A mixture of red kidney beans (*Phaseolus vulgaris* L.) and bee bread of honey bees (*Wallace trigona incise*) as artificial feed for silkworm (*Bombyx mori* L.)

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Abstract. The supply of silk thread in Indonesia is only able to meet 5% of the national demand, and 95% must import it. Success in silk thread production comes from natural silk cultivation activities, namely mulberry cultivation. Meanwhile, the productivity of mulberry leaves in Indonesia is very low. This study aims to determine the feeding ability, growth of silkworm resistance, the effect of cocoon productivity produced by silkworms when fed artificial feed. This research was conducted at the Forest Protection and Entomology Laboratory, Hasanuddin University. Artificial feed formulation in the form of a mixture of red kidney beans and bee bread with the comparison of mulberry leaves, red kidney beans, and bee bread were P1 (33:24:25), P2 (45:24:15); P3 (mulberry leaves and red kidney beans 40:44), P4 (mulberry leaves and bee bread 40:44), and P5 (natural feed of fresh mulberry leaves as control). Treatments P1, P2, P3, and P4 were added agar, vitamin C, sugar, and 100 ml of distilled water. The results of this study indicate that the percentage of artificial feed can be consumed 3 g/larva/day. Parameters of 5th instar larval survival, growth index, and cocoon quality in all feed compositions showed no significant differences.

1. Introduction

Indonesia has many superior commodities, one of which is natural silk activities. Natural silk activities as one of the agro-industry activities in the forestry sub-sector with various series of businesses that are quite long, so that they have a very strategic role because they can open up new jobs and absorb a lot of workers, including village farmers. In addition, natural silk activities can also increase the country's foreign exchange and develop the community's economy [1]. Silk thread has a very high selling value and has a large market potential [2]. However, the supply of silk thread in Indonesia is only able to meet the needs of 5% of the national demand, which is about 30 tons per year which should be 900 tons per year. So that to meet domestic needs, the Indonesian government still has to import 95% from China [3].

Success in silk thread production comes from natural silk cultivation activities, which are largely determined by mulberry cultivation activities. This happens because so far, the main food for silkworms (*Bombyx mori* L.) is only mulberry leaves. However, generally, the productivity of mulberry leaves in Indonesia is very low. Mulberry plants that grow in Indonesia do not experience a period of rest, and leaf harvesting is carried out continuously. Plus, mulberry leaves are less able to survive in the dry
season, so that the leaves produced decrease. In addition, the area of mulberry leaf gardens is decreasing, also becoming an obstacle in the field of natural silk [4].

The above problems have resulted in erratic results in cocoon production in several centers of silk production in Indonesia. So that many silk farmers leave the silk cultivation business and switch to other commodities that are considered more profitable [5]. In the process of maintaining silkworms, if you only rely on natural food in the form of mulberry leaves, it will require a very large area. Artificial feed will greatly help farmers with additional quality feed so that it can help overcome the shortage of natural feed in the form of mulberry leaves as an alternative feed. Artificial feeding will affect the way of life of the larvae, the weight of the larvae, the weight of the cocoons [6].

Artificial feeding in silkworm cultivation is expected to be an effective solution in silkworm cultivation. With the artificial feed, it is hoped that the maintenance of silkworms can be carried out at any time without being limited by the number of mulberry leaves so that maintenance can be carried out and can increase farmers’ income.

2. Methods
This research was conducted in May 2021 at the Forest Protection and Entomology Laboratory, Hasanuddin University, and measurements of cocoon fiber were carried out at the Social Forestry and Environmental Partnership Center of Gowa Regency, South Sulawesi.

2.1. Tools and materials
The material used in this study was 50 silkworms (Bombyx mori L.) which had entered the V instar phase. The silkworm seeds came from the Center for Social Forestry and Environmental Partnerships, Gowa Regency, South Sulawesi. Chlorine, lime, alcohol, mulberry leaves, red beans, bee bread, gelatin, vitamin C, sugar, and water.

