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The influence of feeding media enriched with different oils on the fatty acid composition of the Black soldier fly (*Hermetia illucens)*

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ABSTRACT

The black soldier fly (*Hermetia illucens)* has emerged as an interesting alternative protein source in animal feed due to its ability to grow on various substrates. Although it has many rearing benefits and possible applications, it has an unfavourable fatty acid profile if used for human consumption due to its high content of lauric acid and low content of polyunsaturated fatty acids. In order to investigate whether the lipid composition of black soldier fly larvae can be altered, the feeding media were supplemented with varying concentrations of fish, linseed or coconut oil (1, 2.5 and 5%). Two-week-old larvae were collected, measured and their tissue fatty acid composition was determined. The fatty acid profile of the larvae showed significant plasticity, depending on the life stage and the fatty acid composition of the feeding media. The addition of 2.5 and 5% of different oils significantly changed the fatty acid composition of larvae, depending on the type and percentage of oil. The n6/n3 ratio was considerably improved by supplementing fish and linseed oil. The addition of linseed oil increased the content of linolenic acid, but bioconversion to eicosapentaenoic and docosahexaenoic acids was low. In contrast, the addition of fish oil significantly increased the content of eicosapentaenoic and docosahexaenoic acids in the larvae. The content of lauric acid significantly increased after coconut addition. The trial showed that by using different oils, the lipid composition of black soldier fly larvae could be specifically changed to increase the beneficial long chain n3 polyunsaturated fatty acids, and the amount of lauric or linolenic acid.

Key words: BSFL; fatty acids; life stage; growth rate

Introduction

The black soldier fly (BSF), *Hermetia illucens* (L.) (Order: Diptera, Family: Stratiomyidae) is nowadays becoming a very popular subject for scientific investigations as an alternative feed source. This insect is native to Central and South America, but has become a cosmopolitan species and may be found on all continents, in both tropical and temperate climate zones (MARSHALL et al., 2015). The BSF larvae (BSFL) have a very high content of crude protein, ranging from 300 to 560

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g/kg (DM), and crude fat ranging from 150 to 320 g/kg (DM), depending on the phase of life cycle and feeding media (LIU et al., 2017; WANG and SHELOMI, 2017). Even higher crude fat content could be achieved when using oil-rich food waste (MAKKAR et al., 2014). Due to its composition, the BSFL is becoming an interesting, cheap source of protein for feed worldwide.

BSFL can be produced in simple rearing systems which enable mass production, due to its ability to grow on various substrates: agricultural by-products, household food scraps, fruit, vegetables, seaweed and cadavers, brewery by-products, and animal and human manure (DIENER et al., 2009; NGUYEN et al., 2013; BANKS et al., 2014; ČIČKOVÁ et al., 2015; OONINCX et al., 2015; LILAND et al., 2017; EWALD et al., 2020; SCALA et al., 2020). Moreover, it could possibly be used as an antibacterial additive or for controlling some pathogens, e. g. *E. coli* and *Salmonella* in poultry manure (DE SMET et al., 2018). The European Union approved the use of insect protein in fish feed in July 2017 (EU Regulation 2017/893), while the use in feed for poultry and pigs was authorized in August 2021 (EU Regulation 2021/1372). However, use of insects as human food has been reported in Malaysia, but is still uncommon in the EU (WANG and SHELOMI, 2017).

BSFL have a high content of atherogenic fatty acids, while the polyunsaturated fatty acids (PUFA) value is very low (MAKKAR et al., 2014; SPRANGERS et al., 2017). Interestingly, the high amount of lauric acid present in BSF is not common in other insects (MAKKAR et al., 2014; OONINCX et al., 2015; PINO MORENO and GANGULY, 2016; LILAND et al., 2017). The n6/n3 ratio, as a health indicator, is very high in BSFL tissues, which makes BSFL lipids less nutritionally desirable (OONINCX et al., 2020).

In order to optimize the n6/n3 ratio and modify the unfavourable fatty acid profile in BSFL tissue, we performed a feeding trial using feeding media enriched with fish, linseed and coconut oil, in concentrations ranging from 2.5 to 5%. Using these specific oils, we tested the plasticity of the fatty acid profile of BSFL tissues, including: a) the possibility of accumulation of alpha linolenic (ALA) acid in BSFL tissues, b) the bioconversion of ALA to important long chain n3 PUFA (docosahexaenoic, DHA; eicosapentaenoic acid, EPA), c) the extent of DHA and EPA accumulation in BSFL tissue, and d) the influence of high dietary content of lauric acid on its content in BSFL tissue.

