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# Utilization of Blood Meal as a Source of Dietary Protein

## 1. Blood meal used as dietary protein for the silkworm, *Bombyx mori* L.

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**Abstract**
The recycling of blood from slaughterhouses is an important issue in animal industry and investigations on this subject are being promoted. In the present study, the blood meal extracted from blood from slaughterhouses was examined for possible use as a protein source in the artificial diet for silkworms. Blood meal as a source of protein in comparison with soybean protein meal used presently in the artificial diet for the silk worms was found to be less suitable in terms of palatability and digestibility. However, the weight of the cocoon shell was larger and there was no excess corpulence of pupa. It is thus considered that blood meal is a superior source of protein, which effectively increases the quantity of cocoon shells, and it was confirmed that the use of blood meal in comparison with current protein sources and even in terms of cost per unit weight could be very economical.

**Discipline:** Sericulture
**Additional key words:** corpulence of pupa, soybean protein

## Introduction

In the sericulture industry, the improvement of the cocoon quality as well as production which is affected by silkworm feed is very important.

The production of mulberry leaf which is an excellent food for silkworms is limited by seasons, varieties, management, etc. Any substitute for mulberry introduced in the artificial diet should be similar to mulberry or display a high nutritious value at low cost and be easily available. Although artificial diet for the rearing of young silkworms has been disseminated or popularized, for the rearing of grown silkworms it has not yet been developed.

Blood is one of the main by-products from slaughterhouses. If it is left unused, it becomes a problem in terms of environmental pollution. These by-products of livestock appear to be unused resources. Hence, the recycling of such resources is being investigated or examined in animal industry as a priority. Presently, slaughterhouse blood is being recycled for use as blood meal, fertilizer, feed for domestic animals, etc.

Even for the artificial diet for silkworms, protein sources are being investigated and blood meal could become a new diet source, at a low cost. Accordingly, in this study, investigations were carried out on the commercial use of

blood meal, as a protein source for artificial diet.

## Materials and methods

The composition of the artificial diet used in this experiment is shown in Table 1. Part of the composition of the conventional diet was changed for use in the test. The most conventional protein source of artificial diets is defatted soybean which contains 42% of crude protein. However the percentage of protein of the blood powder used in this investigation may have been too high, 85%. Therefore the author reduced the content of protein of the tested material and cellulose powder was added.

To adjust the percentage of the soybean protein content to that of the blood powder, separated soybean protein (cp 89.3%) and soybean powder with high protein (cp 68.3%) were mixed. Thus the protein content of the soybean powder was adjusted to 85% for use in the experiment.

The blood meal powder used as experimental material was extracted from blood from cows and pigs in slaughterhouses. The extract which shows a black granular appearance and is marketed as compost, was crushed (80 mesh sieve) and used. The crude protein contents were determined by the Kjeldahl method. On the other hand, the fat substances were extracted with chloroform methanol (2:1, V/V), and the crude fat substances were refined by gel filtration. Then the extract was weighed as total fat substances and made to a fixed quantity[3].

For the preparation of the feed, after mixing the substances shown in Table 1, water was added and stirred. After steaming at 100°C for 40 min., and mixing once again, the preparation was hardened by heat radiation.

The race used for experiment was Kinshu × Showa. One group consisted of 20 larvae and 2 groups from both females and males were used separately for the feed experiment. They were reared from the 5th instar larval stage until cocooning.

Percentage of approximate digestibility was measured using the magnetite sand method which was developed by the author[4]. The evaluation of the experimental feed was based on the whole cocoon weight, cocoon shell

**Table 1. Composition of artificial diet**

| Substances | Soybean protein diet | Blood meal diet |
|---|---|---|
| Mulberry leaf powder | 30.0 g | 30.0 g |
| Agar powder | 5.0 | 5.0 |
| Potato starch | 7.0 | 7.0 |
| Sugar | 7.0 | 7.0 |
| ß-Sitosterol | 0.3 | 0.3 |
| Ascorbic acid | 2.0 | 2.0 |
| Salt mixture | 3.0 | 3.0 |
| Citric acid | 4.0 | 4.0 |
| Vitamin mixture | 0.5 | 0.5 |
| Safflower oil | 1.0 | 1.0 |
| Cellulose powder | 15.0 | 15.0 |
| Blood powder (cp 85%) | - | 25.0 |
| Soybean protein (cp 85%) | 25.0 | - |
| Sorbic acid, Antiseptics | 0.2 | 0.2 |
| Water | 250.0 ml | 250.0 ml |

weight and the cocoon shell ratio was adopted as an index.

## Results

The crude protein content of the blood meal used in this experiment was 85% and total fat content 0.06%. Comparative results for approximate digestibility, amount of digested dry substances and amount of ingested dry substances in both feeds are indicated in Table 2.

In both feed groups, the amount of ingested feed and amount of digested feed were different between the female and the male, in particular in the female. The amount of ingested feed by both females and males was less in the blood meal group than the soybean meal group. The feed intake showed the same tendency. The approximate digestibility in the females in the blood meal feed group was slightly lower than that in the soybean protein feed group.

