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Growth and Productivity of Silkworm *Bombyx mori* L. (Lepidoptera: Bombicidae) Given Mulberry (*Morus* sp.) It Contains Vitamin B1

***Umi Kalsum Lubis*[1], *Masitta Tanjung*[2], *Nursal*[2]**

[1],*Undergraduate student, Departement of Biology, Faculty Mathematics and Natural Science, Universitas Sumatera Utara, Jalan Bioteknologi No. 1 Kampus, Padang Bulan, Medan 20155, Sumatera Utara, Indonesia*

[2]*Departement of Biology, Faculty Mathematics and Natural Science, Universitas Sumatera Utara, Jalan Bioteknologi No. 1 Kampus, Padang Bulan, Medan 20155, Sumatera Utara, Indonesia*

Abstract. The effect of mulberry leaves that contain vitamin B1on the growth and productivity of silkworms (*Bombyx mori* L.) was studied. This research used Completely Randomized Design (CRD) with the treatments were 10 silkworm feed with an untreated control leaves and an addition 0.1, 0.2, 0.3 and 0.4 mg/100ml of vitamin B1. Every treatment consisted of 3 replications. The results showed that an addition of vitamin B1 inhibited the growth, morphological structure of instars III, and IV such as head length, head diameter, body length, and body diameter, the weight of instars III, V, and the percentage of cocoon shell. Vitamin B1 has no effect on the morphological structures of instars V, the weight of instars IV, the pupae weight, the fiber length, the fiber percentage, the cocoon weight, and the cocoon shell weight. However, the frontal and posterior glands were decreased at the concentration 0.4 mg/100ml.

Keyword: Silkworm, Morus, Vitamin B1

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1 Introduction

Natural engineering activities are one of the efforts to support land rehabilitation programs by increasing land carrying capacity through the cultivation of mulberry plants combined with silkworm maintenance and post-harvest handling. Natural engineering efforts are seen as having hopes to prosper the community because of its labor-intensive nature and can take advantage of forest areas that are still abandoned[1]. Silkworm (Bombyx mori) is one type of silkworm that has a high economic value for humans and is widely cultivated by people in Indonesia [6] The growth of silkworm types is strongly influenced by climatic and environmental conditions, including temperature, humidity, light [7] Silkworm is a producer of silk fiber which is a raw

**Corresponding author at: Departement of Biology, Faculty Mathematics and Natural Science, Universitas Sumatera Utara, Jalan Bioteknologi No. 1 Kampus, Padang Bulan, Medan 20155, Sumatera Utara, Indonesia

E-mail address: masittatanjung@yahoo.co.id

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material of silk in the field of textiles, surgical threads and parachutes with high quality, can not be defeated by artificial silk fibers. In kokon trading, pricing is based on the quality of the kokon which includes the weight of the kokon, (Kaomini, 2002).The need for silkworm feed has become the object of nutritionists to find and make artificial feed formulas. Therefore, it is necessary to look for alternatives, how silkworm feed is given vitamins that are vitamin B1. Vitamin B1 is a water-soluble vitamin, and serves as a coenzyme in the Krebb cycle (a biological pathway converting blood sugar into energy)[2] . [3] , said that vitamin B1 functions in the rate of metabolic reactions that can increase the amount of feed, because vitamin B1 can only be obtained from the food consumed. In line with the government's efforts to increase the production of silk threads, an effort is carried out in the maintenance of silkworms, with the provision of vitamin B1 in silkworm feed, which is very important for the growth of the body's metabolism, so that later it is expected to increase the growth and productivity of silkworms.

2. Material and Methods

The research method used is a Complete Randomized Design (CRD) with 5 treatments namely: vitamin B1 concentration 0 mg / 100ml, 0.1 mg / 100ml, 0.2 mg / 100ml, 0.3 mg / 100ml, 0.4 mg / 100ml with 3 repeats consisting of 10 caterpillars.

