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Method for Obtaining High-Energy Feed Protein and Fat from Insects

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Abstract: Insects are a valuable and renewable source of feed and food protein and fat. They have an amino acid composition similar to that of fishmeal and meat, and can serve as a worthy replacement for them. The aim of this study was to substantiate the technological parameters of the process of obtaining fat from the *Hermetia illucens* larvae by a mechanical method on a screw press. A laboratory screw press was used for this research. Before squeezing out the fat, the dried larvae were moistened, crushed and heated in a microwave oven to a temperature of 60 °C. The fat from the larvae was squeezed out in a screw press at different larval moisture levels, screw speeds and cake outlets. The results of this study made it possible to obtain optimal technological parameters for obtaining fat on a screw press: a screw rotation speed of no more than 20 ± 5 rpm; a diameter of the hole for the cake outlet of no more than 7–10 mm; a mass fraction of moisture in the pressed material of 8 ± 2%. The obtained fat fraction was tested for one of the main indicators of fat quality—acid number. It was found that the variable factors do not have a significant effect on the acid number of fat, changing it within the normal range of 10 mg KOH per 1 g of fat, which makes it possible to obtain a good quality product.

Keywords: insects; feed; alternative protein sources; feed protein; insect fat; *Hermetia illucens*; fat pressing; screw press; microwave frequencies

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1. Introduction

According to FAO [1], as the population increases, the demand for food increases. A special role in human nutrition belongs to products of animal origin, in particular fish products, which are rich in proteins with an amino acid profile close to the ideal protein, and polyunsaturated fatty acids, including Omega-3 fatty acids, which perform a number of functions, such as plastic, energy and others [2].

The quality of fish products depends on many factors, including the feed that the fish were fed throughout their life cycle [3]. Poor quality feed has a negative impact on the consumer properties of meat. Fish feed, especially valuable species such as sturgeon and salmon, differs from feed for other animals in its high protein and fat content. The protein content in them reaches 50–60% and higher and fat, up to 20%.

The main sources of protein and fat in feed are fishmeal and fish oil. It is obtained from small pelagic fish (protein content 70–72%), large fish (protein content 64–67%) and from processed fish products (59–61%) [4]. According to FAO [5], consumption of world fisheries and aquaculture products for food purposes is increasing, while consumption for non-food uses (including feed production) is decreasing. This leads to an increase in the shortage of fishmeal and fish oil, rising prices and falsification [6]. Therefore, an urgent task of feed production is the search for alternative sources of protein and fat, and the development of technologies, methods and ways of obtaining them [7].

Insects have long been considered by scientists as a renewable source of feed and food protein and fat. Due to their ability to reproduce quickly on organic substrates, including food waste and manure, without releasing toxic substances, insects can be considered as an environmentally friendly way to dispose of waste. Insects have an amino acid composition similar to that of fishmeal and meat and can serve as a worthy replacement [8–12].

The most frequently used insects as feed and food raw materials are the *Hermetia illucens* larvae [8], *Bombyx mori* [9], *Zophobas morio* [10], *Locusta migratoria* [11], *Tenebrio molitor* [13], *Tettigonia viridissima* and *Lumbricina* [12] and others.

The larvae of *Hermetia illucens* have a number of advantages over other insects:

- Fast growth compared to *Tenebrio molitor* by 0.5–1 month [13];
- The diet of *Tenebrio molitor*, *Bombyx mori*, *Tettigonia viridissima*, *Locusta migratoria* is based on dry plant products such as grain, flour, compound feed, dried fruits, etc., while the larvae of *Hermetia illucens* can process any organic waste, including manure [13];
- *Hermetia illucens* is slower and calmer, making it easier to grow than other flies, such as *Tettigonia viridissima* and *Locusta migratoria* [13].

Insect processing products (protein, fat, chitin, etc.), including those from the *Hermetia illucens* larvae, are permitted to be used in feeding various farm animals, birds and fish (Commission Regulation (EU) No. 2021/1372 dated 17 August 2021, Regulation (EU) No. 1925/2006 of the European Parliament and the Council dated 20 December 2006, Order of the Government of the Russian Federation dated 25 January 2017 No. 79-r). Using the whole larva in animal feeding is not effective, since the protein and fat content in feed varies for each animal species, so separating the *Hermetia illucens* larvae into protein and fat is an urgent task.