2.2. Formulation artificial feed
The formulation in making artificial feed: components in making artificial feed according to the treatment, namely P1 (a mixture of 35% mulberry leaves, 24% red beans, 25% bee bread), P2 (45% mulberry leaves, 24% red beans, 15% bee bread), P3 (mixture of 40% mulberry leaves, 44% peanuts), P4 (mixture of 40% mulberry leaves, 44% bee bread), P5 (natural feed of fresh mulberry leaves as control). Treatments P1, P2, P3, and P4 were added 10% agar, 4% vitamin C, 2% sugar, and 100 ml of water, respectively.

2.3. Data analysis
This study used 4 treatments plus a control. Each treatment consisted of 10 replications. Parameters observed were larval productivity (larval weight and length, growth index) and cocoon productivity (cocoon weight, cocoon shell weight, percentage of cocoon shell, fiber length, and fiber weight). Data were analyzed using analysis of variance (ANOVA, Analysis of Variance).

a. Growth Index (%)

\[
\text{Growth index} \% = \left( \frac{\text{Final weight of larvae (gr)} - \text{Initial weight of larvae (gr)}}{\text{Final weight of larvae (gr)}} \right) \times 100
\]  

b. Rasio shell (%)

\[
\text{Rasio shell} \% = \left( \frac{\text{Weight of cocoon shell (gr)}}{\text{Weight of cocoon (gr)}} \right) \times 100\%
\]
3. Result
So far, mulberry leaves are the only food for silkworms. In mulberry leaves, there are stimulants for silkworms, namely glucosides which cause silkworms to refuse to eat leaves of other plants because of the presence of these stimulants [4,6]. In connection with this, the manufacture of artificial feed made from red bean (*Phaseolus vulgaris* L.) and bee bread (*Wallacetrigona incise*) which is given mulberry flour in order to attract the smell of silkworms.

3.1. Amount of artificial feed consumed by instar V larvae
Artificial feed formulation in the form of a mixture of red kidney beans and bee bread with the comparison of mulberry leaves, red kidney beans, and bee bread were P1 (33:24:25), P2 (45:24:15); P3 (mulberry leaves and red kidney beans 40:44), P4 (mulberry leaves and bee bread 40:44), and P5 (natural feed of fresh mulberry leaves as control). From the composition of the artificial feed, there were differences in the amount of feed consumed by the V instar larvae. These differences can be seen as follows:
Feed consumption can be calculated after the amount of remaining feed from the amount of feed given. Feed consumption of larvae in instar V can be seen in Figure 1. Figure 1 shows the amount of artificial feed consumed by silkworms for 5-7 days in each treatment. Artificial feed consumed by V instar larvae was found in P2 (mulberry leaves, red kidney beans, and bee bread were 45:24:15) and P3 (mulberry leaves and red kidney beans 40:44) with the weight of the feed consumed reaching 4 grams/larva in a day.

In each treatment, it was shown that the artificial feed consumed by the V instar larvae would increase from the first day to the 3rd day and will experience a decrease in the amount of feed consumed on the 5th to the 7th day. The time difference in cooing can be caused by differences in the hatching time of the eggs. Thus, the higher the instar stage of the larvae, the more feed the larvae consumed. The feeding time of the larvae is getting longer with increasing instar stages so that the amount of feed consumed by the larvae gradually increases according to the development of larval life. And will multiply the decrease in the amount of feed that will be consumed when the larvae will cocoon [7].

