

# Dried Black Soldier Fly larvae as a dietary supplement to the diet of growing pigs

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## Abstract (Click)

Black soldier fly (*Hermetia illucens*) larvae are a promising source of nutrients for animal feeds. Recent data show that Dried Black Soldier Fly larvae (DBSFL) contains a significant amount of chitin, melanin, antimicrobial peptides, trace elements. Larva's fat is rich in lauric and other medium-chain fatty acids. A new direction in the use of insect biomass is their use as a dietary additive to a pig diet. The aim of our research - to study the influence of small dosages of DLBSF on the growth and development of crossbred pigs.

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## Conclusion

Recent studies have shown that insects can be a source of valuable compounds that can have a positive effect on the immune system of animals, helping to strengthen their health and reducing the use of antibiotics for livestock. Thus, it is possible to consider the prospects of using DLBSF as a dietary supplement to diets of rapidly growing pigs.

## Material & Methods (Click)

In physiological tests the animals divided into 3 groups (N=18): 1 - control group - standard feed (SF), 2 - experimental group (SF+0.3%DBSFL), and 3 - experimental group (SF+0.9%DBSFL). When carrying out industrial tests the animals divided into 2 groups (N=144): 1 - control group (SF), 2 - experimental group (SF+0.3%DBSFL). The materials obtained in the experiment was biometrically processed using the ANOVA method.



## Results (Click)

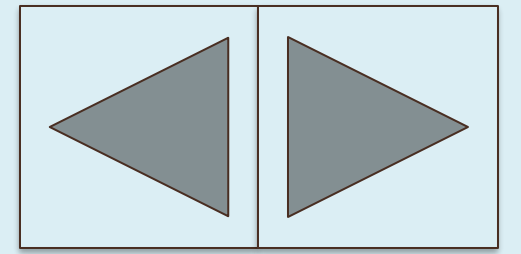
The results of the study showed the use of DLBSF in feed increased average daily gain (ADG) of experimental animals during the growing period by 8.2 and 9.1% ( $424.80 \pm 27.60$  &  $428.46 \pm 26.94$  vs.  $392.68 \pm 14.37$  g,  $p > 0.05$ ) compared to the control group. Biochemical blood test showed a higher concentration of total protein ( $61.14 \pm 1.40$  &  $57.57 \pm 1.17$  vs.  $56.99 \pm 0.53$ , g/L,  $p < 0.05$ ), decrease of bilirubin ( $8.65 \pm 0.80$  &  $9.57 \pm 1.33$  vs.  $13.98 \pm 1.12$ ,  $\mu\text{mol/L}$ ,  $p < 0.05$ ), higher number of leukocytes ( $12.72 \pm 0.53$  &  $14.91 \pm 0.52$  vs.  $8.80 \pm 0.89$ ,  $\times 10^9/\text{L}$ ,  $p < 0.05$ ) in the blood of the experimental animals compared to the control group. Feeding animals with DLBSF did not affect the number of lactobacilli in the large intestine, while the number of bifid bacteria significantly increased in the control group ( $3.0 \times 10^{14}$  &  $1.4 \times 10^{12}$  vs.  $1.0 \times 10^{11}$ , CFU/g,  $p < 0.05$ ).



NordTechSad



# Abstract



## Picture 1. Processing of organic waste by Black Soldier Fly larvae on the basis of NordTechSad, Arkhangelsk, Russia



## Topic

Black soldier fly (*Hermetia illucens*) larvae are a promising source of nutrients for animal feeds. Dried Black Soldier Fly larvae (DBSFL) contains about 40% protein and fat, the amount of which depends on the substrate on which the insect is grown - larvae utilize organic waste and become a good food for animals themselves. In addition, larvae of this species produce biologically active substances that can potentially be used for human and animal well-being[1]. Recent data show that DLBSF also contains a significant amount of chitin, melanin, antimicrobial peptides, trace elements. Larva's fat is rich in lauric and other medium-chain fatty acids. Recent studies have shown that insects could also be sources of valuable compounds that can have a positive effect on the immune system of animals, contributing to their health and reducing the use of antibiotics for livestock production [2].

The breeding of flies larvae as a source of fodder protein, lipids and biologically active substances for agricultural animals has great prospects. The insect is one of the few species of invertebrates able to develop year-round in pure culture in a confined space under artificial conditions, which makes it possible to use *Hermetia illucens* also in biotechnological purposes (bioconversion of waste) [3, 4].

