MUNICIPAL SOLID WASTE MANAGEMENT

Using fresh Black Soldier Fly Larvae to substiute commercial chicken feed

eawag
aquatic research

Sandec
Sanitation, Water and
Solid Waste for Development

Context

Valorising organic waste with the Black Soldier Fly Larvae (BSFL) is becoming increasingly popular, especially in low- and middle-income countries. The popularity links to the opportunity of using the harvested BSFL as an alternative to conventional feed. BSFL could be a very interesting feed source for chicken farms, however due to the young development and little experience to date, following questions arise:

- Are there any negative effects on chicken growth when substituting parts of conventional feed with BSFL?
- Is there a financial advantage for chicken farmers to use BSFL as feed?

This factsheet presents the set up and results of a simple chicken feeding trial where parts of the conventional feed was replaced with live BSFL. It was decided to test the fresh form of BSFL (alive, directly after harvesting) instead of its processed form (dried and defatted), because of their remarkably lower cost price per kg and thus their higher potential competitiveness with conventional feed. However, live BSFL have a high water content, and thus have a lower protein percentage compared to the conventional feed. Moreover, live BSFL are not storable and need to be purchased by the farmers daily, meaning mainly farmers in close distance to a BSF facility would be targeted buyers. The presented data was collected at the FORWARD BSF pilot site in Sidoarjo (Indonesia).

Set up for chicken feeding trial

60 mixed-sexed, two-weeks-old chickens of an Indonesian breed ("ayam kampung"), which are a type of free range chickens, were sourced from a local chicken farmer and were fed with different amounts of live BSFL and commercial complete feed (Charoen Pokphand CP511B). A control group was fed only with the commercial control feed (see Table 1). The total diet protein content (w/w) decreased by increasing BSF amounts in the feed.

Table 1: Feed composition for four different treatments presented as percentage w/w.

Treatment	dry matter	% BSFL live	% chicken feed	Diet protein content	Diet fat content
0-BSF	86%	0	100	20%	5%
10-5BSF	80%	10	90	19%	6%
20-BSF	74%	20	80	18%	6%
30-BSF	68%	30	70	17%	7%

A total of 15 chicken per group were kept in separate cages (4x1 m), which protected the chickens from direct sunlight and rain. The total amount of feed given was based on their age, and was increased weekly according to the feeding schedule of Aryanti (2023) until the chicken reached an age of eleven weeks. The weight of all chicken was measured weekly using a digital scale. Feed was given daily between 9:00 and 10:00. Feed intake per cage was measured by the difference in weight of feed added and the remaining feed at the next day. Feeders had high edges to avoid BSFL crawling away. Clean water including vitamins (Vita Stress Multivitamin Chicken) was provided ad libitum and was changed daily. After a trial duration of nine weeks, three eleven-weeks-old chickens, were randomly taken from each group and were slaughtered, bled out, plucked and eviscerated. The carcasses (including head and feet) were weighed and of each carcasses a breast meat sample was taken and analysed for protein, fat and moisture content.

Chicken breeding performance parameters

From the measured data, the following parameters can be analysed to compare the chicken breeding performance between the different treatments:

- **Body Weight Gain (BWG)** is the total body weight increase (in g) of the chicken during the trial, where W_t is the mean final body weight and W_0 is the mean initial body weight.

$$BWG\ [g] = W_t[g] - W_0[g]$$

- **Feed Conversion Ratio (FCR)** is the ratio between Feed Intake (FI) and chicken body weight gain, where BWG is the total body weight gain over the trial time.

$$FCR = FI\ [g] / BWG\ [g]$$

- **Protein Efficiency Ratio (PER)** is the ratio between body weight gain and feed intake based on the feed protein content.

$$PER = BWG\ [g] / FI\ [g] \times \text{diet protein content}\ [\%]$$

Results and Discussion

Figure 1 shows the weight increase of the chickens of all four trial groups over the trial time. Chickens fed with 20% BSFL substituted feed showed a significantly higher weight starting from an age of seven weeks. Other feed replacement ratios showed slightly higher or similar weight increases compared to the control chicken group.