3.2. **Effect on larvae length**

| Treatment | Before artificial feeding | After artificial feeding |
|-----------|--------------------------|-------------------------|
| P1        | 5                        | 5.82                    |
| P2        | 5.24                     | 5.88                    |
| P3        | 5.04                     | 5.68                    |
| P4        | 5.04                     | 5.62                    |
| P5 (control) | 4.84                  | 5.38                    |

Larval length can be influenced by artificial plant feed given [7]. Data collection on larval length was taken at the beginning of the fifth instar and on the fourth day of artificial feeding. In each replication, the average length of the larvae increased as shown in Table 1. The length of each larva will increase after being given artificial feed. The longest larval length growth was larvae treated with P1, which increased in length by 0.82 cm, and the shortest larval length growth was larvae in P5 (control) treatment, whose length increased by 0.54.
Figure 2. (a) Larvae growth index, (b) Larvae weight gain

In Figure 2 (a), the results show that the highest larval growth index is at P5, which is 24.95. While the lowest is P4. For P1, P2, and P3 the larval growth index was 21.79, 16.28, and 20.18, respectively. This indicates that in the control treatment, the larval growth index was much higher than the artificial feed. The weight gain of the larvae can be seen in Figure 2 (b), the highest is in P5 where the larvae weight is 0.68, and the lowest is P4, with a weight of 0.4. Meanwhile, P1 and P2 had the same larval weight gain of 0.52. Furthermore, at P3 the weight of the larvae reached 0.56. This indicates that the weight gain of larvae at the time of control was better than the artificial feed.

3.3. Effect of artificial supplementary feeding on cocoon production

Use of artificial feed can facilitate the process of improving cocoon quality because it is easier to regulate the content of nutrients as needed by larvae and will be easier to mix with several substances that can stimulate larval growth [4]. Silkworms (Bombyx mori L.) will naturally eat mulberry leaves and silkworms can also grow and develop well when eating artificial feed as long as mulberry flour is added to the artificial feed so that it will attract the silkworm's smell [4,8]. This is in line with the results of research, which states that artificial feeding will affect the percentage of cocoon weight, fiber length, and fiber weight, which can be seen as follows.

3.3.1 Effect of artificial supplementary feeding on cocoon production

Figure 3 shows the heaviest cocoon weight presentation, namely P4, with a cocoon weight percentage of 20.94%. The lowest percentage of cocoon weight was found in P5 with a percentage of cocoon weight
of 15.27%. While for P1, P2 and P3, respectively, the percentage of cocoon weight was 20.33%, 16.80%, and 17.02%. This indicates that artificial feed has a higher percentage than control feed.

3.3.2. Fiber length and weight

The effect of artificial feed can cause differences in cocoon weight, for example, fresh cocoon weight, weight/thickness and thinness of cocoon skin, and pupa weight [4]. Figure 4 (a) above shows that the heaviest percentage of cocoon weight is P4 with a weight percentage of 20.33% of cocoons. The lowest percentage of cocoon weight is P5. While for P1, P2, and P3 respectively 20.33%, 16.80%, and 17.02%. The results of the study for the percentage of cocoon weight showed that the artificial feed had a higher percentage than the control feed using mulberry leaves.

Figure 4 (b) above shows that the largest cocoon fiber weight is in P1 with a weight of 1.021 grams of cocoon fiber, and the smallest cocoon weight is in P2 with a cocoon weight of 0.872 grams then the weight of cocoon fibers P3, P4 and P5 respectively. - 0.886 grams, 0.988 grams and 0.981 grams, respectively. This shows that the fiber weight of artificial feed cocoons and control cocoons still shows an average that is relatively the same, but among the 5 artificial feed treatments, the closest to the control is P5. Based on statistical tests, the survival parameters of the fifth instar larvae, namely the growth index and cocoon quality in all feed compositions, did not show significant differences.

4. Conclusion

Artificial feed made from a mixture of red beans (Phaseolus vulgaris L.) and bee bread (Wallacetrigona incise) can be consumed by silkworms (Bombyx mori L.) with the highest feeding ability found in P2 treatment (mulberry leaves, red kidney beans and bee bread were 45:24:15) and P3 (mulberry leaves and red kidney beans 40:44) with the weight of feed consumed can reach 4 g/larva in a day. In addition, artificial feeding affects the growth index of caterpillars, larval length, cocoon quality, and also the resulting fiber. Based on the parameters of 5th instar larval survival, growth index, and cocoon quality in all feed processes showed no significant differences.

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