Materials and methods

Rearing of insects and experimental design. Black soldier fly eggs and adults were obtained from the certified commercial breeder, "Insektarij" in Zagreb, Croatia. *Hermetia illucens* eggs were incubated inside a closed container (47 cm length x 32 cm width x 23 cm height) at 27.0 °C ± 2 °C and ~60% relative humidity. Strips of corrugated cardboard filled with the eggs were placed over 2 kg of the control diet (Table 1) mixed with water (70%). The strips were not in direct contact with the substrate. After the eggs hatched, the larvae were left to feed undisturbed until the 7th day (nursery phase). On the 7th day, the larvae were weighed (1.0 g, ≈130 larvae), counted, and transferred into non-transparent plastic containers (38 cm length x 28 cm width x 20 cm height) with transparent lids, to prevent the larvae from escaping (Figure 1A). The containers contained the control or experimental feeding media in excess (2 kg) to prevent the influence of other variables on the results (competition for the food, variability in mortality). Groups were formed using two different concentrations of fish, linseed or coconut oil (2.5 or 5%, Figure 1A). Every group had four replicates (twenty-eight containers in total). The feeding media were thoroughly mixed with water (70% moisture). All feeding experiments were conducted in a temperature and moisture-controlled environment (temperature 28 °C ± 2 °C; relative humidity ~80%).

Table 1. Ingredient composition and nutrient content of experimental diets

Item	Control	L2.5%	L5%	F2.5%	F5%	C2.5%	C5%
Ingredients (%)[1]							
Corn	40.0						
Wheat bran	13.0						
Soybean meal	21.1						
Yeast	5.0						
Sunflower meal	10.5						
Mineral and vitamin mix[2]	5.0						
Supplemented oils							
Sunflower oil	5	2.5	0	2.5	0	2.5	0
Linseed oil	0	2.5	5	0	0	0	0
Coconut oil	0	0	0	2.5	5	0	0
Fish oil	0	0	0	0	0	2.5	5
Calculated composition (%)[3]							
Crude protein	22.3						
Crude fat	7.1						
Crude fibre	2.8						
Crude ash	5.2						
Calcium	0.9						
Phosphorus	0.7						
Fatty acid composition (% of total fatty acids)							
C10:0	0.0	0.0	0.0	0.0	0.0	2.7	3.9
C12:0	0.9	0.2	0.1	0.0	0.0	32.7	38.0
C14:0	0.5	0.7	0.5	1.8	2.3	13.2	16.8
C16:0	15.9	19.9	9.1	18.4	16.4	22.2	19.7
C16:1n7	0.6	0.0	0.0	4.3	6.1	0.0	0.0
C18:0	4.4	21.2	12.1	5.0	4.4	5.6	4.8
C18:1n9	29.5	20.0	25.3	24.9	26.1	9.4	9.7
C18:1n7	1.3	0.0	0.0	0.0	0.0	0.0	0.0
C18:2n6	44.7	11.6	17.4	25.5	12.9	14.1	7.1
C18:3n3	1.8	26.0	35.1	1.0	2.4	0.0	0.0
C18:4n3	0.0	0.2	0.2	1.1	1.6	0.0	0.0
C20:1n9	0.4	0.2	0.3	0.2	0.8	0.0	0.0
C20:4n3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C20:5n3	0.0	0.0	0.0	9.3	15.6	0.0	0.0
C22:5n3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C22:6n3	0.0	0.0	0.0	8.6	11.4	0.0	0.0
Summarized fatty acid profile[4]							
n6	**44.7**	11.6	17.4	25.5	12.9	14.1	7.1
n3 (C18)	1.8	**26.1**	**35.3**	2.1	4.0	0.0	0.0
n3 LCPUFA[4] (C20+C22)	0.0	0.1	0.0	**17.9**	**27.1**	0.0	0.0
MCFA[5] (C10+C12)	0.9	0.2	0.1	0.0	0.0	**35.4**	**41.9**

[1] Ingredients and composition are identical in the control and all experimental groups