In the conditions of subarctic climate of Russia LLC «NordTechSad» organized small-capacity production of BSF larvae. A new direction in the use of insect biomass is their use as a dietary additive to a pig diet. Many aspects of the breeding and cultivation of larvae, the use of larvae in animal feeding still need clarification and more research. The aim of our research - to study the influence of small dosages of DLBSF on the growth and development of crossbred pigs.

### References:

1. Müller A., Wolf D., Gutzeit H.O. The black soldier fly, *Hermetia illucens* - a promising source for sustainable production of proteins, lipids and bioactive substances. *Z Naturforsch C*. 2017 Sep 26;72(9-10):351-363. doi: 10.1515/znc-2017-0030.
2. Gasco L., Finke M., van Huis A. Can diets containing insects promote animal health? *Journal of Insects as Food and Feed*, 2018; 4(1): 1-4. DOI 10.3920/JIFF2018.x001.
3. Newton, G.L. Dried *Hermetia Illucens* Larvae meal as a supplement for swine / G.L. Newton, C.V. Booram, R.W. Barker, O.M. Hale // *Journal of Animal science*. – 1977. – Vol. 44. – P. 395–400.
4. Driemeyer H. Evaluation of black soldier fly (*Hermetia illucens*) larvae as an alternative protein source in pig creep diets in relation to production, blood and manure microbiology parameters / Thesis presented in fulfilment of the requirements for the degree of Master of Science in the Faculty of AgriScience at Stellenbosch University. December 2016. P. 99



# Materials and Methods

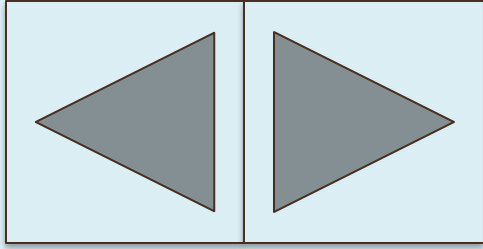


Table 1. Experiment design

Group	Heads	Feeding characteristics
Stage 1. Physiological experiment		
1 - control	6	Standard feed (SF)
2 - experimental	6	SF + 0.3%DLBSF
3-- experimental	6	SF + 0.9%DLBSF
Stage 2. Scientific experiment		
1 - control	74	Standard feed (SF)
2 - experimental	70	SF + 0.3%DLBSF

In physiological tests the animals divided into 3 groups (N=18): 1 - control group - standard feed (SF), 2 - experimental group (SF+0.3%DLBSF), and 3 - experimental group (SF+0.9%DLBSF). The experiment was conducted on fattened young pigs - 18 heads of crossbreds (F-2: KBxLxD) during the period of growing (age from 56 to 97 days).

When carrying out industrial tests the animals were divided into 2 groups (N=144): 1 - control group (SF), 2 - experimental group (SF+0.3%DLBSF).

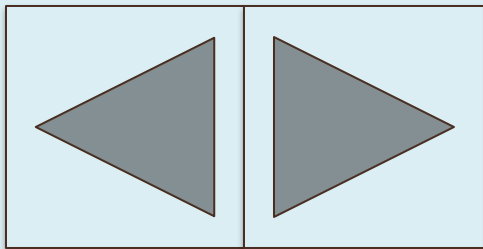
Mixed fodders included: wheat, barley, soybean meal, sunflower meal, wheat bard, protein fodder mix, lysine sulfate, methionine, threonine, salt, monocalcium phosphate, limestone flour, premix. Antibiotics were not used in the composition of mixed fodders. The main diet and the conditions for keeping all groups of animals (temperature, humidity, light regime and gas composition of air in the room) were the same within the limits of zoohygienic norms.

In the Department of Physiology and Biochemistry of livestock of L.K. Ernst Federal Science Center for Animal Husbandry, a chemical analysis of feeds and feeding meal from *Hermetia Illucens* larvae was carried out with standard methods. In the laboratory of microbiology of L.K. Ernst Federal Science Center for Animal Husbandry, it was checked the presence of pathogenic microorganisms (*Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella* spp., *Escherichia coli* (hemolytic), *Staphylococcus saprophyticus*, p. *Enterobacter* spp., p. *Citrobacter* spp as well as yeast-like fungi and molds and general toxicity.

