Comparison of nutritive value between intact and defatted black soldier fly larvae for animal feed

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Abstract. In this study, the possibility black soldier fly (BSF) larvae as a novel feedstuff for animal was investigated. The objective of this study was to compare the nutritive value between intact and defatted BSF larvae for animal feed by means of chemical composition determination and *in vitro* rumen fermentation technique. The following treatments were tested: intact BSF (T1), BSF low in lipid by mechanical extraction (T2), BSF low in lipid by chemical extraction (T3), and soybean meal (T4). The samples were subjected to proximate analysis, Van Soest's fiber fraction and cell wall nitrogen determination. The samples were further incubated *in vitro* with buffered-rumen fluid in four replicates, represented by two incubation units per replicate, and conducted for 48 h at 39^{o}C. Parameters measured in the *in vitro* evaluation were total gas production and methane emission at regular time point intervals. Other parameters measured after the incubation were dry matter degradation, organic matter degradation, total volatile fatty acid (VFA), ammonia concentration and pH. Data were tested using analysis of variance (ANOVA) and if there was a significant different at $P<0.05$ then continued with Duncan's multiple range test. Results revealed that removal of lipid from BSF larvae either by mechanical or chemical extraction increased dry matter degradability (DMD), organic matter degradability (OMD) and total gas production values as compared to intact BSF ($P<0.05$). However, these values were still lower than those of soybean meal ($P<0.05$). Concentrations of ammonia and total VFA were similar across all dietary treatments. It can be concluded that removal of lipid from BSF larvae by either mechanical or chemical extraction improves its utilization in the *in vitro* rumen fermentation system.

1. Introduction

The provision of high-quality livestock feed is one of the factors determining the success of an industry farm and it has become the largest component in the business activity, i.e. 50-70%. Protein source for feed is generally based on plant and animal protein. Among all nutrients, protein is the most expensive nutrient. The increasing price of conventional feed protein sources such as soybean meal, corn gluten meal, etc., requires exploration of other alternatives of protein sources. Insect is a class of animal that potentially can be used as feed and is characterized by a high protein content with a good and balance amino acid profile [1]. The use of insects as a source of feed is expected to effectively address the increasingly limited supply of feed protein. One of the species of insects that could be used as feed is black soldier fly larvae (BSF, *Hermetia illucens*) because its production system in relatively easy. Furthermore, BSF larvae is growing rapidly and contains a high protein content, i.e., about 40% [2]. However, BSF contains relatively high fat 29.65% [3] and may hamper nutrient digestion particularly in the rumen. This study aimed to compare the nutritive value between intact and defatted BSF larvae for animal feed.

2. Materials and Methods

The following treatments were tested: intact BSF (T1), BSF low in lipid by mechanical extraction (T2), BSF low in lipid by chemical extraction (T3), and soybean meal (T4). The BSF larvae was obtained from Laboratory of Feed Science and Technology, Faculty of Animal Science, Bogor Agricultural University. The samples were further incubated *in vitro* with buffered-rumen fluid in four replicates, represented by two incubation units per replicate, and conducted for 48 h at 39ºC. Allocation of dietary treatments into the experimental units followed a completely randomized design.

Parameters measured in the *in vitro* evaluation were total gas production and methane emission at regular time point intervals. Other parameters measured after the incubation were dry matter degradation (DMD), organic matter degradation (OMD), total volatile fatty acid (VFA), ammonia concentration (AOAC 1991) [4] and pH. The *in vitro* procedure was performed according to Theodorou and Brooks [5]. Data were tested using analysis of variance (ANOVA) and if there was a significant different at $P<0.05$ then continued with Duncan's multiple range test.

3. Result and Discussion

Degradation of organic matter in each treatment was directly proportional to the degradation of dry matter produced; higher DMD was lead to a higher OMD (Table 1). This is possible since organic matter is a part of the dry matter. Suardin *et al*. [6] stated that high digestion of organic matter is in line with high digestion of dry matter, and vice versa. According to Tillman *et al*. [7], most of organic matter is dry matter components. The highest DMD and OMD values were obtained in T4. It is within a normal range according to Firsoni et *al*. [8]. Lower fiber content in T4 apparently causes such higher degradation coefficients so that rumen microbes are easier in degrading the feed component.

