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INSECTS ARE A SOLUTION TO THE PROBLEM OF PROTEIN SUPPLY OF MIXED FODDER'S

Abstract

In the materials of this article, the problems of protein deficiency in the production of compound feed are considered, and ways to solve them due to the use of alternative, non-traditional protein components - insects that have high nutritional properties, provide rapid accumulation of biomass, serve as sources of biologically active substances and are safe from from the point of view of issues of veterinary medicine and ecology. It is predicted that up to 15% of additional protein will be provided by insects in 2050, and their market will be estimated at $1.2 billion. The characteristics of the black lion fly (Hermetia illucens) and its larvae, peculiarities of cultivation and chemical composition are presented. Larvae mostly consist of protein and fat, and also contain 7.0% chitin, 5.0% calcium, 1.5% phosphorus and iron. The amino acid composition of the protein demonstrates the presence of a wide range of amino acids and a relatively high content of lysine, which makes it possible to use them in the development of new components of complete feed for farm animals and poultry. A method of introducing dry larvae of the black lion fly into the compound feed through granulated and extruded mixtures with a mass fraction of larvae from 10 to 50% has been developed. The structural scheme of the introduction of larvae in the production of compound feed is presented, which includes cleaning of grain raw materials, grinding, sieving, mixing the passing fraction of the sieve with dry larvae in a certain ratio, and subsequent granulation and extrusion of the mixture. The results of the study of the physical properties of the samples of the molded mixtures are given, and it is established that the sample with 15% dry larvae has the best physical properties. With an increase in the content of dry larvae in the mixture by more than 25%, the samples at the exit were characterized by significant fragility and fatness and required an additional drying operation, which would significantly increase the cost of the finished compound feed. Calculated recipes of complete ration compound feed for adult laying hens using larvae from 15 to 20%, which made it possible to exclude expensive feeds of animal origin (fish meal, meat and bone meal) and partially replace soybean meal (up to 12%), which significantly reduced the cost of finished compound feed.

Key words: compound feed, Black lioness larva, recipe, physical properties, granulation, extrusion, technology.

Introduction

The development of new components of combined feed for farm animals and poultry is one of the topical directions of the modern combined feed industry. The feed base, which determines the largest item of expenditure, is represented by various ingredients of plant and animal origin, as well as feeds obtained with the help of microbiological synthesis.

Considerable attention is paid to their protein supply when balancing complete ration compound feeds, therefore, the search for new sources of protein is quite an urgent issue. So, let's consider the problems of lack of protein in modern fodder production and the possibility of its replenishment. To understand why the creation of alternative proteins is generating so much interest in the animal feed industry, we need to first appreciate the context in which this new industry has emerged over the past decade. High-protein components are necessary to ensure the animal's need for protein, its balance, and therefore, for the full development of the body.

First, the grain and legume group (barley, oats, wheat, corn, soybeans, peas) serves as raw material for the production of not only compound feed, but also food products for humans, which causes competition for these sources of protein. large areas of arable land that could be used for food production.

Secondly, the geographical isolation of fish production and the decline of global fish stocks can contribute to the shortage of fish meal, which is almost the main full-fledged source of animal protein in animal nutrition, forcing technologists around the world to invent new sources of raw materials. In addition, fish meal is a rather expensive type of raw material, in addition, there is a significant amount of counterfeiting of this compound feed component on the feed raw material market.

Thirdly, such protein components as soybean meal, fodder yeast, dry amino acid preparations are also characterized by high cost and falsification.

One of the areas of use of new alternative protein components is non-traditional types of raw materials, which can reduce the intensity of these problems and expand the possibilities of the compound feed industry.

Literary review

The base of non-traditional feeds is expanding every year, which makes it necessary to conduct experiments with various biological objects, to study the possibilities of their use as feed ingredients, to identify the most promising ones from an economic point of view. Such objects must have high nutritional properties (primarily in terms of protein and fat content), provide rapid accumulation of biomass, serve as sources of biologically active substances and be safe from the point of view of veterinary and ecological issues. These requirements are met by insects, in particular the black lionfly (Hermetia illucens) and its larvae [1].

The work of both foreign and domestic scientists, who proved the expediency of their use from both a productive and an economic point of view, is devoted to the issue of the prospective use of insects in the production of compound feed [1, 2, 3]. Therefore, one of the most promising alternative proteins for compound feed for animals is currently considered to be insects. The very first modern studies on the cultivation of flies and larvae of the Black Lioness (Hermetia Illucens) were conducted by three researchers Furman, Young and Catts back in 1959. According to forecasts, it is expected that by 2050 (Fig. 1), insects can provide 15% of the additional protein that will be needed by that time [1, 4-6].