2.1. Maintenance of Silk Worm *Bombyx mori* L.

Silkworm eggs are obtained from candiroto silkworm nursery center, Central Java. The eggs are put into white HVS paper, folded with carbon paper and arranged into a plastic basket until hatched. Silkworms that have hatched are fed mulberry leaves that have been dipped in vitamin B1 solution. Caterpillars are put in a petri dish that has previously been coated with wet wipes and paper. Mulberry leaves that are given vitamin B1 and without vitamin B1 given are cut into small pieces. Feeding is given three times a day: morning, noon and evening. At the end of the instar I which is marked by the caterpillar stops eating and changes the skin (molting) where the maintenance of silkworms is cleaned by replacing the base paper, lifting feces and the rest of the feed. The same is done at the beginning and end of instar II through V.

Treatment

Fresh mulberry leaves are first cleaned, dipped in vitamin B1 with each concentration: 0 mg/100ml, 0.1 mg/100ml, 0.2 mg/100ml, 0.3 mg/100ml and 0.4 mg/100ml. The leaves are cut into small pieces and given to caterpillars during instar I and II. But in the treatment of instar III-V mulberry leaves given vitamin B1 are not cut into small pieces but given whole. Feeding is given in the morning (07.00 am -08.00 am WIB), noon (12.00 pm -1.00 pm WIB) and afternoon (4.00 pm-5.00 pm WIB).

Observation parameters include

Growth of larvae and pupae

a. Morphological Changes (instar III-V)

Measuring body length, body diameter, head length, head diameter using threads cut to size and measured using a 30 cm ruler.

b. Weight of the final larva of the instar (g)

The initial weight weighing of the instar and the end of the instar. Weight gain is obtained by reducing the final weight with the initial weight of the instar.

c. Weight of Silk Glands (g)

At the end of the larva instar V is put into aluminum foil and placed into the refrigerator for 2 x 24 hours until the larvae die. Larvae are dissected and then their glands are rinsed in 0.75% NaCl and then dried with filter paper and weighed using digital scales. The weighing of the weight of the gland is divided into three parts, namely the front, middle and back glands.

d. Weight of pupa

Weighing pupae by splitting the kokon, then removed pupa.

Productivity

a. Percentage of kokon skin

The percentage of cocon skin is obtained by the following formula:

$$Percentage\ of\ Kokon\ skin = \frac{Kokon\ skin\ weight}{\boldsymbol{Kokon\ skin\ weight\ contains\ pupae}}\ x100 \qquad (1)$$

b. Length of silk fiber

The length of silk fiber is determined based on the length of the fiber extended from a kokon. The length of the fiber is expressed in meters (m).

c. Percentage of silk fiber

The percentage of silk fiber is the percentage of weight of silk decomposed against, the weight contains pupae, expressed in percent (%)

$$Percentage\ of\ Kokon\ skin = \frac{Weight\ of\ Slik\ Fiber}{\boldsymbol{Fresh\ Kokon\ Weight}}\ x100 \qquad (2)$$

The data obtained from each observation parameter (variable) is recorded and organized into table form. Quantitative data (dependent variables) obtained, tested its meaning on the influence of treatment groups (independent variables) with the help of computer statistics program, namely SPSS release 21 program. The test sequence begins with the normality test, the homogeneity test. If the test results show $p<0.05$ then the data is transformed and continued with a non-parametric test. To see the difference from 2 treatments continued Mann-Whitney test. If the test results show $p>0.05$ then continued the one-way fingerprint test (ANOVA) for data with repeated observation (more than 2 times) or more than 2 treatments and if the difference is real ($p <0.05$) then continued with the Post Hoc analysis test – Bonferroni level 5%. To see the difference of 2 treatments is done with the t (parametric) test.

3. Result and Discussion

a. Morphology of the Body of the SilkWorm Bombyx mori

Observations of body morphometry, the addition of body weight of silkworms (Bombyx mori) instar III, IV, V and pupae weights that consume mulberry leaves given vitamin B1, can be seen in Table 1

Table 1. Average Morphometry of The Body of SilkWorm Instar III with different Concentrations.