[2] Mineral and vitamin mix comprising per kg: Ca, 180 g; P, 50 g; Na, 23 g; Methionine, 50 000 mg; Lysine, 24,000 mg; retinol acetate, 300,000 IU; cholecalciferol, 40,000 IU; DL; tocopheryl acetate, 600 mg; menadione, 40 mg; thiamine hydrochloride, 20 mg; riboflavin sodium phosphate, 120 mg; pyridoxine, 40 mg; cyanocobalamine, 300 µg; C, 300 mg; niacin, 800 mg; calcium pantothenate, 240 mg; folic acid, 10 mg, biotin, 2 mg; choline chloride, 10,000 mg; Fe, 1200 mg; I, 1200 mg; Cu, 100 mg; Mn, 1600 mg; Co, 3 mg; Zn, 1000 mg; Se, 3 mg; BHT antioxidant, 3000 mg.

[3] The most characteristic fatty acids for experimental groups are marked in bold.

[4] LCPUFA: long chain polyunsaturated fatty acids (fatty acids with 20 and 22 carbon atoms).

[5] MCFA: medium chain fatty acids (C10: decanoic and C12: lauric fatty acid)

Measurements. On the 14th day, the larvae were removed from the containers and washed in water to remove feeding media residues. Access water was removed by air-drying. The larvae were weighed individually using an electronic balance (AW320, Shimadzu, Japan), and their length was determined on photographs by measuring software (IC Measure, The Imaging Source Europe GmbH, Bremen, Germany). Other life stages used for the fatty acid analyses were collected when available (Figure 1B).

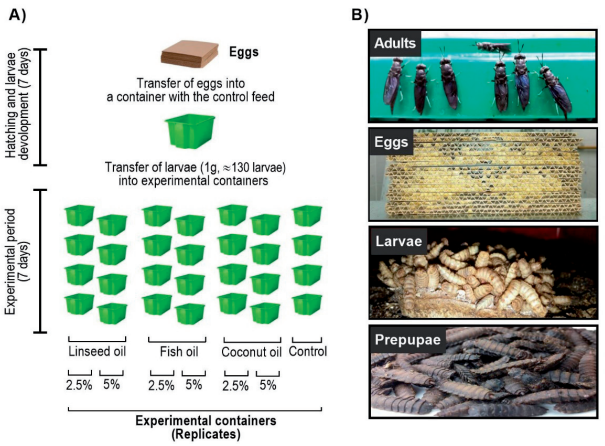

Fig. 1. A) Experimental design. B) Different life stages of BSF that were tested for the fatty acid profile. BSF stages were distinguished using characteristic features.

Fatty acid analyses. All chemicals were HPLC grade, provided by Sigma-Aldrich Sigma (Sigma–Aldrich, Steinheim, Germany). The larvae were killed by freezing, and individually homogenized for lipid extraction (12 larvae per replication). The lipids were extracted according to FOLCH et al. (1957) using a chloroform/methanol mixture (2:1, v/v). Total lipids were extracted from whole homogenized insects with the addition of butylated hydroxytoluene as an antioxidant (30 mg per 100 ml), and nonadecanoic acid (C19:0) as an internal standard. Transmethylation was performed using 2M KOH in methanol at room temperature. The analysis of fatty acid methyl esters was performed by a Shimadzu GC-MS QP2010 Ultra Gas Chromatograph Mass Spectrometer (Shimadzu, Kyoto, Japan) with a capillary column BPX70 (0.25 mm internal diameter, 0.25 µm film thickness, 30 m long, SGE, Austin, TX, USA) and helium as the carrier gas, as previously described (STARČEVIĆ et al., 2017). The injector temperature was 250 °C, the injection volume was 1 µL, the split ratio was 1:80, and linear velocity was 35 cm/s. The oven program was set as: initial temperature - 40 °C, held for 3 min, then increased at the rate of 20 °C/min up to 130 °C, then increased at 1.5 °C/min up to 200 °C, and then increased at 45 °C/min up to 250 °C and held for 10 °C. The results of fatty composition were expressed as the percentage of total fatty acids.

Statistical analyses. The data were analysed using one-way analysis of variance (ANOVA) followed by the Tukey test in order to determine statistical differences between different experimental groups vs. the control, and additionally within the same treatment (2.5 vs. 5%). Data were analysed using Statistica software (STATISTICA 12 program, Tulsa, OK, USA). The statistical significance was set at $P<0.05$.

