA significantly different from the control. At 24 JSA it was seen that the mortality of S.exigua did not show a very large percentage, this was thought to be due to the fact that vegetable pesticides need time to process and affect the larvae. Some active substances of vegetable pesticides require more time to show the effect of killing larvae (Zulkarnain *et al.*, 2019). After 48 JSA onwards, the percentage of pest mortality increased.

The highest mortality percentage was 72.50% with the treatment of vegetable pesticides papaya leaf extract with a concentration of 60% (Table 2). The death of S. exigua caterpillars is thought to be due to the content of papaya leaf compounds, namely papain enzymes, alkaloid compounds, saponins, tannins and flavonoids. Papain enzyme enters the natural holes of the larvae and spreads and attacks the nerves thus inhibiting growth hormones (Mawuntu, 2016). Alkaloids inhibit and even cause metamorphosis failure because they inhibit growth, exfoliating hormones, brain hormones (Fathoni et al., 2013), discoloration of the larval body becomes more transparent and when the larvae are stimulated by touching the larval body will move slowly accompanied by indentations (Cania & Setyaningrum, 2013). According to (Sa'diyah *et al*., 2013). Saponins enter the larval body as a stomach poison and are able to disrupt and damage the process of molting in larvae. Saponins can also damage appetite so that the larval body is not fulfilled with nutrients which results in death in larvae. Tannins are compounds in plants that work in the food digestion system. Insects that eat plants with high tannin content will cause little food to be obtained so that there is a decrease in growth (Koneri & Pontororing, 2016). Tannins are also repellent to insects so that they can be used as a form of plant defense (Manikome & Handayani, 2020).

The lowest mortality percentage was 27.50% with the 30% concentration of mahogany leaf extract vegetable pesticide treatment (Table 2). The content of mahogany extract is alkaloid, flavonoid, terpenoid, saponin and tannin. The highest compound content in mahogany leaves is flavonoids Koneri & Pontororing, (2016), that flavonoid group compounds that are strong as insecticides are isoflavones. Isoflavones cause anti-fertility (Soelistijono, 2023). Other flavonoid compounds that can work as vegetable pesticides are retenoids. Retenoids as toxins inhibit metabolism and slow down the nervous system.

The cause of mahogany leaf extract is much lower than papaya leaves is the content of secondary metabolite compounds that can eradicate S. exigua caterpillars get help from papain and kimo papain enzymes that have been described previously. So that S. exigua larvae are killed faster than mahogany leaf extract which only contains secondary metabolite compounds.

Table 2. Percentage of mortality of *S. exigua* due to papaya leaf extract, mahogany leaf extract and their combination

Treatment	Mean Mortality of S. exigua (%)			
	24 Hours	48 Hours	72 Hours	96 Hours
M0 (Control)	0,00^{k}	0,00^{k}	0,00^{k}	0,00^{k}
M1 (Papaya Leaf Extract 30%)	2,50^{jk}	17,50^{jk}	37,50^{ef}	47,50^{cd}
M2 (Papaya Leaf Extract 60%)	10,00^{jk}	30,00^{fg}	50,00^{bc}	72,50^{a}
M3 (Mahogany Leaf Extract 30%)	5,00^{jk}	10,00^{jk}	22,50^{hi}	27,50^{gh}
M4 (Mahogany Leaf Extract 60%)	2,50^{jk}	10,00^{jk}	25,00^{hi}	30,00^{fg}
M5 (E. Papaya Leaf 15% + E. Mahogany Leaf 15%)	7,50^{jk}	22,50^{ij}	40,00^{de}	50,00^{bc}
M6 (E. Papaya Leaf 30% + E. Mahogany Leaf 30%)	7,50^{jk}	22,50^{ij}	35,00^{ef}	55,00^{ab}

Description: Numbers followed by the same letter indicate that they are not significantly different in the 5% Duncan test.

There was a significant effect between the mixture of papaya and mahogany leaf extracts on the mortality of S. exigua larvae. The concentration of papaya 30% + mahogany 30% with the highest result is 55%. But the percentage of mortality of S.exigua caterpillars mixed papaya leaves mahogany leaves did not show an increase in the average but a decrease when compared to a single papaya leaf extract, this can be caused because each extract is only half the part taken compared to a single papaya leaf extract so that the compounds of both extracts are less dominant. This is also in accordance with the research of Mawuntu, (2016) which states the results of the mortality rate of the treatment of soursop and papaya leaf combination extracts are low compared to the treatment of soursop extracts and papaya leaves alone. If the combination of extracts gives a lower effect than the single factor, it can be due to the presence of non-synergistic factors Safirah *et al*., 2016). From the results of the data above, it can also be seen that the higher the concentration of leaf extract vegetable pesticides, the higher the mortality rate of S. exigua. In line with the research of Jayati *et al*., (2020) stated that the higher the concentration used, the higher the mortality.

Symptoms of Attack and Behavior

The initial symptoms of *S. exigua* caterpillar death in the mahogany extract treatment were characterized by larvae that were initially active in moving to become less active, moving to the surface of the container, shaking their heads, moving away from the feed and finally dying. Changes in the body color of S. exigua larvae from fresh yellow green to brown to black, the larval body becomes soft and decomposed, and if pressed, it will release black liquid. Research by Heviyanti *et al*., (2016) also stated the same symptoms and behavior, namely less active movement than before, away from food, discoloration to blackish brown, soft body and if pressed, black liquid is released.