The main methods for obtaining fat and oil are mechanical pressing on screw or plunger presses, water extraction and extraction with chemical solvents [8,13–27]. In studies conducted by scientists in [8,13–18], the separation of fat from the protein part of insects occurs by water extraction or extraction with chemical solvents. Despite their effectiveness [8,13–18], they have a number of disadvantages: extraction with chemical solvents has a negative impact on the quality of the oil compared to the mechanical method of obtaining fat [19,20]; bulkiness and high cost of extraction equipment; duration of the process (from 1.5 to 6 h) and high-pressure values (25–35 MPa) [17]. One promising method for separating the *Hermetia illucens* larvae into protein and fat fractions is to extract the fat using a screw press. In one study [22], scientists compared the energy costs of extracting oil from plant materials using a screw press, a plunger press, and solvent extraction. The results of the study showed that the minimum energy consumption is observed when using a screw press. With mechanical pressing, the quality characteristics of the oil are higher than with solvent extraction [19,20]. Conducting research on the study of the process of squeezing fat from the *Hermetia illucens* larvae and substantiating its optimal parameters is a relevant area of research.

2. Materials and Methods

2.1. Material for Research—Larvae of the Hermetia illucens

For this research, dried *Hermetia illucens* larvae were purchased from Ecobelok LLC (Russia, Moscow region, Shchelkovsky district, Fryanovo settlement) [21]. The moisture content of the *Hermetia illucens* larvae was 6%.

The mass fraction of moisture in the larvae was determined by drying in a drying box until constant mass was reached. For this, a 5 g sample was placed in a drying container and sent to a drying box. Drying was carried out for 4 h at a temperature of 105 °C. Then, the dried sample was weighed and sent to a drying box for another 30 min at the same temperature and then weighed. This procedure was carried out until the sample mass stopped decreasing. The final result was taken as the arithmetic mean of two parallel measurements. The discrepancy between two parallel measurements was no more than 0.2%.

2.2. Variable Factors and Criteria for Evaluating the Efficiency of a Screw Press

Based on the analysis of references [22–27], 3 factors were identified that have the greatest influence on the process of oil (fat) extraction: mass fraction of moisture of the pressed material, % (W), auger rotation speed, rpm (n) and the diameter of the hole for the outlet of the cake, mm (d), κ, which directly affects the pressure created in the working chamber of the screw press and, accordingly, the efficiency of the pressing process (Table 1).

Table 1. Designation of levels of variation by factors.

Factors		Levels					I	Dimension
		−1.682	**−1**	**0**	**1**	**1.682**		
W	x1	6.0	7.8	10.5	13.2	15.0	2.7	%
n	x2	5.0	11.3	20.5	29.7	36.0	9.2	rpm
d	x3	6.0	7.2	9.0	10.8	12.0	1.8	mm

The second-order rotatable central compositional design was chosen for the experimental design. The choice of such an experimental design is justified by the minimization of systematic errors associated with the inadequacy of the representation of results by second-order polynomials. With the number of variable factors of = 3, the stellar shoulder was calculated using Formula (1):

$$\alpha = 2^{\frac{\kappa}{4}} = 1.682 \tag{1}$$

The number of experiments N_o was determined by Formula (2):

$$N_o = 2^{\kappa} + 2\kappa + \kappa_o \tag{2}$$

$$N_o = 2^3 + 2 \times 3 + 2 = 16$$

The levels of variation of factors with a star shoulder of 1.682 are presented in Table 1.

The rotation frequency of the screw was changed by a frequency converter. The diameter of the hole for the outlet of the cake was varied by replaceable fittings (Figure 1).

Figure 1. Replaceable nozzles with variable diameter for cake outlet.

The experimental design matrix was compiled using the STATISTICA 10 program (Table 2).