Table 2 presents chicken breeding performance parameters. In week seven all chicken cages were affected by a virus and two to five chickens died due to a virus in each cage. After a vaccination, the chickens recovered and the trial continued with a reduced number of chickens per cage and feed was adjusted accordingly (see Table 2). The mean final chicken weights of all BSFL fed groups were higher compared to the control group, however only the treatment with 20% replace-

Using fresh Black Soldier Fly Larvae to substiute commercial chicken feed

eawag aquatic research
Sandec
Sanitation, Water and Solid Waste for Development

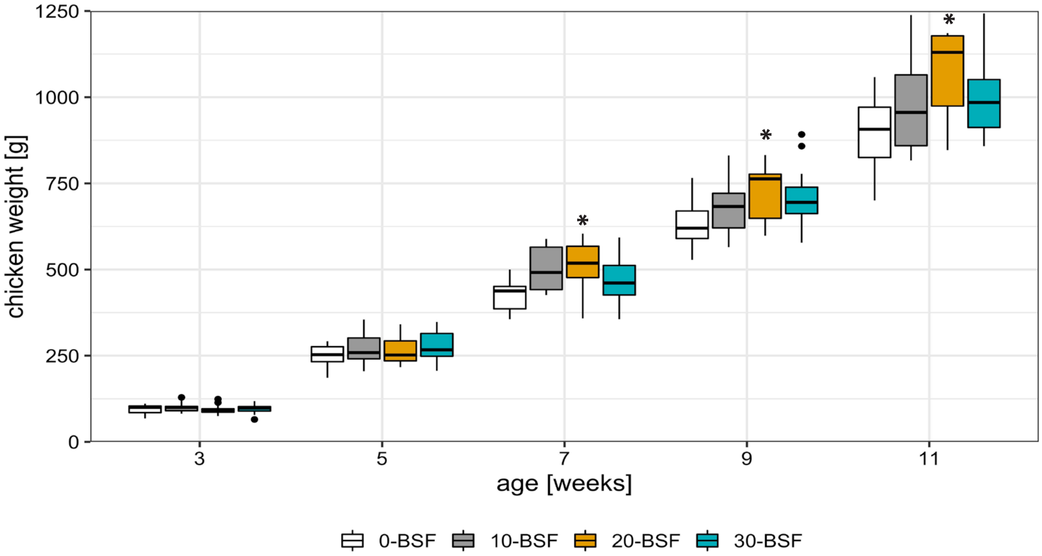

Figure 1: Chicken weight increase for 0-BSF, 10-BSF, 20-BSF and 30-BSF over 11 weeks (n=10-15). * indicates a significant difference to the control group 0-BSF (ANOVA, with Tukey post hoc, significance level: a < 0.05).

The total body weight gain as well as the total feed intake was higher for all treatments with BSFL. Feed containing BSFL seemed to be very attractive for the chickens and resulted in an immediate feed consumption when new feed was provided. The chickens from the control group, seemed less active when new feed was added. This could be an indication, that the addition of fresh BSFL may increase the appetite of the chickens, which then results in faster weight gains. FCRs were similar among all treatments and a bit higher than the standard values for the growing phase of broilers (MacLeod, et al., 2013) but a bit lower than reported values for free-range chickens (Resnawati, et al., 2010). Although the chicken breed used in this trial was similar to free range chickens, they were farmed similar to broiler farming in a more intensive manner using cages, which could explain the low FCR values. The lower protein content of the BSFL feed resulted in a better PER for BSF treatments and shows that the reduced protein content (w/w) did not affect the chicken's growth.

Table 2: Chicken breeding performance parameters for treatment 0-BSF, 10-BSF, 20-BSF and 30-BSF. Different letters indicate significant differences. (ANOVA, with Tukey post hoc, significance level: a < 0.05).