Results

We first investigated the fatty acid composition in different BSF life stages (Fig. 2A, B, C). The main groups of fatty acids differed significantly in the life stages, with an increasing content of saturated fatty acids (SFA) and a decreasing content of polyunsaturated (PUFA) and monounsaturated fatty acids (MUFA) from the larvae to the egg. Individual SFA were also different with an increase in C12:0 and a decrease in C16:0 from the larvae to the egg. Individual PUFA and MUFA contents significantly decreased from the larvae to the egg. The only fatty acid that strongly increased during the maturation of BSF and further in the egg was C12:0.

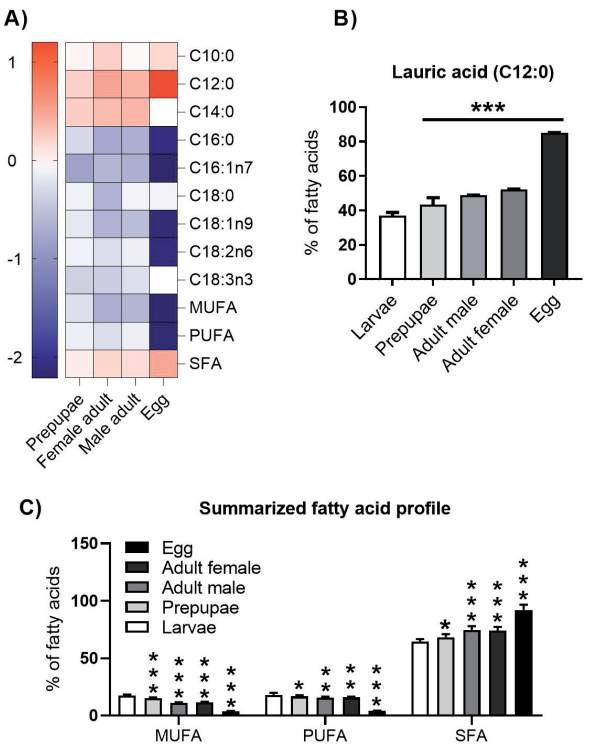

Fig. 2. The influence of life stage and sex on the fatty acid profile of BSF: A) Heat map showing differences in the fatty acid profile of different life stages of BSF versus the larvae (log_2 fold change), B) The content of lauric acid in the different life stages and C) Summarized fatty acid profile of different life stages (MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids and SFA: saturated fatty acids). *P< 0.05, **P< 0.01 and ***P< 0.001 different stages vs. the larvae.

The weight and length of the BSFL fed on the feeding media enriched with the different oils are presented in Fig. 3. Different oils and oil concentrations did not have any statistically significant influence on the weight and length of the BSFL.

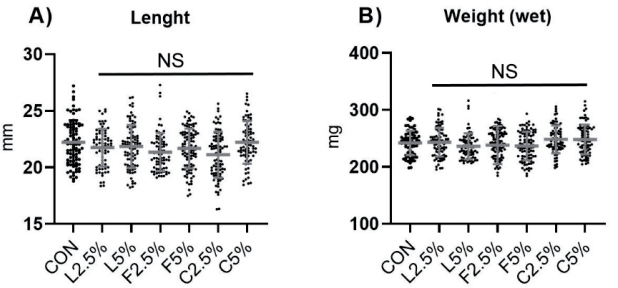

Fig. 3. The influence of different oils and oil concentrations on BSFL weight and length. CON: Control (control diet); L 2.5%: 2.5% of linseed oil added; L 5%: 5% of linseed oil added; F 2.5%: 2.5% of fish oil added; F 5%: 5% of fish oil added; C 2.5%: 2.5% of coconut oil added; C 5%: 5% of coconut oil added; NS: not significant vs. the control diet.

Total fat content of BSFL (wet tissue) ranged from 10.95 % (±1.74) to 12.62 % (±2.20) and values were not significantly different between the experimental groups. The addition of 2.5 and 5% oils into the feeding media had a significant effect on the fatty acid profile of the BSFL (Table 2). The amount of lauric acid, which was already very high in the control group, increased considerably with the addition of coconut oil, while fish oil had the opposite effect. Eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids were detectable only in the groups with the addition of fish oil, with the exception of EPA that was detectable in very low quantities in the group supplemented with 5% linseed oil. The high n6/n3 ratio decreased significantly in the fish and linseed oil groups, as opposed to the coconut oil groups where the ratio did not change significantly.