The efficiency of the screw press was assessed by varying the selected factors using two criteria: the productivity of the screw press and its energy consumption. The productivity was assessed by weighing the pressed fat (fat productivity, Q_f, kg/h) and cake (kg/h) on VLTE-4100 laboratory scales (Gosmeter Company, St. Petersburg, Russia) (highest weighing limit—4.1 kg; lowest weighing limit—5 g; accuracy—0.01 g). The total volumetric productivity Q_o was determined by adding the productivity for fat Q_f and the productivity for cake Q_{oc}. The energy consumption of the screw press during operation with varying factors, such as N and kW h/kg (3), was measured using a universal digital multimeter DT-832 (Resanta Company, Shanghai, China) and a tachometer with removable attachments of the PCE-VT 204 type (PCE instruments, Meschede, Germany). Before the measurement, the equipment was calibrated in accordance with the instructions for use. The measurements were carried out in triplicate, and the average value of three measurements was taken as the final result.

$$N = \frac{N_p}{Q_o} \quad (3)$$

where N_p is the power consumed by the screw press, kW [26].

Table 2. Values of variable factors for each experiment.

Number of the Experiment	Final Moisture Content of the Larvae, %	Auger Rotation Speed, rpm	Diameter of the Hole for the Outlet of the Cake, mm
1	7.8	11.3	7.2
2	7.8	11.3	10.8
3	7.8	29.7	7.2
4	7.8	29.7	10.8
5	13.2	11.3	7.2
6	13.2	11.3	10.8
7	13.2	29.7	7.2
8	13.2	29.7	10.8
9 (C)	10.5	20.5	9.0
10	6.0	20.5	9.0
11	15.0	20.5	9.0
12	10.5	5.0	9.0
13	10.5	36.0	9.0
14	10.5	20.5	6.0
15	10.5	20.5	12.0
16 (C)	10.5	20.5	9.0

All measuring equipment undergoes annual verification in accredited laboratories, which ensures the necessary measurement accuracy. The experimental results were processed using Microsoft Excel 2013 and STATISTICA 10.

2.3. Preparation of Insects for Pressing

Dried *Hermetia illucens* larvae (Figure 2a) were moistened with tap water to values from 6 to 15% according to the experimental design matrix (Table 2). For each experiment, 3 kg of dried larvae was weighed, placed in a horizontal mixer SG-1.5 (Agropostavka, Nizhny Novgorod, Russia) and water was added by spraying it through nozzles. The amount of water m_w required to bring the *H. illucens* larvae to the required humidity was determined using Formula (4):

$$m_w = m_l \cdot \frac{W_2 - W_1}{100 - W_2} \quad (4)$$

where m_l is mass of crushed moistened fly larvae, g; W_1 is initial humidity, %; and W_2 is final humidity, %.

Figure 2. Dried *Hermetia illucens* larvae: (**a**) whole; (**b**) crushed.

Moistening was carried out for 2 h with periodic stirring. During this time, moisture penetrated and spread throughout the entire volume of the larvae [28].

After moistening, the *Hermetia illucens* larvae were ground in a laboratory knife mill to a particle size passing through a 1.0 mm sieve of at least 60% [29] (Figure 2b). During grinding, partial destruction of fat-containing cells occurred, which ultimately increased its yield [30]. Thus, the size of the larvae did not affect the pressing process, since before pressing it was crushed and thus became homogeneous.

The crushed mass was heated in a microwave oven with a power of 1000 W to a temperature of 60 ± 5 °C. Microwave treatment reduces the viscosity of fat [29], partially destroys cells containing fat, which promotes a more intensive release of fat during pressing [29] and has a disinfecting effect [18,30,31].

The prepared mass entered the working chamber of the screw press, where the fat was squeezed out. Figure 3 shows the diagram of the mechanical extraction of fat from the *Hermetia illucens* larvae.

