A novel protein source: Maggot meal of the Black Soldier fly (*Hermetia illucens*) in broiler feed

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Introduction

Protein quality plays an important role in animal nutrition. However, high-quality protein sources such as fish meal are either expensive and ecologically questionable or banned alltogether from the feed chain within the European Union (meat and bone meal). Only recently, first steps were taken by the European Commission to reintroduce protein from certain terrestrial animal sources to livestock nutrition. Regulation (EC) 1774/2002 will be replaced by regulation (EC) 1069/2009 in March 2011. A revision of the second regulation denying the use of animal by-products in feed for livestock (EC 0999/2001) has already begun.

This perspective encouraged the exploration of novel protein sources for livestock nutrition. Fed on waste food material once judged suitable for human comsumption (waste meals, post-shelf life material), the maggots of the Black Soldier fly consist of 35-40% (in dry matter) crude protein and a similar amount of crude fat. Additionally, preliminary analysis showed, that the amino acid pattern of maggot meal of *Hermetia illucens* ('Hermetia meal'; HM) is very similar to that of fishmeal (Figure 1)

Based upon this knowledge the potential use of HM in broiler feed was to be explored in a first study.

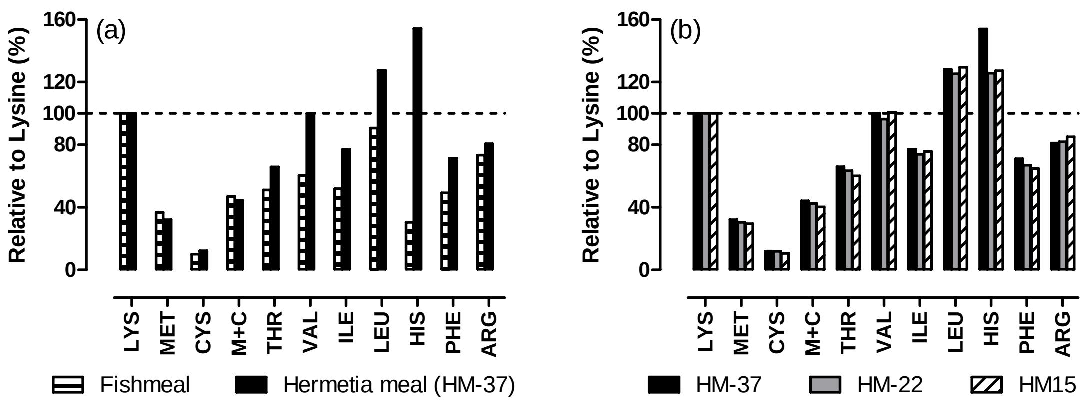

Figure 1: Comparison of amino acid patterns: (a) fishmeal and Hermetia meal (fulfat) and (b) Hermetia meal of varying degree of de-fatting used in the present study.

Materials and Methods

The study was conducted during the Starter (days 1-10) and Grower (days 11-24) phases. Each fattening phase represented an individual sub-trial, experimental designs being different between the two phases (Table 1).

Diets were formulated and adjusted for the respective fattening phase according to breeder's recommendations (Aviagen, 2007). In the Starter phase, all-vegetable and fishmeal diets served as negative and positive control, respectively. In the test diets, different Hermetia meals (defined by their level of de-fatting) were supplemented at such levels as to supply similar amounts of crude protein as the fishmeal did contribute to the positive control diet. Differences in the concentration of first limiting amino acids (lysine, methionine+cystine) were accounted for by additional supplementation of these amino acids. In the Grower period, only an all-vegetable and a partly de-fatted Hermetia meal were compared. Diets were calculated to be of equal energy and nutrient concentration within fattening phase (Table 2).

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Day-old, male Ross308 broiler chickens were placed in groups of 15 chickens in each of 54 experimental pens (~1 sq.m.). At the end of the Starter period, the number of broilers was reduced to 10 in such a way that variation within pen was minimised. The birds had *ad libitum* access to water and feed. Initial bedding consisted of wood shavings and was not renewed throughout the study. Light and temperature regimes followed breeder's recommendations.

Table 1: Experimental design in Starter and Grower phases.

	Grower phase			
Starter phase	**Hermetia meal 22** [1]	**All-vegetable**	Sum of pens	Sum of broilers
All-vegetable	6	6	12	180
Fishmeal	5	5	10	150
Hermetia meal 37 [1]	5	5	10	150
Hermetia meal 22 [1]	6	6	12	180
Hermetia meal 15 [1]	5	5	10	150
Sum of pens	27	27		
Sum of broilers	270	270		

[1] The number indicates the proportion of crude fat in the Hermetia meal. De-fatting was done by mechanical means.