Table 2. The influence of oil addition and oil concentration on the fatty acid profile of BSF larvae (% of total fatty acids)

	CON[1]	L2.5%	L5%	C2.5%	C5%	F2.5%	F5%
C10:0	0.61±0.05	0.55±0.08	0.51±0.03*	0.60±0.04	0.76± 0.09	0.24±0.01***,a	0.53± 0.02*,b
C12:0	37.3±0.57	37.4±2.11a	32.6±1.90*,b	38.6±1.46a	43.3±2.71*,b	20.7±0.89***,a	30.4±1.86**,b
C14:0	7.99±0.33	7.84±0.26a	6.57±0.42*,b	9.4± 0.27***,a	11.5± 0.19***	4.91±0.32***,a	6.74±0.24**,b
C16:0	18.6±0.48	17.8±0.95a	15.9±0.32***,b	17.4±0.71	16.4± 0.48**	20.3±0.25**,a	17.2±0.67*,b
C16:1n7	1.74±0.27	1.37±0.18*,a	0.97±0.08**,b	1.48±0.17	1.65±0.15	2.63±0.20**,a	3.79± 0.17***,b
C18:0	2.72±0.08	2.40±0.25	2.70±0.20	2.58±0.24	2.42±0.25	7.67±0.61*	2.77±0.20
C18:1n9	14.3±0.57	13.5±0.56a	13.9±0.19b	13.3±0.47a	11.39±0.60**,b	20.5±1.08**	17.8±0.73**
C18:1n7	0.64±0.13	0.55±0.02	0.48±0.04*	0.50± 0.03*	0.44± 0.07*	0.95±0.36a	1.71±0.18**,b
C18:2n6	15.2±0.28	14.2±0.69	14.0±0.84	15.0±0.49a	11.3±1.06**,b	19.2±.28*,a	13.8±0.14b
C18:3n3	0.82±0.06	4.12±0.85**,a	12.0±0.87**,b	0.87±0.03	0.66±0.17	1.22±0.21	0.87±0.06
C18:4n3	*nd*	0.03±0.03	*nd*	*nd*	*nd*	*nd*	0.32±0.01
C20:1n9	*nd*	*nd*	*nd*	*nd*	*nd*	0.19±0.17a	1.16±0.17b
C20:5n3	*nd*	*nd*	0.16±0.00	*nd*	*nd*	1.14±0.26a	2.20±0.17b
C22:6n3	*nd*	*nd*	*nd*	*nd*	*nd*	0.14±0.13a	0.58±0.09b
n6	15.2±0.28	14.2±0.69	14.0±0.84	15.0±0.49a	11.3±1.06**,b	19.2±1.28*,a	13.8±0.14b
n3	0.82±0.06	4.16±0.82**,a	12.1±0.87**,b	0.87±0.03	0.66±0.17	2.50±0.56*,a	3.96±0.25**,b
n6/n3	18.7±1.17	3.52±0.71***,a	1.15±0.01***,b	17.4±0.07	17.5±2.56	7.91±1.48**,a	3.49±0.20***,b
MUFA	16.6±0.91	15.4±0.72	15.4±0.15	15.3±0.37a	13.4±0.81**,b	24.3±1.80*	24.5±1.04***
PUFA	16.0±0.33	18.4±0.87*,a	26.1±1.70**,b	15.9±0.51a	11.9±1.23**,b	21.7±1.75*	17.7±0.36*
SFA	67.2±0.82	66.1±1.20a	58.4±1.85**,b	68.7±0.80a	74.5±1.98**,b	53.9±3.18*	57.7±1.36*

[1] CON: Control (control diet); L2.5%, 2.5% of linseed oil added; L5%, 5% of linseed oil added; C2.5%, 2.5% of coconut oil added; C5%, 5% of coconut oil added; F2.5%, 2.5% of fish oil added; F5%, 5% of fish oil added.*P< 0.05, **P< 0.01 and ***P< 0.001 significant vs. Control; [a-b] values within the same oil treatment with different superscripts differ significantly. *nd*, not determined (bellow quantification level)