Table 1. Dry matter degradability (DMD), organic matter degradability (OMD) and pH values of the BSF treatments.

Treatments	DMD (%)	OMD (%)	pH
T1	$13.25^a \pm 1.08$	$11.08^a \pm 0.98$	$6.85^b \pm 0.05$
T2	$42.33^c \pm 1.76$	$41.29^c \pm 1.42$	$7.19^c \pm 0.01$
T3	$26.02^b \pm 3.29$	$24.27^b \pm 3.32$	$6.84^b \pm 0.01$
T4	$72.67^d \pm 3.66$	$71.02^d \pm 2.36$	$6.74^a \pm 0.02$

Different superscripts in the same column show significant difference at $P<0.05$.
T1, intact BSF; T2, BSF low in lipid by mechanical extraction; T3, BSF low in lipid by chemical extraction ; T4, soybean meal.

Meanwhile, the lowest DMD and OMD was observed in T1. Such low degradation of T1 may be caused by the high composition of fiber in BSF (including chitin), which is difficult to be degraded. It had been reported that crude fiber content in BSF was 29.58 % [9]. This is supported by Longo *et al.* [10] who described that feed fermentation in the rumen is largely influenced by the fiber fraction composition. Furthermore, Despal [11] also observed that crude fiber had a negative relationship with digestion. The lower composition of rough fiber in T4 causes the higher degradations of dry matter and organic matter because rumen microbes can be easier in degrading the feed. It is in line with Rudini [12] who states that composition of rough fiber in soybean meal is 7.28%. Values of pH in the *in vitro* rumen fermentation system were changed by treatments. In the *in vitro* batch system, buffering capacity of incubation medium is maintained as adequate as possible in order to keep relatively constant pH until the end of incubation [10,11].

Table 2. Total gas production at 24 and 48 h of the BSF treatments.

Treatments	24 h (ml)	48 h (ml)
T1	48.5^{c} ± 0.62	68.0^{a} ±1.89
T2	36.0^{a} ± 1.65	79.0^{b} ± 0.96
T3	42.0^{b} ± 0.63	69.0^{a} ± 0.76
T4	91.5^{d} ± 3.54	164^{d} ± 0.63

Different superscripts in the same column show significant difference at P<0.05.
T1, intact BSF; T2, BSF low in lipid by mechanical extraction; T3, BSF low in lipid by chemical extraction ; T4, soybean meal.

The highest gas production both at 24 and 48 h was observed in T4 and it was significantly higher as compared to other treatments (P<0.05; Table 2). Such high gas production in T4 is apparently due to the relatively lower crude fiber content of T4. It is supported by Wahyuni *et al*. [13] who described that the extent of gas production is largely influenced by fibre components, in particular the lignocellulose fraction.

Concentrations of ammonia and total VFA were similar across all dietary treatments (Table 3). The VFA is a final product of carbohydrate fermentation in the rumen and serves as a primary energy source for ruminant livestock. Beside the VFA, carbohydrate fermentation in the rumen produces CO_2 and CH_4 [14]. Total VFA concentration in the present study is within the normal range to support rumen microbial growth, i.e., around 80-160 mM according to Sutardi [15]. With regard to ruminal NH_3 concentration, it is an intermediate product of protein metabolism in the rumen. Higher extent or rate of protein degradation results in higher ruminal NH_3 concentration [12]. Ammonia concentration in this research is still sufficient to fulfil microbial needs, which is between 6.0 – 17.65 mM [14].

Table 3. Ammonia (NH_3) and total volatile fatty acid (VFA) concentrations of the BSF treatments.

Treatments	NH_3 (mM)	Total VFA (mM)
T1	49.60 ± 3.88	103.9 ± 4.57
T2	57.46 ± 11.30	130.6 ± 15.5
T3	73.21 ± 10.13	158.3 ± 4.83
T4	96.56 ± 11.08	175.6 ± 6.56

Different superscripts in the same column show significant difference at P<0.05.
T1, intact BSF; T2, BSF low in lipid by mechanical extraction; T3, BSF low in lipid by chemical extraction ; T4, soybean meal.

4. Conclusion

Based on the results of this research, it can be concluded that removal of lipid from BSF larvae by either mechanical or chemical extraction improves its utilization in the *in vitro* rumen fermentation system. However, the nutritive value of defatted BSF is still lower than that of soybean meal.

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