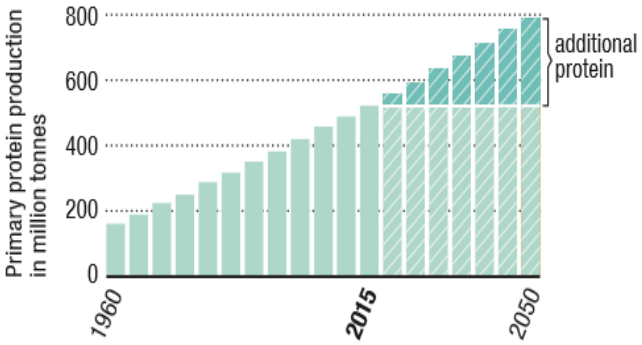

Fig. 1. Prospects for providing protein through the use of insects

The use of edible insects and the animal protein produced from them is rapidly gaining momentum around the world. According to UN forecasts, this market will be valued at $1.2 billion in two years [1, 6]

In China, EU countries, and especially in the USA, insect protein is actively used for the production of compound feed: in particular, in 2020, a subsidiary of Nestle Purina began producing such feed [7]. This is quite an important event, because previously large transnational holdings showed a rather restrained interest in alternative protein. If one of the global giants enters this market, it can be expected that others will follow. This means that production and the range of available products will grow exponentially in the foreseeable future.

Black soldier fly (Hermetia illucens, or Black Soldier Fly) is a large American fly from the family Stratiomyidae (Fig. 2), whose natural range is North and South America [1, 2]. The insect is one of the few species of invertebrates capable of fully developing in pure culture in a confined space of artificial conditions, which allows the species to be used for biotechnological purposes.

A variety of sources serve as a feed substrate for the larvae of this type of insect: manure, substandard grain and processed products of the agricultural and food industry, food waste. Every day, up to a third of the volume of produced products is thrown away as food waste, a large part of which is of plant origin (the remains of fruits and vegetables, which is connected with the complexity of their storage and transportation). The products quickly decompose and become unsuitable for further use. Bioconversion of waste when growing larvae on it partially solves the problem of utilization and allows obtaining a high-quality protein fodder product [8, 9].

Fig. 2. Black lioness fly and larvae

When breeding Black lion flies, the main factors that affect the growth, development and production of fodder biomass are lighting, humidity, temperature regime, fodder substrate, chemical factors, which include the gas composition of the air, mineral composition of water, acidity, mechanical and chemical composition the environment in which the insect develops, its air penetration and density, as well as noise, gamma radiation and electromagnetic oscillations [10, 11]. But, despite the entire range of necessary factors of the distribution environment, the insect is unpretentious, and its larvae (Fig. 2) are omnivorous and able to develop in a wide range of temperatures (+20-50°C) and relative air humidity (40-90%) [9, 10].

The Black Lionfly and its larvae have gained great popularity in the last decade due to its introduction as a fodder for reptiles, poultry and other domestic and farm animals [12-14]. First of all, this is due to the high nutritional value of larvae grown on organic waste, which contains proteins (≈40%) and fats (≈40%) [10]. In fig. 3 shows the chemical composition of the larvae of the Black lioness fly grown on pig droppings.

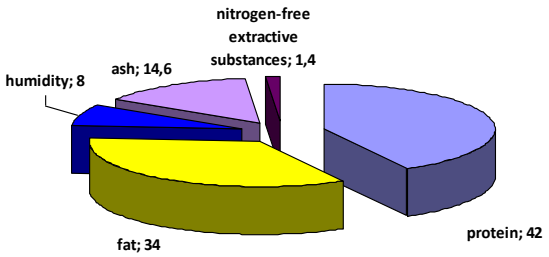

Fig. 3. Chemical composition of the larvae of the Black lioness fly

As can be seen from the diagram, the larva's body consists mostly of protein and fat. When conducting research, it was found that the protein content in the larva is not affected by the composition of the feed substrate, while the amount of fat and ash varies depending on the type of feed - for fat 20-45%, for ash 3-20% [1, 2, 3] In the composition of fatty acids, lauric acid accounts for 50% [3]. Omnivorousness and nutrition is determined by the ability of Black lioness larvae to eat any solid organic waste without exception and as a result accumulate in their body a complex of macro- and microelements, the percentage of which depends on the diet. On average, the larva contains 7.0% chitin, 5.0% calcium, 1.5% phosphorus and iron. In the table 1 shows the results of the study of the amino acid composition contained in the dry flour of fly larvae [1-3].

The amino acid composition of the protein in the larva shows the presence of a wide range of amino acids and a relatively high content of lysine (Table 1). In addition, it contains useful organic compounds that have commercial and industrial value.