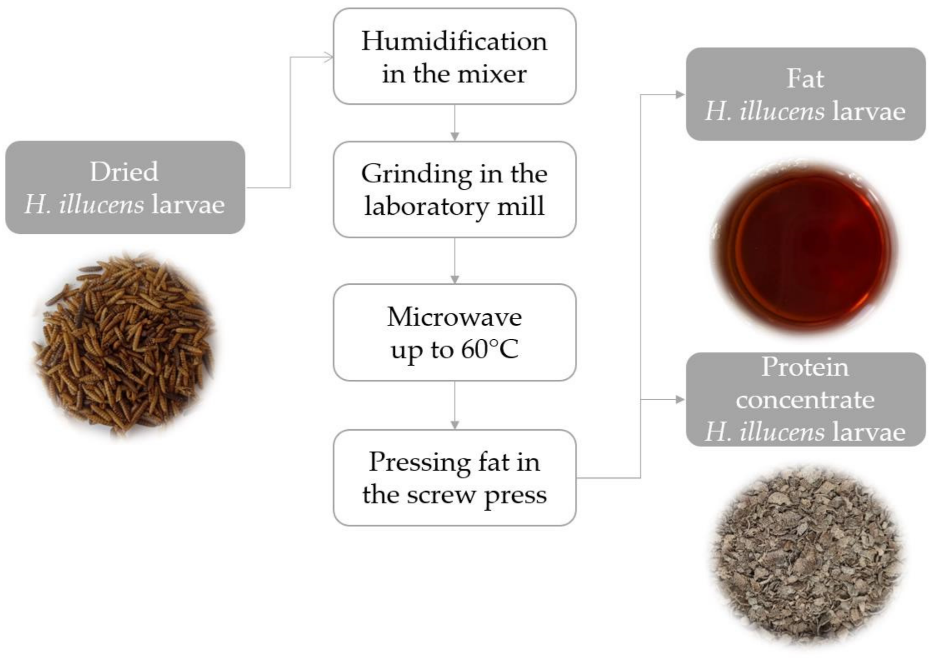


Figure 3. Scheme of mechanical extraction of fat from *Hermetia illucens* larvae.

2.4. Laboratory Screw Press for Research

To conduct the research, a laboratory screw press from the Belogorye company, Russian Federation, was selected (Figure 4). The working element of the screw press is a grain chamber with round holes with a diameter of 0.8 mm (the size of such a hole ensures an intensive outflow of squeezed fat and does not allow the protein part to pass through [29]) and a screw with a flight depth of 1.5 mm, a flight thickness of 5 mm, a flight length of 290 mm, a diameter of 50 mm, a flight pitch of 20 mm and a helical line angle of 8°.

Figure 4. General view of the laboratory screw press: 1—receiving bin; 2—electric drive; 3—extracting box; 4—heating element to maintain the temperature of the press.

The technical characteristics of the laboratory screw press are presented in Table 3.

Table 3. Technical characteristics of the laboratory screw press of the Belogorye company, Russian Federation.

Indicator Name	Values
Installed capacity, kW	4.0
Engine speed, rpm	1430
Voltage, V	220–240
Current frequency, Hz	50
Electric current strength, A	15.1–14.5
Maximum developed pressure in the working chamber, MPa	25
Overall dimensions, mm: length width height	 1250 950 680
Press weight, kg	250

The source of electricity for the screw press is an electric motor. The transmission of torque from the electric motor to the gearbox is carried out by means of a chain transmission, and to the auger by means of a belt transmission.

2.5. Analysis of Fat and Protein Fraction Quality

The acid number is the main indicator of the quality of veterinary fat. The acid number is the number of milligrams of potassium hydroxide required to neutralize free fatty acids contained in 1 g of fat or oil (standards for animal and vegetable fats and oils, which specify the determination of acid number and acidity [32]). For the application of the *Hermetia illucens* larvae fat in feed, the acid number value should not exceed 10 mg KOH per 1 g of fat (requirements for veterinary fat from fish and marine mammals [33].

At high temperatures and exposure to air, the acid number may increase [19,20]. Therefore, the fat of the *Hermetia illucens* larvae, obtained by pressing it on a screw press, was tested for acid number using the titrimetric method. The sample of the fat being analyzed was placed in a conical flask, to which a pre-neutralized mixture of diethyl ether and ethyl alcohol was added, and a solution of phenolphthalein (10 g of phenolphthalein dissolved in 1000 cm^3 of 95–96% ethyl alcohol solution) was used as an indicator. The resulting solution was titrated with potassium hydroxide 0.1 mol/dm^3 to the equivalence point of the indicator (pink color of phenolphthalein, stable for 10 s). Two determinations were performed on the same sample. The acid number was calculated using the following formula:

$$A_n = \frac{V \cdot c \cdot 56.1}{m} \tag{5}$$

where V is the volume of the used standard titrated solution of potassium hydroxide, cm^3; c is the concentration of the used standard titrated solution of potassium hydroxide, mol/dm^3; 56.1 is the mass of potassium hydroxide corresponding to 1 cm^3 of 1 mol/dm^3 of potassium hydroxide solution; and m is the sample weight, g.