Figure 1: Symptoms of *S. exigua* attack. Point a) *S. exigua* before application; b) *S. exigua* after application of the body state shrinks and the body shrinks; c) The body of *S. exigua* changes color to blackish brown; d) The body of *S. exigua* dries up.
Source: Personal Documentation, 2023

The symptoms and behavior of papaya extract are not much different from mahogany extract, namely S. exigua larvae moving less actively, moving up to the surface of the container, moving away from the feed, convulsing and then finally dying. This is also in accordance with the research of Siahaya & Rumthe, (2018), the initial symptoms of death in Plutella xylostella larvae where the larvae move to the top of the container surface, are not actively moving and experiencing convulsions. Changes in behavior and symptoms of attack after the application of vegetable pesticides are in accordance with previous research which states the same thing. Alfaizal *et al*., 2021) explained that due to toxic compounds that enter the pest, disrupting the metabolic activities of the pest will result in the appearance of a foul smell at the time of pest death.

Likewise, research by Najmi, (2023) Symptoms of death of S.litura larvae are characterized by slowed movement, discoloration to blackish brown, reduced body size, oozing liquid and smelling bad. According to Jayati *et al*., (2020) vegetable pesticides have a very specific work system, which can interfere with the development of eggs, larvae, pupae and imago, inhibit molting, interfere with insect communication, inhibit insect reproduction, repellent, and reduce appetite.

Duration of Death

The fastest mortality time of S. exigua larvae in this study was 24 hours with a total of 14 larval deaths and in the control did not cause mortality of S. exigua larvae. At 48 hours and 72 hours, S. exigua mortality increased and at 96 hours mortality decreased. In accordance with the statement Zulkarnain *et al*., 2019) that some plant-based pesticide compounds require more time to show a killing effect on larvae. So many larvae die in 72 hours. At 96 hours the death of larvae decreases, this is because vegetable pesticide extracts have decomposed. At the first application in 24 hours the vegetable extract is still concentrated and in the following days the concentration of the extract decreases. This is also in accordance with (Wiranata & Sunardi, 2023) on days 3 to 5 larval death has decreased drastically even until no more larvae die, this is due to reduced extract concentration from the following days.

Table 3. Time of Mortality

Tretments	Time of Mortality			
	24 Hours	48 Hours	72 Hours	96 Hours
M0	0	0	0	0
M1	1	6	7	4
M2	4	8	8	9
M3	2	2	5	2
M4	1	3	6	2
M5	3	4	7	6
M6	3	8	5	6
Total	**14**	**31**	**38**	**29**
Mean	2,3	5,17	6,3	4,83

Biosafety Test

Natural enemy testing using extracts that resulted in the highest percentage of mortality in S.exigua was M2 concentration (Papaya Leaf Extract 60%) with a result of 72.5% observed for 24 hours. The results of this study showed that the treatment of papaya leaf extract with a concentration of 60% was very safe on natural enemies (parasitoids and predators) with the result of no death in natural enemies (Table 4). This proves that vegetable pesticides with the highest mortality with a dose of 60% are still safe to apply. This research is also in line with Syarief, (2023) with mahogany extract concentrations of 20 ml / 1 and papaya extract 10% stated that it does not result in disruption of tritrophic interaction patterns and preserves non-target antrhopods. According to Wardana *et al*., 2023) in a study applying synthetic pesticides and vegetable pesticides to test the diversity population of black ants as armyworm predators, synthetic pesticides cause a reduction in the population of armyworms. The increase in pest populations is strongly influenced by natural balances such as the presence of natural enemies and not according to the way insecticides are applied (Armaniar et al., 2019).

Table 4. Mean Survival Rate on 24-Hour Mortality Results

Parasitoids/Predators	Replay (%)			
	1	2	3	4
Trichogramma sp.	100	100	100	100
Cheilomenes sexmaculata	100	100	100	100

CONCLUSION

Vegetable pesticide treatment of papaya leaves, mahogany leaves and a combination of papaya and mahogany had a significant effect on the mortality of S. exigua. The highest mortality yield was 72.50% with 60% papaya leaf treatment and the lowest mortality was 27.50% with 30% mahogany leaf treatment. The mortality result of the combination of both is 55.00% with a concentration of 30% papaya leaves + 30% mahogany leaves and 50.00% with a concentration of 15% papaya leaves + 15% mahogany leaves. In vegetable pesticides, 60% papaya extract shows 100% survival results of natural enemies.

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How To Cite This Article, with *APA style* :

Siregar, W.S., Ginting, T.Y., & Lubis, N. (2024). The Effectiveness Assay of Vegetables Pesticides Papaya and Mahogany Leaf Extracts in Pest Control of *Spodoptera exigua* (Lepidoptera: Noctuidae) on Onion (*Allium ascalonicum* L.) Cultivation. *Jurnal Pembelajaran dan Biologi Nukleus*, 10(1), 304-316. https://doi.org/10.36987/jpbn.v10i1.5394

Conflict of interest	:	The authors declare that they have no conflicts of interest.
Author contributions	:	All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submited by [**Winda Sari Siregar**]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.