Performance parameter	Unit	0-BSF	10-BSF	20-BSF	30-BSF
Amount of chickens after week 7	#	13	10	10	11
Initial chicken weight W2 (mean ± SD)	g	49 ± 5[a]	50 ± 5[a]	50 ± 5[a]	50 ± 5[a]
Final chicken weight W11 (mean ± SD)	g	891 ± 106[a]	973 ± 137[ab]	1068 ± 135[b]	1026 ± 153[ab]
Body weight gain (BWG)	g	842	923	1018	976
Feed intake per chicken (over 9 weeks)	g	2136	2314	2451	2339
Feed conversion ratio (FCR) (over 9 weeks)	-	2.5	2.5	2.4	2.4
Protein efficiency ratio (PER) (over 9 weeks)	-	2.0	2.1	2.3	2.5

Figure 2 gives a closer look at the feed intake and FCR for each trial week. The sickness in week seven led to a drastic drop in feed intake for all treatments in that week. The sickness also affected the body weight gain, which also resulted in a spike of the FCR at this trial stage. This shows that all treatments were similarly affected by the sickness and the addition of BSFL in the feed seems unrelated. Figure 2 confirms that the feed intake was for most weeks slightly higher for the treatments with BSFL compared to the control group. The FCR was similar for all treatments over the trial time and was, except for week seven, between 0.6 and 1.4, which is in line with standard values for broiler chickens in the growing phase (MacLeod, et al. 2013).

Meat quality parameters of the slaughtered chickens from the different treatments are listed in Table 3. The carcasse weights of the BSFL fed chickens were slightly higher. Whereas protein content was a bit lower in the meat of the BSFL fed chickens, the fat content was a bit higher. Differences were not significant, however the sample size was very low with only three values. The overall protein content (w/w) of the diet was reduced by adding BSFL, but at the same time fat content (w/w) was slightly increased, which could explain the observed differences (see Table 1).

Using fresh Black Soldier Fly Larvae to substiute commercial chicken feed

eawag aquatic research
Sandec
Sanitation, Water and
Solid Waste for Development

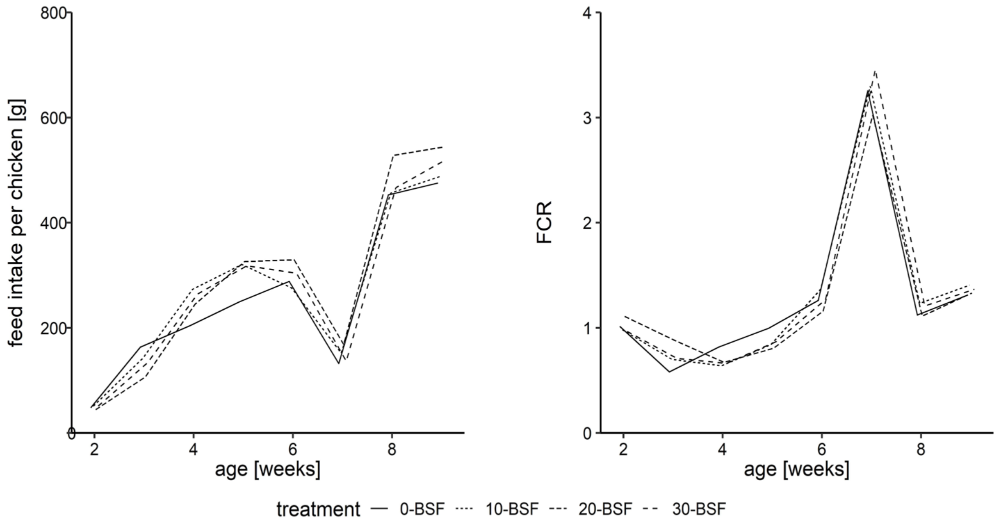

Figure 2: Feed intake per chicken [g] (left) and feed conversion ratio (FCR) (right) over nine weeks for 0-BSF, 10-BSF, 20-BSF and 30-BSF.