Discussion

The nutritional composition of BSFL may be substantially altered by changing the feeding media (OONINCX et al., 2015; STARČEVIĆ et al., 2019). In order to test the ability for improving the lipid composition, we reared BSFL in feeding media enriched with different percentages of fish, linseed and coconut oil. The choice of oils was to evaluate several key points of lipid metabolism in BSFL. The fish oil was used to evaluate the transfer of EPA and DHA from feeding media to BSFL tissues, while the linseed oil was used to evaluate the *in vivo* bioconversion of ALA into EPA and DHA. Lastly, coconut oil was used to assess lauric acid metabolism due to the high content of that fatty acid in both the coconut oil and the BSFL tissues.

First, we evaluated the influence of oil type and percentage on the length and weight of the BSFL, for possible adverse effects. In some insects (e.g. *Gryllus assimilis*), adverse effects are connected with a higher content of supplemented oils (STARČEVIĆ et al., 2017). Our trial showed that the oil type and percentage (from 2.5 to 5%) did not influence BSFL length and weight. The overall weight and length of BSFL in all groups was within the limits reported in other trials (BANKS et al., 2014; STARČEVIĆ et al., 2019).

The type and percentage of the oil used significantly influenced the fatty acid profile of the BSFL, including the n6/n3 ratio and the content of MUFA, PUFA and SFA. The n6/n3 ratio is nowadays an important indicator of dietary lipid quality and its possible influence on health (SIMOPOULOS, 2016). The n6/n3 ratio was drastically improved in the groups fed with fish oil and linseed oil, with even lower values with higher percentages of oils. Unfortunately, in edible insects interesting for mass production (e.g. crickets) the n6/n3 ratio is very high, making the lipids obtained from these species less desirable (STARČEVIĆ et al., 2017). Therefore, the enrichment of feeding media with n6/n3 ratio lowering oils for these species could be an interesting nutritional strategy. The content of PUFA and, especially, the beneficial

long chain n3 PUFA (DHA and EPA) is also very low in these insect species. The addition of linseed oil significantly increased the accumulation of ALA in BSFL tissue (from 4 to 12%) in our trial. The extent of accumulation of ALA in BSF tissue is comparable or even higher compared to different organs of broilers fed with 5% of linseed oil (MAŠEK et al., 2014). Unfortunately, in the linseed oil supplemented BSFL, the DHA content was not detectable, while the EPA content was only detectable in the 5% supplemented group. These data imply that bioconversion of ALA to EPA and DHA is very low in BSFL tissues. In contrast, fish oil supplementation increased DHA and EPA concentrations in a dose dependent way.

Concerning the fatty acids essential for mammals, LA and ALA, it should be noted that some insects such as *Acheta domesticus, Gryllus spp.* and *Periplaneta americana*, possess Δ^{12} desaturase (CRIPPS et al., 1986; BLOMQUIST et al., 1991), which allows *in vivo* synthesis of these fatty acids in these insects.

Among the individual fatty acids, the BSFL tissue was characterized as having a very high content of lauric acid, which was also observed in previous trials (MAKKAR et al., 2014; OONINCX et al., 2015; EWALD et al., 2020). In contrast, in other potentially interesting insects the content of lauric acid is very low or even undetectable (FINKE, 2013; MAKKAR et al., 2014; STARČEVIĆ et al., 2017). The content of lauric acid increased further in groups supplemented with coconut oil, but decreased in the groups supplemented with fish oil. Concerning lauric acid, it is evident that the fatty acid profile of BSFL does not depend solely on the feed composition, but is also species-specific (OONINCX et al., 2015; EWALD et al., 2020). The content of lauric acid strongly changed during the maturation of the BSF in our trial. Changes in fatty acid composition during development are not uncommon, and they have been reported in various insect species (STANLEY-SAMUELSON et al., 1988; LI et al., 2016). LIU et al. (2017) described the changes in lauric acid concentration during BSF maturation, with values slightly different in comparison to our results. Nevertheless, the trend was similar as in our trial, with the highest concentration of lauric acid in the eggs and the lowest content in the larvae. These differences could be attributed to the variations in the fatty acid composition of the feeding media. The content of lauric acid in our trial was low in the feeding media, which means that it originated from BSF metabolism. Lauric acid is interesting for its anti-microbial and anti-fungal properties (NAKATSUJI et al., 2009). Many insect species produce substances that have antimicrobial properties, including BSF, which enable them to grow easily in different environmental conditions (CHOI et al., 2012). The natural growth media of BSF is heavily contaminated with different microorganisms, which makes BSFL's antimicrobial defence extremely important. Therefore, their antimicrobial properties, as well as possible use as biodiesel fuel (LEONG et al., 2016), make lauric acid an interesting additional product in BSF rearing.