The final result was taken as the arithmetic mean of two measurements.

Before the fat was pressed from *Hermetia illucens* larvae using a screw press, it was tested for the amount of fat it contained. Also, after squeezing, the protein portion of the larvae was examined for residual fat content.

The amount of fat in the samples was determined using the Soxhlet method [34]. For this purpose, a pre-crushed sample in the amount of 8–10 g was placed in an extraction cartridge (made of filter paper) and carefully sealed. Next, the cartridge with the analyzed sample was placed in a Soxhlet apparatus. Hexane solvent was used to extract fat. Extraction was carried out for at least 8 h. The end of extraction was set as follows: the hexane solution was taken from the Soxhlet extractor where the cartridge with the sample being studied was located; one drop of hexane was placed on the glass; after the solvent (hexane) evaporated, no greasy stain should remain as this would indicate the end of the extraction. After the extraction was completed, hexane was distilled off and the flask with oil was dried in a drying box for 1.5 h at a temperature of 105 °C. Next, the flask with oil was cooled in a desiccator and weighed on an analytical balance. After this, the flask was again placed in the drying box at the same temperature for 30 min. After the time had elapsed, the weighing was repeated. Drying was continued until constant weight was reached. Two determinations were performed on the same sample. The fat content in the analyzed samples in percentage was calculated using the following formula:

$$F = \frac{(m - m_1) \cdot 100}{m_2} \tag{6}$$

where m is the mass of the flask with fat, g; m_1 is the mass of empty flask, g; and m_2 is the sample weight, g.

The final result was taken as the arithmetic mean of two parallel determinations. The discrepancy between parallel determinations did not exceed 0.5%.

The selected methods of analyzing the quality of the obtained products ensure high measurement accuracy.

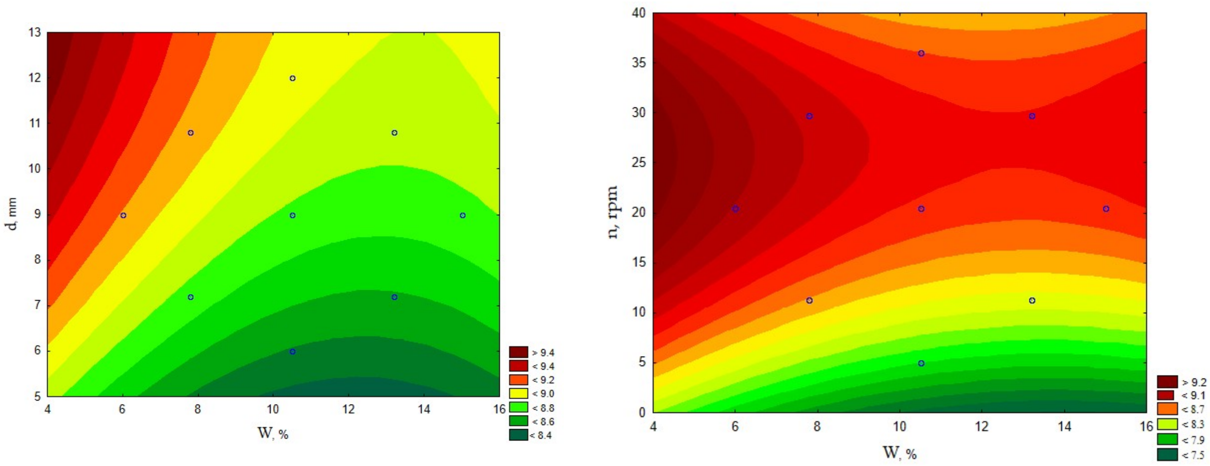
The fat content of the larvae will affect the productivity of the screw press. The higher the fat content, the higher the volume of fat fraction obtained. In this experiment, larvae with a fat mass fraction of 32% were used.