Individual weighting of animals (in the morning before feeding) was carried out to determine the increments of live weight (absolute, average daily): at the beginning of the experiment, at the end of the experiment, and every 10-14 days, daily individual and group accounting of feeds and their residues. At the end of the experiment, blood was collected from the jugular vein, with further determination of the biochemical parameters (biochemical analyzer Chem Well (Awareness Technology, USA)), the content of the large intestine was also selected at the end of the experiment from 3 animals from each group. And the final fattening was determined in the Laboratory of Microbiology of of L.K. Ernst Federal Science Center for Animal Husbandry.

The materials obtained in the experiment were biometrically processed using ANOVA method (Statistica, vers.10, StatSoft, Inc., 2011).

# Results



Biomass of larvae can also be used as a valuable raw material for the pharmaceutical, microbiological, cosmetic and food industries. The complex technology of larva biomass processing allows the selection of many physiologically active substances - chitin, antimicrobial peptides, fatty acid complex, organic forms of minerals, hormones, etc. The isolated fractions from the hemolymph of the larva showed high antiviral and antifungal activity, as well as the effectiveness towards the oncology and diabetic diseases.

The biomass of larvae was grown at the small innovative enterprise NordTechSad (Arkhangelsk region, Russia). Eggs of the third day of incubation were placed in plastic containers with nutrient substrate and covered with a fine mesh net. On the fifth day, the substrate with larvae was placed in containers, where larvae processed agricultural waste, as well as overdue vegetables and fruits. The feeding of the larvae was carried out once the former feed had been eaten.

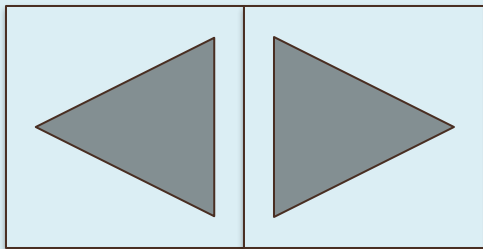
The data obtained by us showed the absence or presence in a minimum concentration of pathogenic microorganisms in the feeding meal of *Hermetia Illucens*, and the absent toxicity was also confirmed.

Table 2. Comparative composition of feeds

Title	ME, MJ / kg	CP, %	CF, %	Chitin, %	Ca, %	P, %
Larvae of the fly <i>Hermetia Illucens</i> (production NordTechSad)	19.39	37.9	37.3	9.4	0.44	0.26
Larvae of the fly <i>Hermetia Illucens</i> (on manure)	15.3	47.7	15.7	8.0	0.6	0.6
Larvae of the fly <i>Hermetia Illucens</i> (on forage grains)	15.3	37.6	38.3	5.2	0.4	0.3
Larvae of the fly <i>Hermetia Illucens</i> (on corn grain)	21.4	36.5	45.5	8.9	0.47	0.39
Fly larva <i>Musca Domestica</i>	16.9	57.1	19.9	unexplored	0.5	0.4
Fish feeding meal	15.2	60.2	8.1	-	4.4	2.6
Bone feeding meal	8.9	17.8	15.7	-	22.9	10.2
Meat feeding meal	16.5	56.1	15.3	-	6.1	3.1
Meat-bone feeding meal	11.5	40.1	11.2	-	14.3	7.4
Blood meal	14.2	67.5	2.5	-	1.7	0.5



## Results



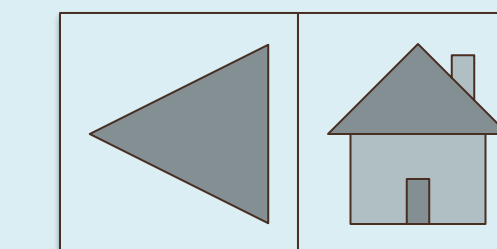
**Table 3.** Dynamics of live weight of growing pigs, feed costs, survival during the testing period

Group	Index					
	Live weight at the beginning, kg	Live weight at the beginning, kg	Average daily gain, g	% to the control	Feed costs, kg feed / 1 kg increment	Pig survival, %
Stage 1. Physiological experiment						
1 - control	15.12±0,23	31.22±0.56	392.68±14.37	100.0	2.894	100.0
2 - experimental	15.87±0.31	33.28±1.44	424.80±27.60	108.2	2.676	100.0
3-- experimental	15.57±0.25	33.13±1.02	428.46±26.94	109.1	2.653	100.0
Stage 2. Scientific experiment						
1 - control	13.46±0.31	31.0±0.64	565.81±13.60	100.0	unexplored	98.6
2 - experimental	13.96±0.37	32.95±0.73*	612.58±13.53*	108.3	unexplored	100.0

\*- p<0,05

The results of the Stage 1 study showed the use of DLBSF in feed increased average daily gain (ADG) of experimental animals during the growing period by 8.2 and 9.1% (424.80±27.60 & 428.46±26.94 vs. 392.68±14.37 g, p>0.05) compared to the control group.

