Mealworm as an alternative protein source: potential for the processing of fish meal and soybean meal replacement feed on broiler performance

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Abstract. The availability of feed is the main requirement in supporting the success of livestock development. One of the feed alternatives that is being discussed worldwide is insects because they have a high protein source. Insects are currently being discussed in the animal husbandry sector because insects include an alternative source of animal protein with high nutritional quality, efficiency and can be provided continuously and have nearly the same nutritional content as fish meal and soybean meal. Problems globally, the search for alternative protein sources to substitute a fish meal and soybean meal has become a major topic in research in the field of animal feed and nutrition. The fluctuating price of feed will affect business in the field of animal husbandry, where we know that the cost of feed contributes nearly 60-70% of the total business operating costs. Based on literature studies show that insects can replace fish meal and soybean meal 25-100%, one type of insect that has the potential as a feed ingredient is a mealworm which contains 32-52% crude protein and low crude fat 7%. Reported that the use of mealworms in the broiler feed to give effect to the performance of broilers from feed intake, feed conversion ratio (FCR), and final weight. It was concluded that mealworms were an alternative source of high protein and fat.

1. Introduction

The availability of feed is the main requirement in supporting the success of livestock development. The development of animal husbandry in Indonesia as an effort to fulfill the need for animal protein continues to increase along with the increasing population. The supply of feed has problems due to its fluctuating availability depending on weather factors and the production capacity of farmers. The Chair of the Aquaculture Division of the Indonesian Feed Producers Association revealed that the production capacity of fish meal in Indonesia is only around 45,000 tons or 30% of the total needs every year [1]. To meet the needs, feed ingredients must be imported from outside the region or abroad at a higher price, thereby increasing production costs. The fluctuating price of feed will affect business in the field of animal husbandry, where we know that the cost of feed contributes nearly 60-70% of the total operational cost [2].

Feed problems that are very crucial need to be considered for the sustainability of the livestock business, especially the problem of feed that is sourced from protein, one of which is fish meal and soybean meal. Fish meal and soybean meal are high protein feed sources, namely 45-65%, and 42-46%, and have the potential to meet the nutritional needs of livestock, however, the price of fish meal and

soybean meal is currently too expensive and raw materials are still imported. These obstacles, make breeders pressured to run the business.

One of the efforts to overcome this problem is by finding alternative protein solutions that are of almost the same quality as fish meals and soy meals. Several protein-based feed ingredients have not been used in the poultry diet. Animal source feed ingredients, one of which is potential as a substitute for fish meal and soybean meal, is insects. Insects include alternative sources of animal protein with high quality and quantity, namely 42-63% crude protein, 5-7% crude fiber, 8-36% crude fat, and 3-20% ash [3]. and can be provided sustainably with nearly the same nutritional content as fish meal and soybean meal with nutrient content of 42-65% crude protein, 1-7% crude fiber, 2-12% crude fat, and 6-30% ash.

One type of insect that has potential as an alternative protein feed is the *mealworms*. Several research results showed that 10% dry mealworm based on dry matter in the starter phase broiler feed used did not cause negative effects on feed consumption, body weight gain, and feed efficiency. Several research results indicate that the level of palatability of the mealworm is very good as well as a substitute for basal feed, especially fish meal and soybean meal. The use of dried mealworm produced an egg ratio of 2.4% which was higher than other basal feeds [3].

2. Alternative raw feed materials for protein sources

The mealworm, or yellow mealworm, is the larva of a parent insect named *Tenebrio molitor*. The mealworms have the same life phase as other types of caterpillars, namely starting from eggs, then hatching into larvae (called the mealworms), after reaching their maximum size, the larvae will turn into pupa or cocoon, and the last phase into insects [4].

The mealworm has great potential to be used as a protein source for broilers (up to 10% inclusion in feed) and production costs at the industrial level will be significantly lower than conventional protein sources. Schiavone et al. [5] stated that substitution of basal feed with 25% of mealworms was found to be very good on broiler performance. The protein quality of the mealworm was similar to soybean meal, but the methionine content still did not meet the requirements of poultry [6]. Also, content Ca and the ratio of Ca:P is not adequate for the production of poultry (in particular, for the hen), but such problems can be overcome by feeding mealworm with feed for 1 or 2 days [3].

Insects are reported to be rich in nutrients, both macronutrients (protein and energy) and micronutrients (vitamins and minerals) [7]. Biasato et al. [21] reported that the nutrient content contained in insects is highly dependent on the nutrient content of the substrate or growth media used in cultivating these insects, *species*, cultivation management, and life cycle phases [9]. Insects in their life cycle undergo metamorphosis (change in shape). The nutritional content of mealworms has differences in nutritional content between mealworm meals and fish meals. The nutritional content can be presented in table 1.

Table 1. The difference in nutritional content between fish meal and mealworm meal.

Nutrition (Dry material)	Mealworm meal [3]	Fish Meal [10]
Crude protein (%)	52.8	55.87
Crude fat (%)	21.57	10.52
Crude fiber (%)	7.20	2.66
Dry matter	93.90	95.02
Calcium (%)	0.27	4.34
Phosphorus (%)	0.78	2.79

Table 1 showed that there are differences in the nutritional content of mealworms. The nutritional content of mealworm meals is not much different from the nutritional content of the fish meal, especially its crude protein content. This shows that the mealworm meal has the potential to replace a fish meal as a feed ingredient for rations, where the nutritional content of the mealworm is almost the same as fish meal.