Table 2: Diet composition (g/kg) and analysed nutrient concentrations (g/kg) in experimental diets

Ingredients	Starter					Grower	
	Veggie	FM	HM-37	HM-22	HM-15	Veggie	HM-22
Wheat	387.1	427.8				465.1	474.9
Corn	150.0	150.0	130.6	131.2	134.9	150.0	150.0
Soybeanmeal hipro	360.0	305.0				290.0	240.0
Fishmeal	-	30.0	-	-	-	-	-
Hermetia meal 37	-	-	65.6	-	-	-	-
Hermetia meal 22	-	-	-	53.7	-	-	50.0
Hermetia meal 15	-	-	-	-	47.1	-	-
Soya oil	56.0	44.0	26.9	38.2	41.1	53.0	43.0
L-lysine HCl	2.7	2.4	3.1	3.1	3.1	2.7	2.9
DL-methionine	3.6	3.4	3.7	3.7	3.6	3.2	3.2
Minerals, Premix, Enzymes, L-Threonine	40.6	37.4				36.0	36.0
Nutrients							
AME_N, MJ/kg	12.1	12.7	12.3	12.4	12.7	12.2	12.6
XP	235	237	236	239	231	202	205
EE	61	67	63	64	59	63	65
Lysine	14.7	14.8	14.8	15.0	15.0	12.9	13.0
Methionine+Cystine	10.2	10.6	10.5	10.5	10.5	9.1	9.1
Threonine	9.9	10.2	9.9	10.0	9.8	8.4	8.5

At the beginning and at the end of each fattening period, body weight (BW) was determined. Feed consumption and BW of losses was recorded. BW gain, daily feed consumption per bird (FC), feed conversion ratio (FCR, corrected for mortality) as well as the European Efficacy Factor (EEF) was calculated.

Statistical analysis was conducted as ANOVA either one- or bifactorially for Starter and Grower periods, respectively, with the major effects investigated being Starter diet or Starter and Grower diets as well as their interaction. Significance level was $p \leq 0.05$, taking into account multiple comparisons (Tukey/Tukey-Kramer test). All statistical analysis was performed using SAS 9.2 (SAS Institute, 2008).

Results and Discussion

Relative to lysine, Hermetia meal contains higher levels of threonine and valine as well as isoleucine and leucine as compared to the fishmeal used in the study (Figure 1a). The highest difference was observed

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for histidine. Methionine is slightly lower in HM than in fishmeal. Mechanical de-fatting has a slightly decreasing effect upon the relative concentrations of most amino acids (Figure 1b). Although de-fatting decreased histidine concentration from 154 to 125% (relative to lysine) it is still about four times higher than in the fishmeal (30%)

During the Starter period, the broiler chickens grew from 39.9 g at placement to 267-286 g on day 10 (Table 3). Fulfat Hermetia meal yielded similar high BW after 10 days as compared to the fishmeal diet. Increasing level of de-fatting the Hermetia meal resulted in decreasing FC and decreased BW. There was hardly an effect of FCR to be observed.

Table 3: Results of the Starter period

Diet	BW day 10 g	BW gain g/d	FC g/d	FCR feed/gain	Losses %	EEF
All vegetable	$281^{(a)b}$	$24.1^{(a)b}$	25.9^{b}	1.080	1.1	220^{ab}
Fishmeal	285^{b}	24.5^{b}	26.4^{b}	1.079	0.7	$227^{(a)b}$
Hermetia meal 37	286^{b}	24.6^{b}	26.4^{b}	1.073	1.3	$227^{(a)b}$
Hermetia meal 22	274^{ab}	23.4^{ab}	25.3^{ab}	1.082	1.7	213^{ab}
Hermetia meal 15	267^{a}	22.8^{a}	24.5^{a}	1.080	2.0	207^{a}

Values within a column not sharing a common superscript are significantly different (p≤0.05). Superscripts in brackets indicate a statistical tendency (p≤0.1)

Grower period was started with an average BW of 283 g, final BW ranged from 1235 to 1285 g without any significant effects of Starter or Grower diet and their interaction (Table 4). There were tendencies to be observed for slightly poorer FCR but decreased number of losses in the Hermetia meal treatment as compared to the all-vegetable diet fed birds.

Table 4: Results of the Grower period, in detail for final BW and FC, least square means for Grower diet type for parameters BW gain, FCR, Losses and EEF

	BW day 24, g			**FC, g**		
Starter	**Hermetia meal 22**	**All vegetable**	**mean**	**Hermetia meal 22**	**All vegetable**	**mean**
All vegetable	1245	1278	**1262**	103.0	104.9	**103.9**
Fishmeal	1285	1275	**1280**	106.2	104.7	**105.5**
Hermetia meal 37	1259	1274	**1266**	105.9	103.5	**104.7**
Hermetia meal 22	1259	1253	**1256**	103.0	103.5	**103.3**
Hermetia meal 15	1235	1256	**1245**	101.6	101.7	**101.7**
mean	**1257**	**1267**		**104.0**	**103.7**	

	BWgain g/d	**FCR feed/gain**	**Losses %**	**EEF**
Hermetia meal 22	69.6	$1.493^{(b)}$	$3.0^{(a)}$	454
All vegetable	70.3	$1.475^{(a)}$	$5.6^{(b)}$	450

Superscripts in brackets indicate a statistical tendency of difference (p≤0.1)

Conclusions

Hermetia meal could serve as a source of protein for broilers. Results of the Starter period suggest that fulfat Hermetia meal is of a similar high quality as fishmeal. Further research is encouraged regarding optimal and maximal inclusion levels as well as protein quality and homogeneity between production batches.

References

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