Treatment	Morphology of the Body (cm)			
	Diameter of Head	Length Head	Diameter Body	Length Body Diameter
P0	$0.25^{a}\pm0.03$	$0.94^{a}\pm0.09$	$0.33^{a}\pm0.03$	$2.29^{a}\pm0.12$
P1	$0.20^{b}\pm0.03$	$0.91^{a}\pm0.09$	$0.31^{a}\pm0.03$	$2.20^{a}\pm0.13$
P2	$0.16^{b}\pm0.03$	$0.83^{b}\pm0.08$	$0.30^{a}\pm0.04$	$2.13^{a}\pm0.19$
P3	$0.16^{b}\pm0.02$	$0.74^{b}\pm0.14$	$0.28^{a}\pm0.03$	$2.09^{a}\pm0.12$
P4	$0.14^{b}\pm0.03$	$0.74^{b}\pm0.09$	$0.22^{b}\pm0.02$	$1.96^{b}\pm0.09$

Information: P0: Control, P1: 0.1 mg/100ml, P2: 0.2 mg/100ml, P3: 0.3 mg/100ml, P4: 0.4mg/100ml The same notation in the same column shows no real difference ($p>0.05$)

Table 1. Morphometry of the body of the larvae of instar III includes the diameter of the head, head length, body diameter, body length between control and treatment (P1,P2,P3,P4) decreases. After statistical tests on the diameter of the head between the control group and the treatment showed a noticeable difference ($p<0.05$). Head length between the control group and P1 showed no real difference ($p>0.05$), while between controls and P2,P3,P4 differed markedly. The body length and diameter of the silkworm body between the control group and P1, P2, P3 showed no real difference, while in P4 the difference was real.

Table 2. Average Morphometry of Instar IV SilkWorm Body with different Concentrations

Treatment	Morphology of the Body (cm)			
	Diameter of Head	Length Head	Diameter Body	Length Body Diameter
P0	$0.25^{a}\pm0.03$	$1.11^{a}\pm0.08$	$0.39^{a}\pm0.02$	$3.21^{a}\pm0.14$
P1	$0.24^{a}\pm0.03$	$1.00^{b}\pm0.07$	$0.38^{a}\pm0.03$	$3.20^{a}\pm0.16$
P2	$0.23^{a}\pm0.02$	$0.98^{b}\pm0.06$	$0.38^{a}\pm0.04$	$3.11^{a}\pm0.21$
P3	$0.21^{a}\pm0.02$	$0.97^{b}\pm0.10$	$0.37^{a}\pm0.03$	$2.95^{b}\pm0.18$
P4	$0.19^{b}\pm0.03$	$0.94^{b}\pm0.06$	$0.35^{a}\pm0.03$	$2.75^{b}\pm0.11$

Description: P0: 0 mg/100ml, P1: 0.1 mg/100ml, P2: 0.2 mg/100ml, P3: 0.3 mg/100ml, P4: 0.4 mg/100ml. The same notation in the same column shows no real difference ($p>0.05$)

Table 2. The morphometry of the body of the iv instar larva includes the diameter of the head, head length, body length and body diameter between control and decreased treatment. After testing head diameter statistics between the control group and treatment (P1,P2,P3) showed no real difference ($p>0.05$), while in P4 the difference was real ($p<0.05$). The length of the silkworm head between the control group and the treatment showed a noticeable difference. The weight of the silkworm between control and treatment (P1,P2,P3,P4) showed no real difference. The diameter of the silkworm body between the control group and the treatment (P1,P2) showed no real difference, while in P3 and P4 the difference was real.

Table 3. Average Morphometry of Instar V SilkWorm Body with different Concentrations

Treatment	Morphology of the Body (cm)			
	Diameter of Head	Length Head	Diameter Body	Length Body Diameter
P0	$0.33^{a}\pm0.07$	$1.28^{a}\pm0.15$	$0.54^{a}\pm0.04$	$3.86^{a}\pm0.17$
P1	$0.33^{a}\pm0.07$	$1.26^{a}\pm0.15$	$0.52^{a}\pm0.04$	$3.79^{a}\pm0.19$
P2	$0.31^{a}\pm0.04$	$1.20^{a}\pm0.15$	$0.50^{a}\pm0.05$	$3.78^{a}\pm0.25$
P3	$0.31^{a}\pm0.02$	$1.18^{a}\pm0.14$	$0.48^{a}\pm0.05$	$3.73^{a}\pm0.25$
P4	$0.29^{a}\pm0.04$	$1.16^{a}\pm0.14$	$0.47^{a}\pm0.02$	$3.60^{a}\pm0.30$