Mealworms are generally used as supplement feed or main feed for livestock because they contain high nutritional content, especially protein. The mealworm is a favorite feed because it has good nutritional content for livestock and high palatability. The nutritional content includes 48% crude protein, 40% crude fat, 3% ash content, 57% water content, and 8% non-nitrogen extract content [11].

The content in the larvae of the mealworm includes 37.80% crude protein, 28.63% crude fat, 13.36% ash content, 7.28% crude fiber, and 84.31% dry matter [21]. Listiani [13] further stated that the mealworm contains 48% crude protein, 40% crude fat, 3% ash content, 8% BETN, and 57% water content and contains chitin. The high nutritional content of larvae is referred to as a premium feed and has the potential to be extracted as a protein source [9].

3. Application of the mealworms meal to poultry

3.1. Broilers

Several research results indicate that the addition of mealworm meal to poultry feed, especially broilers, affect broiler performance. One of them is feed consumption, feed conversion ratio (FCR), live weight gain, and average body weight gain per day. The effect of adding mealworms meal to feed can be seen in the research of [15], for the final weight (g/head), respectively 44.17 (control), 68.53 (0.4% dry mealworm meal), 74,98 (0,4% super mealworms meal) were obtained, while FCR was obtained 0.85 (control), 0.29 (0.4% dry mealworm meal), 0.23 (0.4% mealworm).

Other research has shown that the use of mealworm at different levels shows an effect on live weight, daily feed consumption, and feed conversion. According to Katayane et al. [2], the effect of giving mealworm has a significant effect on the live weight of broilers where it is seen that the provision of 0.5%, 0.10%, and 0.15% at 12 consecutive days of live weight of broilers is 308 g, 350 g, and 358 g, 25 days old 1,129 g, 1,272 g, and 1,253, while those aged 53 days 3,641 g, 3,463 g and 3,373 g and likewise with daily feed consumption, it was seen that it had a significant effect on broiler consumption but had no significant effect on feed consumption. According to [17,7] stated that the replacement of soybean meal with 29.6% mealworms meal had a significant effect on the performance of broiler chickens and had an effect on the growth performance of broiler chickens.

Mealworm did not harm native chickens and did not affect health in chickens [18] and was strengthened by research by [7,19] stated that the provision of mealworm in feed did not harm the growth of broilers and weaned pigs on the feed supplements given. This showed that the decrease in the FCR value of broilers from 2.1 to 1.9 which were fed with mealworm from 0% to 10% of the inclusion in the feed [20]. Feeding on the period of the age of 30-62 days did not show a difference between the groups, suggesting that the mealworms have dry palatability of good, as well as the provision of 30%, shows a good performance for broilers. Previous studies did not show a negative effect because the texture or palatability of the mealworm meal in broiler feed had a positive effect on body weight growth [6].

The addition of mealworms up to 10% (based on the dry matter) in sorghum and soy-based broiler starter feeds can be used without negative effects on feed consumption, weight gain, and feed efficiency. The addition of mealworms can increase the level of feed palatability because of the good texture of the mealworms [6]. In another study, the addition of 25% mealworm as a substitute for basal feed was found to be very good on broiler performance [5].

3.2. Japanese quails (Coturnix japonica)

Feeding mealworms of 22.5 and 30 g/kg of basal feed had better FCR values while feeding of 30 g/kg of quail basal feed showed good performance, especially BW, FCR, carcass yield, meat quality, and jejunal histology [19]. Laponte et al. [21] reported that adding 250 to 500 g of mealworms feed/kg of feed-in partridge improved growth performance.

3.3. Mealworm antimicrobial activity

The performance of broiler chickens fed by mealworms has a significant effect because the content of the mealworm contains chitin. Chickens that consume chitin from insects cannot be degraded or absorbed by the small intestine which can then be fermented by microbes into probiotics. Brownawell et al [22], that the use of chitin can balance microbial colonies, improve the performance of the large intestine or colon even when high fat is in the ration. According to Sizmaz and Sacakli [24], chitin obtained from insects can be used as a material for making chitosan. Chitosan can be used as a *feed additive* in broiler ration which functions as a natural antimicrobial.

Chicken has the chitinase enzyme in the digestive tract so that it can degrade chitin, but this enzyme is still limited. On this basis, it is necessary to separate chitin from insects before it is applied to livestock. According to Hidayat [23], chitin separation can be done physically, by drying in the sun or by extraction using lye or using the chitinase enzyme.

Based on the study, it was found that mealworms can be used as feed additives and can replace antibiotics (AGP). Islam and Yang [15] reported that supplementation of mealworms and super mealworms (*Zophobas morio*) as an alternative to antibiotics in chicken feed supplemented with *Salmonella* and *Escherichia coli* could not affect organ weight in an insignificant manner the relative exchange that was reduced by dietary supplementation. Likewise, Biasato et al. [16] reported that the proportion of liver and gizzard was not seen in broiler chickens that were fed with different TM levels. In fact, with the results obtained in this trial, [20] reported that TM supplementation for the diet of broilers increased the relative weight of gizzard compared to controls.

Antimicrobial activity Also has been extracted from the mealworms that are active against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Staphylococcus pyrogen*, *Micrococcus luteus, Corynebacterium diphtheriae*. Also against fungi that are important in poultry. According to the report of a study, AMPs are released from hemocytes which are secreting that protein and peptides into the hemolymph of insects such as mealworms where they diffuse to the infection area and attack the cell wall. The most commonly known AMPs are, for example, microcyne, colicyne, and lantibiotics. Inhibition of Salmonellae species by these microcytes, in particular, is increasing its importance in poultry [24].

4. Conclusion

One type of insect that has the potential as an alternative protein feed is the mealworms and can reduce or replace the use of fish meal and soybean meal.

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