In 2017, the use of insects in fish feed was approved by the EU (EU Regulation 2017/893), while approval for their use in feed for poultry and pigs was authorized in 2021 (EU Regulation 2021/1372). Since 2017 the safety of the food and feed that contain insects has become an even more important topic. There are some possible hazards, such as: heavy metals (VAN HUIS, 2015; PURSCHKE et al., 2017), and different pathogens - viruses, bacteria, microsporidia, fungi and nematodes, although they are specific to invertebrates and generally should not be harmful for vertebrates (EILENBERG et al., 2015). For that reason, protocols for disease monitoring should be used to control rearing systems, and to prevent the emergence of any disease in insects used for feed or food.

Our data showed that the addition of 2.5 and 5% of different oils could significantly improve the lipid composition of BSFL, without affecting the growth rate. Using different oils, the lipid composition could be specifically changed to increase the beneficial long chain n3 PUFA, to increase ALA content or to increase the content of lauric acid. The investigations into how to improve the feed conversion and the quality of BSFL reared on permitted feed components should be continued.

Conflict of interest
The authors have declared no conflict of interest.

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Author contribution
Tomislav Mašek designed the study and performed GC-MS analyses. Liča Lozica and Aleksandar Gavrilović performed trial on animals. Liča Lozica wrote the manuscript with support from Tomislav Mašek and Kristina Starčević.

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LOZICA, L., K. STARČEVIĆ, A. GAVRILOVIĆ, T. MAŠEK: Utjecaj supstrata obogaćenog različitim uljima na masnokiselinski sastav crne vojničke muhe (*Hermetia illucens*). Vet. arhiv 92, 291-300, 2022.

SAŽETAK

Crna vojnička muha (*Hermetia illucens*) zanimljiv je alternativni izvor bjelančevina u hrani za životinje zahvaljujući mogućnosti uzgoja u različitim vrstama supstrata. Iako uzgoj navedene muhe ima mnoge prednosti, njezina primjena je ograničena zbog nepovoljnog masnokiselinskog sastav koji obilježava visoki udio laurinske kiseline i niski udio višestruko nezasićenih masnih kiselina. Pokus je napravljen u svrhu istraživanja mogućnosti promjene lipidnog sastava larvi crne vojničke muhe primjenom ribljeg, lanenog ili kokosova ulja (1, 2,5 i 5 %) u supstratu za uzgoj. Larve u dobi od dva tjedna prikupljene su, izvagane i izmjerene te je analiziran njihov masnokiselinski sastav. Rezultati su pokazali znakovitu varijabilnost sastava masnih kiselina, ovisno o razvojnom stadiju i sastavu supstrata. Dodatak ulja u koncentraciji od 2,5 i 5 % znakovito je promijenio masnokiselinski sastav larvi, na što su utjecaj imali vrsta i postotak ulja. Omjer n6/n3 znakovito je poboljšan primjenom ribljeg i lanenog ulja. Primjenom lanenog ulja povećan je udio linolenske kiseline iako je biokonverzija u eikozapentaensku i dokozaheksaensku kiselinu bila niska. No, dodatak ribljeg ulja znakovito je povećao udio eikozapentaenske i dokozaheksaenske kiseline u larvama. Također, udio laurinske kiseline bio je znakovito povećan primjenom kokosova ulja. Rezultati su pokazali da se primjenom različitih vrsta ulja može utjecati na lipidni sastav larvi crne vojničke muhe u svrhu povećanja udjela n-3 dugolančanih višestruko nezasićenih masnih kiselina, odnosno s ciljem povećanja udjela linolenske ili laurinske kiseline.

Ključne riječi: larva crne vojničke muhe; masne kiseline; razvojni stadij; stopa rasta