The results of the Stage 2 study were comparable with results of Stage 1. The use of DLBSF in feed increased ADG of experimental animals during the growing period by 8.3% (612.58±13.53 vs. 565.81±13.60 g, p<0.05) compared to the control group. The survival in the experimental group was 100%, in contrast to the control, where there was retirement of 1 head. It should also be noted that in general in the control group, in some cases, the use of an antibiotic was required for the period of the experiment. In the experimental group, no antibiotic injections were used.



## Results

**Table 4.** Biochemical blood indices of experimental animals

Index	Group		
	1-control	2-experimental	3-experimental
Total protein, g/L	56.99±0.53	61.14±1.40*	57.57±1.17
Albumin, g/L	27.55±0.45	28.97±1.65	28.24±0.93
Globulin, g/L	29.44±0.63	32.17±0.54*	29.33±0.28
A/G ratio	0.94±0.03	0.90±0.06	0.96±0.02
Urea, mmol/L	5.58±0.37	6.05±0.14	6.49±0.48
Creatinine, mmol/L	82.99±1.71	77.30±11.12	74.52±9.55
Bilirubin, µmol/L	13.98±1.12	8.65±0.80*	9.57±1.33
Alanine aminotransferase, IU/L	41.33±4.38	44.50±2.44	45.10±4.26
Aspartate aminotransferase, IU/L	32.41±1.91	35.68±0.75	31.92±3.63
Alkaline phosphatase, mmol/L	500.87±79.15	400.43±37.47	482.45±35.58
Cholesterol, mmol/L	3.59±0.11	3.12±0.14	3.36±0.08
Glucose, mmol/L	7.31±0.37	6.99±1.10	7.55±0.42
Calcium, mmol/L	2.96±0.14	3.00±0.01	2.89±0.09
Phosphorus, mmol/L	3.75±0.10	3.35±0.05	3.72±0.17
Ca/P	1.02±0.05	1.11±1.17	1.19±1.16
Magnesium, mmol/L	0.99±0.04	1.02±0.09	1.02±0.01
Iron, µmol/L	31.44±2.87	25.07±1.82	33.82±10.82
Leucocytes, 10 <sup>9</sup> /L	8.80±0.89	12.72±0.53	14.91±0.52
Erythrocytes, 10 <sup>12</sup> /L	9.59±0.61	10.73±0.37	10.58±0.40
Hemoglobin, g/L	102.67±6.38	113.93±2.99	113.23±1.24
Hematocrit, %	49.52±2.79	54.69±1.22	55.09±1.17

**Table 5.** Composition of the microflora of the contents of the large intestine of piglets at the end of the experiment

Microorganisms	Group		
	1-control	2-experimental	3-experimental
<i>Lactobacilli</i> , CFU/g, 10 <sup>9</sup>	5.32±2.44	4.70±2.14	4.80±1.18
<i>Bifidobacteria</i> , CFU/ml, 10 <sup>11</sup>	1.0	3013.3±1514.4	13.67±8.17
Hemolytic microorganisms, CFU/g, incl. <i>Streptococci</i> , 10 <sup>3</sup>	7.67±6.23	83.33±16.67*	10.67±9.68
Lactose-positive coliform, CFU/g	7.67±6.17	1504.0±998.6	21.0±5.77

\*- p<0,05

Biochemical blood test showed a higher concentration of total protein (61.14±1.40 & 57.57±1.17 vs. 56.99±0.53, g/L, p<0.05), decrease of bilirubin (8.65±0.80 & 9.57±1.33 vs. 13.98±1.12, µmol/L, p<0.05), higher number of leukocytes (12.72±0.53 & 14.91±0.52 vs. 8.80±0.89, x 10<sup>9</sup>/L, p<0.05) in the blood of the experimental animals compared to the control group. Feeding animals with DLBSF did not affect the number of lactobacilli in the large intestine, while the number of bifid bacteria significantly increased in the control group (3.0x10<sup>14</sup> & 1.4x10<sup>12</sup> vs. 1.0x10<sup>11</sup>, CFU/g, p<0.05).