Information: P0: 0 mg/100ml, P1: 0.1 mg/100ml, P2: 0.2 mg/100ml, P3: 0.3 mg/100ml, P4: 0.4 mg/100ml. The same notation in the same column shows no real difference ($p>0.05$)

The same is seen in Table 3. morphometry of the body of the larva instar V head diameter, head length, body length and body diameter between control and treatment (P1,P2,P3,P4) decreased. After statistical tests of head diameter, head length, body length and body diameter showed no noticeable difference ($p>0.05$). So it can be said that the administration of vitamin B1 decreases the morphometry of larvae instar III, IV and V in the form of head length, head diameter, body length and body diameter.

According to [4], in insects vitamin B1 acts as a coenzyme that will help the body function. But in this case the role of cellular metabolism to produce glucose energy is too

excessive so that it experiences a state of growth delay, where the growth is delayed including a relatively equal number of cells or an enlarged size in fat tissue or skin. Vitamin B1 in doses that are too high can cause metabolic disorders of the body [2]. It can be said that vitamin B1 in mulberry leaves is sufficient for the growth of silkworms, so there is no need for addition from the outside.

Table 4. Average Weight Gain of Silk Worms Instar III, IV, V and Pupa Weights with different concentrations.

Treatment	Weight Gain (g)			Pupa Weight (g)
	III	IV	V	
P0	2.39^{a}±0.56	0.53^{a}±0.18	0.45^{a}±0.23	0.22^{a}±0.09
P1	1.71^{b}±0.35	0.49^{a}±0.22	0.31^{b}±0.16	0.20^{a}±0.03
P2	1.48^{b}±0.50	0.43^{a}±0.18	0.30^{b}±0.13	0.15^{a}±0.02
P3	1.35^{b}±0.41	0.31^{a}±0.22	0.27^{b}±0.12	0.14^{a}±0.02
P4	1.21^{b}±0.37	0.23^{a}±0.16	0.27^{b}±0.10	0.13^{a}±0.02

Information: P0: 0 mg/100ml, P1: 0.1 mg/100ml, P2: 0.2 mg/100ml, P3: 0.3 mg/100ml, P4: 0.4 mg/100ml. The same notation in the same column shows no real difference ($p>0.05$)

Table 4. It can be seen that the increase in the weight of larvae instar III, IV, V and pupaweight between control and treatment (P1, P2, P3, P4) decreased in weight, where from the results of statistical tests on the weight of larvae instar III and V between the control and treatment of vitamin B1 showed a real difference ($p<0.05$). The weight of the iv instar larva and the weight of the pupa based on the results of statistical tests showed that the inter-control and treatment did not differ markedly ($p>0.05$). This proves that by giving vitamin B1 can reduce the weight gain of larvae instar III, IV, V and pupae weight. This decrease is due to the provision of excess vitamins to silkworms that cause hyper vitamins, where in the growth of caterpillars are in dire need of nutrients (vitamins) in optimal amounts, when excess greatly affects the growth of silkworms [3].

The provision of vitamin B1 in silkworm feed decreases the growth of silkworms, so there is no need to add vitamin B1 from beyond the possibility of vitamin B1 contained in mulberry leaves is enough for the growth of silkworms.

b. Weight of Silk Glands

Observations of the weight of bombyx mori silk glands given vitamin B1 covering the front, middle and back glands can be seen in Table 1

Table 1. Average Weight of Silk Glands of Silk Worms with different Concentrations.

Treatment	Weight of Slik Glands (g)		
	Front	Middle	Back
P0	0.041^{a}±0.24	0.127^{a}±0.026	0.141^{a}±0.020
P1	0.041^{a}±0.14	0.126^{a}±0.029	0.126^{a}±0.024
P2	0.038^{a}±0.20	0.125^{a}±0.032	0.124^{a}±0.030
P3	0.034^{a}±0.18	0.122^{a}±0.048	0.122^{a}±0.026
P4	0.016^{b}±0.06	0.121^{a}±0.021	0.115^{b}±0.023

Information: P0: 0 mg/100ml, P1: 0.1 mg/100ml, P2: 0.2 mg/100ml, P3: 0.3 mg/100ml, P4: 0.4 mg/100ml. The same notation in the same column shows no real difference ($p>0.05$)

Table 1. Administration of vitamin B1 at doses of 0,1;0,2;0,3;0.4 mg/100ml in feed decreased compared to controls. However, after statistical tests on the weight of the front and back silk glands between the control and treatment groups (P1,P2,P3) showed no real difference, while in P4 based on the results of statistical tests showed a real difference ($p<0.05$).