3. Results

3.1. Results of the Study of the Influence of Variable Factors on the Productivity and Energy Consumption of a Screw Press

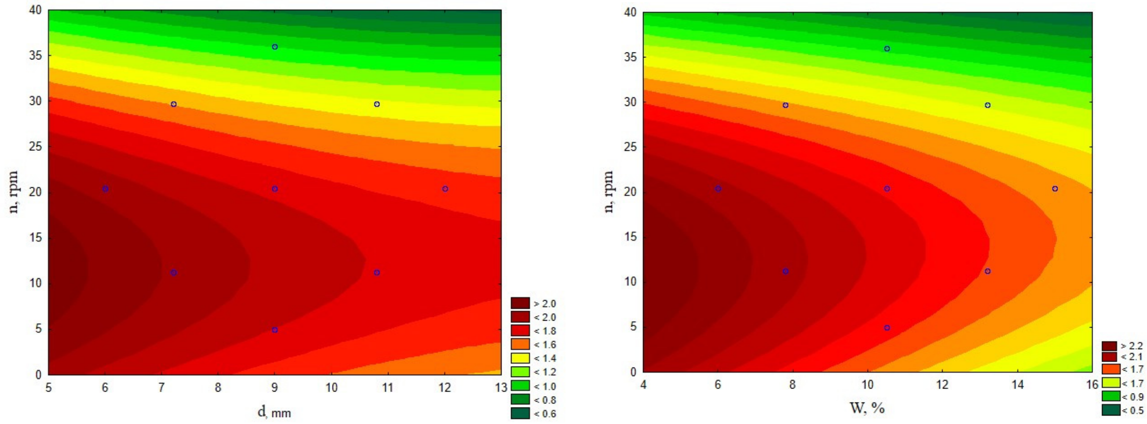
Fisher's criterion, according to the experimental values of productivity and energy intensity of the process do not exceed the tabulated values; therefore, the dispersions are homogeneous [35].

Based on the research results, the data presented in Figures 5–7 were obtained.



(**a**) (**b**)

Figure 5. The influence of variable factors on overall productivity Q_o, kg/h: (**a**) Influence of the mass fraction of moisture in the pressed material, W, % and the diameter of the hole for the outlet of the cake, d, mm; (**b**) influence of auger rotation frequency, n, rpm and the mass fraction of moisture in the pressed material, W, %.

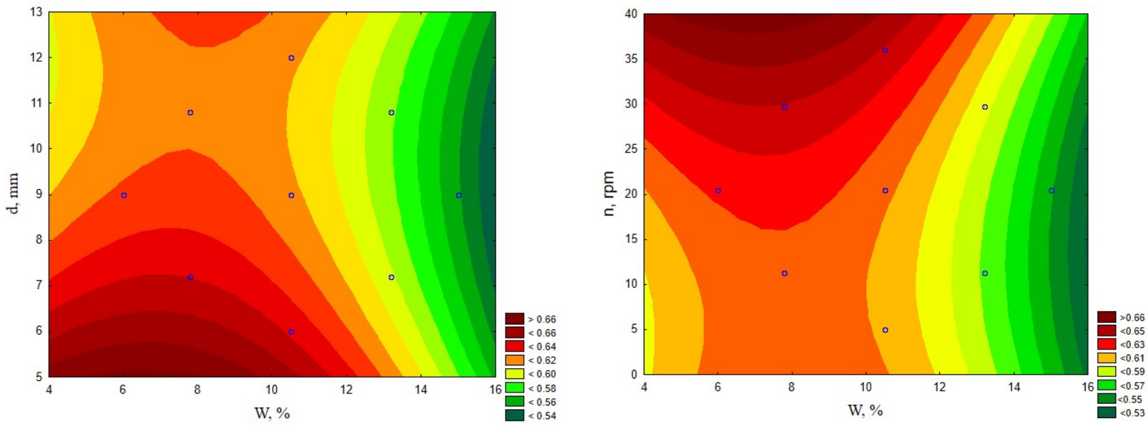


(**a**) (**b**)

Figure 6. Effect of variable factors on fat productivity, Q_f, kg/h: (**a**) Influence of auger rotation frequency, n, rpm and the diameter of the hole for the outlet of the cake, d, mm; (**b**) influence of auger rotation frequency, n, rpm and the mass fraction of moisture in the pressed material, W, %.