In Table 3, the cocoon weight, cocoon shell weight and cocoon shell ratio in every group were investigated and the results of cocoon tests are listed.

In the soybean meal group the cocoons were heavier than in the blood meal group. On the

**Table 2. Digestibility of blood meal diet and soybean protein diet**

| Amount of food (Dry matter weight) | Number of larvae | | | Diet[a)] | |
|---|---|---|---|---|---|
| | Sex | Number | Groups | Soybean protein | Blood meal |
| Ingested (g) | ♀ | 20 | 2 | 5.21±0.01 | 5.06±0.06 |
| | ♂ | 20 | 2 | 4.08±0.07 | 3.61±0.09 |
| Feces (g) | ♀ | 20 | 2 | 3.09±0.01 | 3.16±0.03 |
| | ♂ | 20 | 2 | 2.45±0.04 | 2.19±0.04 |
| Digested (g) | ♀ | 20 | 2 | 2.09±0.02 | 1.90±0.03 |
| | ♂ | 20 | 2 | 1.64±0.04 | 1.42±0.04 |
| Approximate digestibility (%) | ♀ | 20 | 2 | 40.1±0.5 | 37.6±0.1 |
| | ♂ | 20 | 2 | 40.1±0.1 | 39.4±0.2 |

a): Values are mean ± S.D.

**Table 3. Comparison of cocoon characteristics between blood meal diet and soybean protein diet**

| | Number of larvae | | | Diet[a)] | |
|---|---|---|---|---|---|
| | Sex | Number | Groups | Soybean protein | Blood meal |
| Whole cocoon weight (g) | ♀ | 20 | 2 | 3.13±0.06 | 2.87±0.16 |
| | ♂ | 20 | 2 | 2.25±0.04 | 2.20±0.14 |
| Cocoon shell weight (mg) | ♀ | 20 | 2 | 570±13 | 619±55 |
| | ♂ | 20 | 2 | 470±8 | 535±9 |
| Percentage of cocoon shell weight (%) | ♀ | 20 | 2 | 18.3±0.1 | 21.1±0.1** |
| | ♂ | 20 | 2 | 20.9±0.0 | 25.1±1.1** |

a): Values are mean ± S.D. ** Significant at 1% level.

other hand, in the blood meal group, the cocoon shell weight of the females and males was 619 and 535 mg, respectively, whereas in the soybean meal group, the cocoon shell weight of the females and males was 570 and 470 mg, respectively.

It thus appears that the cocoon shell ratio in the blood meal group became higher than that in the soybean meal group, suggesting that blood meal enables to improve the cocoon quality and production. On the other hand, the cocoon weight in the soybean meal group was larger, whereas the cocoon shell weight was lower and the cocoon shell ratio was low, indicating that the soybean meal improved the nutrition of the pupa, but did not improve the cocoon quality.

Therefore, it is obvious that the silkworms reared on blood meal can produce cocoons with a high cocoon shell ratio and cocoon shell weight, though the cocoon weight was lower. As a result, it was found that blood meal as a protein source in the silkworm artificial diet is more effective than the soybean protein source in improving the cocoon quality and production.

## Discussion

In this investigation, attempts were made to determine whether slaughterhouse blood could be used as a protein source in the artificial diet of the silkworms.

Since silkworm rearing on artificial diet was initiated in 1960, it accounts for more than 30% of the total brushing quantity in the country and many research reports and general reviews have been published[1,2]. However the use of artificial diet for grown silkworms for which feed consumption is the highest has not been achieved practically yet, mainly due to the high cost of artificial diet. Hence, the availability of low cost artificial diet is becoming important.

On the other hand, since sericulture based on mulberry leaves is constrained by the seasons, it is difficult to rear silkworms throughout the year, and only the use of artificial diets enables the production of cocoons throughout the year.

A large part of the components of the cocoon consists of protein. As the silkworm can not digest a large amount of starch and cellulose, protein in the meal plays a major role. Although many types of protein sources have been evaluated as ingredients for the artificial diet, there are no reports on the use of blood meal.

The results of the current experiment showed that blood meal palatability and digestibility were comparatively lower than those of soybean meal, but that the cocoon shell was heavy and the corpulence of pupa was not excessive. In other words, it was demonstrated that blood meal is an excellent component as a protein source, due to its efficiency in increasing the amount of cocoon.

Furthermore, compared with the protein sources currently used, the unit weight cost of blood meal is lower. Crude protein content ratio is also higher than that of any other low-cost meal substances even when the protein quantity per unit price is higher.

However, since the crude protein content ratio of blood meal amounts to 85%, if the amount of blood meal is raised, the protein content ratio in the diet may become excessive and it may be necessary to add cellulose powder as shown in Table 1. As components such as cellulose or starch are costly, it is necessary to identify new low cost components as substitutes as well as to improve the blood meal for practical use.

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