It is suspected that the administration of vitamin B1 can reduce the weight of silk glands so that it decreases because it provides cytotoxic effects in the body of caterpillars. According to [5], that the greater the provision of vitamin B1 contained in the feed consumed will cause high levels of toxic existing. The addition of vitamin B1 will affect the hormonal system of silkworms so that the production of the hormone ectison will inhibit growth. The hormone ectison has an important role in regulating the synthesis of fibrion and serisin, which will stimulate the release of the hormone ectone from the prothorasic gland. It is this ectison that causes the synthesis process of fibrion and serisin which are the main raw materials of the silk glands.

According to [6)] silkworms have a pair of silk glands in the shape of circles in the body, the back gland produces a protein called fibrion, while the middle produces a paste-like protein called serisin.

c. SilkWorm Productivity

Observation of vitamin B1 administration of silkualate productivity consuming mulberry leaves given vitamin B1 can be seen in Table 1

Table 1. Average Percentage of Kokon Skin, Fiber Length, Fiber Percentage, Kokon Weight and SilkWorm Kokon Skin Weight with different Concentrations.

Treatment	Kokon Skin Percentage (%)	Fiber Length (m)	Fiber Percentage (%)	Kokon Weight (g)	Kokon Skin Weight (g)
P0	54.3^{a}±16.2	679.4^{a}±228.1	22.8^{a}±6.7	0.64^{a}±0.11	0.28^{a}±0.06
P1	29.3^{b}±13.6	635.6^{a}±401.7	19.4^{a}±10.4	0.63^{a}±0.21	0.18^{a}±0.04
P2	27.7^{b}±12.2	603.7^{a}±305.5	19.3^{a}±6.7	0.61^{a}±0.16	0.14^{a}±0.02
P3	25.0^{b}±8.35	557.8^{a}±481.2	16.1^{a}±2.6	0.58^{a}±0.13	0.14^{a}±0.03
P4	22.0^{b}±6.83	340.9^{a}±127.7	15.4^{a}±2.5	0.55^{a}±0.12	0.13^{a}±0.02

Information : P0: 0 mg/100ml, P1: 0.1 mg/100ml, P2: 0.2 mg/100ml, P3: 0.3 mg/100ml, P4: 0.4 mg/100ml. The same notation in the same column shows no real difference (p>0.05)

Table 1. It can be seen that the percentage of cocon skin between control and treatment is different, which is indicated in the control of 54.34% which is low at a dose of 0.4 which is 22.04%. This proves that the administration of vitamin B1 can not increase the percentage of skin kokon because the intake of vitamin B1 has been fulfilled from the feed consumed by the silkworm so that no more intake of vitamin B1 from the outside. According to [6], the content of mulberry leaves itself has 8 types of B vitamins. In Table 1. It can also be seen the length of fiber, fiber percentage, cocon weight and cocon skin weight from the results of statistical tests showed no real difference, where on the control of fiber length 679.4 m, fiber percentage 22.82%, cocon weight 0.64 g and cocon skin weight 0.28 g, while the lowest in vitamin B1 administration at dose 0.4 mg / 100ml. It can be said that the administration of vitamin B1 decreases the percentage of fiber, fiber length, cocon weight and skin weight of cocon because vitamin B1 with a high dose will decrease the quality of silkworm productivity. According to [2], that the decrease is due to the hyper-vitamin concentration in silkworms so that under certain circumstances feed ingredients can contain a substance that can block the activity of a vitamin and even damage it. Evidenced also by [9] the administration of vitamin B1 will affect the instability of the system because vitamin B1 is supposed to be complex in the body.

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