Table 3: Meat quality parameters for 0-BSF, 10-BSF, 20-BSF and 30-BSF. All values are presented as mean ± standard deviation (n=3). Different letters indicate significant differences. (ANOVA, with Tukey post hoc, significance level: a < 0.05).

Meat quality parameter	Unit	0-BSF	10-BSF	20-BSF	30-BSF
Weight of carcasses	g	880 ± 39[a]	959 ± 73[a]	1085 ± 14[a]	1057 ± 157[a]
Protein content (based on dry matter)	%	29 ± 1[a]	26 ± 1[a]	26 ± 2[a]	25 ± 3[a]
Fat content (based on dry matter)	%	2 ± 1[a]	4 ± 0.2[ab]	3 ± 2[b]	4 ± 3[ab]

Figure 3:Chickens eating commerical feed mixed with live BSFL. Left: 4 weeks old, Right 5 weeks old.

Using fresh Black Soldier Fly Larvae to substiute commercial chicken feed

eawag
aquatic research

Sandec
Sanitation, Water and
Solid Waste for Development

Feed cost predictions using fresh BSFL

The conventional chicken feed "Charoen Pokphand CP511B" used in this trial was bought at a price of 0.6 USD per kg in Indonesia. The BSF pilot site is currently selling the fresh BSFL at a price of 0.4 USD per kg. At these current prices chicken farmers could save up to 7% in feeding costs by replacing 30% of their conventional feed with fresh BSFL. Also at a slightly higher BSFL kg price of 0.5 USD/kg chicken farmers could still save between 1% and 3% of their feed costs (see Table 4).

Table 4: Feed cost saving for different BSF replacement ratios at 0.4 USD/kg and 0.6 USD/kg BSF live.

Treatment	% BSF	Cost saving at 0.4 USD/kg BSF	Cost saving at 0.5 USD/kg BSF
0-BSF	0	0%	0%
10-5BSF	10	2%	1%
20-BSF	20	4%	2%
30-BSF	30	7%	3%

Conclusions & suggested usage of fresh BSFL

Based on the presented results, fresh BSFL are suitable as feed for the Indonesian chicken breed “Ayam Kampung”. Replacing 20% of the feed with BSFL showed a significant faster growth compared to the control group. Feed intake was slightly higher for all BSFL treatments, indicating an increased appetite in chickens when fresh BSFL are added to the feed. Chickens fed with BSF gave overall more meat compared to the control, but the meat had lower protein percentages and higher fat percentages, which might be due to the shifted diet protein and fat contents in the BSF treatments.
Based on current sales prices replacing conventional feed with BSFL reduces feed costs up to 7%. Especially for small scale chicken farmers, costs for feed contribute largely to the operational costs and therefore even a small cost reduction of 1% would have a beneficial impact on the farmer’s business. Although, chickens grew faster by replacing 20% of the feed with BSFL, they consumed also more feed, which would not further reduce the expenditures for feed. But faster growth results in more meat in the same breeding time. This would be an advantage of feeding BSFL apart from reducing feeding costs. For farmers located next to a BSFL waste processing facility, we suggest to replace 20% of the conventional feed with fresh BSFL. This could increase the chicken’s appetite and thereby support a fast growth and reduce the operational costs at the same time.

References

- Aryanti, F., Aji, M. B., & Budiono, N. (2013). Pengaruh Pemberian Air Gula Merah terhadap Performans Ayam Kampung Pedaging= Influence of Palm Sugar Water in the Native Chicken Performance. Jurnal Sain Veteriner, 31(2013).
- MacLeod, M., Gerber, P., Mottet, A., Tempio, G., Falcucci, A., Opio, C., Vellinga, T., Henderson, B., & Steinfeld, H. (2013). Greenhouse gas emissions from pig and chicken supply chains – a global life cycle assessment. Food and Agriculture Organization of the United Nations.
- Resnawati, H., & Sartika, T. (2010). The growth and productivity of selected kampung chicken. Research Institute for Animal Production in Bogor, 354–357.

Figure 4: "Ayam Kampung" chickens fed with 20% BSFL, 10 weeks