The influence of diameter on overall productivity. It is evident from Figure 5a,b that with an increase in the diameter of the hole for the cake outlet, d, mm, the total productivity, Q_o, kg/h increases. The increase in total productivity occurs when the value of d is more than 7 mm.

The influence of humidity on overall productivity. When the humidity of the pressed material is up to 8%, productivity increases slightly. The overall performance of the screw press decreases at moisture levels above 10% (Figure 5b). These data are consistent with the results presented in [26,36]. Thus, for squeezing oil from sunflowers [27], the optimal humidity is 6–7%, and for squeezing fat from greaves, it is 9–10%. The influence of material moisture on the spinning process from the point of view of physical and mechanical processes is described in detail in [22,36–39]. In these works, the authors note that with an increase in humidity, the material in the working chamber of the screw press becomes more plastic, resulting in the formation of a counterflow to the main flow (the pressed material passes through the gap between the screw turn and the inner wall of the working chamber of the press) [22,28,38,39].



(**a**) (**b**)

Figure 7. The influence of variable factors on the energy consumption of a screw press, N, kW h/kg: (**a**) Influence of the mass fraction of moisture in the pressed material, W, % and the diameter of the hole for the outlet of the cake, d, mm; (**b**) influence of auger rotation frequency, n, rpm and the mass fraction of moisture in the pressed material, W, %.

The influence of auger speed on overall productivity. The auger speed also has a significant impact on the overall performance of the press, accelerating the passage of the mass through the working chamber. The highest value of overall productivity is observed at values of 20–30 rpm (Figure 5b). At values above 30–35 rpm, there is a slight decrease in productivity. According to [22,26,38,39], with an increase in the frequency of the auger rotation, the material rotates, resulting in a decrease in the overall productivity of the press (volumetric productivity).

The influence of diameter on fat productivity. The diameter of the pulp outlet has a direct impact on the extraction of fat: at its minimum values (5–7 mm), the fat yield is maximum (Figure 6b).

The influence of humidity on fat productivity. The mass fraction of moisture also affects the fat yield: at values from 6 to 9% (Figure 6b), the highest fat yield is observed. As humidity increases, the separation of fat from the protein portion decreases. This phenomenon is described in [22,26,38,39], where the authors note the following: with increasing humidity, the material becomes plastic and, as a result, the pressure and intensity of squeezing decrease.

The influence of auger speed on fat productivity. The most efficient fat separation occurs at a screw rotation speed of 5 to 20 rpm (Figure 6b). Further, the separation of fat decreases and, as the experiment showed, at values of 36 rpm and above, the separation of fat from the protein part stops. A mixture of fat and protein passes through the openings of the working chamber of the screw press.

The influence of diameter on the energy consumption of a screw press. The highest values of energy intensity of the pressing process are observed at a diameter for the cake outlet of 5–7 mm (Figure 7a). At diameters for the cake outlet of more than 8 mm, the energy intensity decreases, which, according to previous studies [22,26,38,39], is associated with a decrease in the pressure generated by the screw.

The influence of humidity on energy consumption of a screw press. At humidity up to 10% (Figure 7), the maximum values of energy intensity are observed. According to data [22,26,38,39], with increasing humidity the viscosity of the material decreases, and, consequently, the energy consumption for moving and compressing the material is lower.

The influence of the screw rotation frequency on the energy consumption of the screw press. The energy intensity increases sharply at a screw speed above 25 rpm (Figure 7b). This is consistent with the results of previous studies, where the number of screw revolutions directly affects the energy intensity of the process [22,26,38,39].

3.2. Results of the Analysis of the Quality of Fat and Protein Fraction

The cake obtained after pressing the fat and the pressed fat were examined for quality indicators: mass fraction of fat (in the cake) m_{fat}, %, in the cake, acid number of fat, m_{KOH}, and mg KOH per 1 g of fat. The results of this study on the influence of variable factors on the residual oil content in the cake of the *Hermetia illucens* larvae and the acid number of fat are presented in Table 4.

Table 4. Results of this study on the influence of variable factors on the residual oil content in the cake of the *Hermetia illucens* larvae and the acid number of fat.

Number of the Experiment	W, %	n, rpm	d, mm	m_{fat}, %	m_{KOH}, mg KOH per 1 g of Fat
1	7.8	11.3	7.2	7.12 ± 0.73	8.4
2	7.8	11.3	10.8	9.65 ± 0.85	8.1
3	7.8	29.7	7.2	15.65 ± 1.15	8.9
4	7.8	29.7	10.8	18.26 ± 1.28	8.5
5	13.2	11.3	7.2	10.39 ± 0.89	8.2
6	13.2	11.3	10.8	13.54 ± 1.05	8.1
7	13.2	29.7	7.2	17.83 ± 1.26	8.8
8	13.2	29.7	10.8	20.08 ± 1.37	8.7
9 (Control)	10.5	20.5	9.0	12.82 ± 1.01	8.5
10	6.0	20.5	9.0	11.05 ± 0.92	8.5
11	15.0	20.5	9.0	18.04 ± 1.27	8.3
12	10.5	5.0	9.0	12.57 ± 1.00	8.2
13	10.5	36.0	9.0	20.13 ± 1.38	9.0
14	10.5	20.5	6.0	10.24 ± 0.88	8.7
15	10.5	20.5	12.0	14.83 ± 1.11	8.4
16 (Control)	10.5	20.5	9.0	12.80 ± 1.01	8.5

Table 4 shows that the minimum amount of fat is contained in experiments 1, 2, 5 and 14. The smallest amount is in experiment 1, with a mass fraction of moisture value of 7.8%, a diameter of the hole for the outlet of the cake of 7.2 mm and a rotation speed of the screw of 11.3 rpm. With an increase in the diameter of the hole for the outlet of the cake (Table 4, experiment number 2) by 3.6 mm, the oil content of the cake increases by 2.5%. This is probably due to a decrease in the pressure in the working chamber of the screw, as a result of which the intensity of separation of fat from the protein part decreases [38,39]. The highest mass fraction of fat in the studied samples was observed in experiments 4, 8, 11 and 13 at high values of the screw speed of more than 20 rpm (Table 4; experiment 4, 8, 13) and a high mass fraction of moisture in the pressed material at 15% (Table 4; experiment 11). The acid number of fat changes slightly depending on the variable factors and remains within the normal range—10 mg KOH per 1 g of fat. The acid number increases slightly with an increase in the number of revolutions of the auger in combination with a small diameter of the hole for the outlet of the cake. This is due to a slight increase in pressure and, accordingly, temperature in the working chamber of the screw press, which, in turn, increases the acid number of the fat. This is consistent with the results of previous studies [22,26].

4. Conclusions

The fat and protein of the Hermetia illucens larvae are promising raw materials for use in feed, pharmaceutical, cosmetic and food production. The mechanical method of obtaining fat from insects by separating it from the protein fraction in a screw press is cost-effective, allows the preservation of the quality of the fat and allows it to be produced in small quantities, which is very important for small businesses. The conducted research allowed us to determine the optimal technological parameters for the process of squeezing fat from the Hermetia illucens larvae using a screw press: the rotation speed of the auger should not exceed 20 ± 5 rpm; the diameter of the hole for the pulp outlet should not exceed 7–10 mm; the mass fraction of moisture of the pressed material should be $8 \pm 2\%$. When using lower values of the factors specified above, the spin intensity can be slightly increased, but the productivity is sharply reduced and the energy consumption of the process increases. Exceeding the specified values of the factors leads to the rotation of the pressed mass in the working chamber of the screw press and an increase in plasticity, and, as a result, the degree of fat squeezing is sharply reduced or stops altogether.

Further studies will conduct a thorough analysis of the economic efficiency of using Hermetia illucens larvae fat in the feed, and pharmaceutical and cosmetic industries as an alternative source of traditional fats.

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Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

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