Table 1 – Amino acid composition of flour from the Black lioness

№	Amino acid	Content, %
1	*Lysine*	3.37
2	*Threonine*	0.55
3	*Methionine*	0.86
4	*Valin*	3.41
5	*Leucine*	3.53
6	*Isoleucine*	1.96
7	*Tryptophan*	0.20
8	*Phenylalanine*	2.20
9	*Arginine*	2.24
10	*Histidine*	1.91
11	*Aspartic acid*	4.56
12	*Serine*	0.12
13	Glutamic acid	3.81
14	Proline	3.26
15	Glycine	2.88
16	Alanine	3.69
17	Cystine	0.06
18	Tyrosine	2.51
	A total of	40.12

Formulation of the problem

In this regard, the goal of the work was to find, characterize and process the possibility of alternative protein raw material - larvae of the Black lioness, as a component of compound feed for agricultural poultry.

Materials and methods

The object of the study was dried larvae of the Black lioness, as well as granulated and extruded mixtures of grain with larvae. The mass fraction of dry black lionfish larvae in the mixtures was 10, 15, 25, 35, 50%.

In the work, standard analytical, physical and chemical research methods were used to evaluate chemical and physical properties.

The mass fraction of moisture was determined by the accelerated method, by drying the weight of the sample in a drying cabinet at a temperature of +130°C for 40 minutes. Volumetric mass using a liter flask with a falling load and laboratory scales of the 2nd accuracy class. The angle of the natural slope was determined according to the degrees applied to the side surface of the special device R.L. Zenkova by pouring the product from a watering can. Average particle size by sieving a portion of bulk product through a sieve with openings of a specified size and weighing the residue on the sieve. Flowability by measuring the flow rate of the product through an opening of a certain diameter. Granule fragility according to the granule abrasion index in the PPG 2 apparatus. To obtain molded mixtures - technological methods of granulation and extrusion.

Results of the study and their discussion

Taking into account the high content of fat in the larvae, as well as the satisfactory physical properties of the dry larvae of the Black Lioness, when introducing them into the compound feed, a method of their use has been developed (Fig. 3), which includes cleaning the grain raw material - corn grain, grinding it with subsequent sifting through a sieve PR No. 30-40, mixing the passing fraction of the sieve with dry larvae in a certain ratio and subsequent granulation and extrusion of the mixture under the following technological modes:

- granulation in a press granulator of the OPG 150 brand (the number of pressing rollers - 2 pcs., the diameter of the die of the matrix 4.0 mm; the mass fraction of moisture of the mixture that is fed to granulation – 16...18%; the temperature of heating the matrix – + 90 ± 5ºC; pressure – 2-3 MPa; temperature of granules at the exit from the press – + 70 ± 5 ºC);

- extrusion in an EZ-150 extruder (the diameter of the die at the exit 10.0 mm, the mass fraction of moisture of the mixture that is fed to granulation is 16...18%; the temperature in the working area is + 120 ± 5ºC; the pressure is 1 MPa; the temperature of the extrudate at the exit is + 100 ± 5ºC).

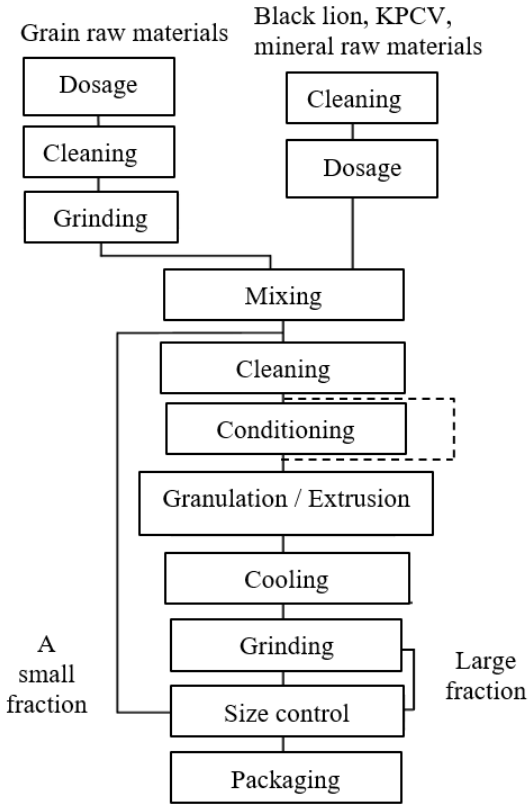

Fig. 3. Structural diagram of the introduction of Black Lioness larvae during the production of compound feed

The physical properties of the obtained samples of the obtained molded mixtures in the form of granules and extrudate (Fig. 4) were investigated. The best physical properties were in the sample of the mixture, which included 15% of dry larvae (Table 2).

When the mass fraction of dry black lionfish larvae in the composition of the mixture was increased to more than 15%, the effect of its extrusion (swelling) was not noted, as a result of the increase in fat content and the acquisition of a more plastic shape by the product due to this. With an increase in the content of dry larvae in the mixture by more than 20%, the samples at the exit were

Fig. 4. Granulated and extruded mixtures of grain with larvae (maize grain:larvae)

Table 2 - Physical properties of compound feed

Index	Dry insects	Granules	Extrudate
Mass fraction of moisture, %	45.6	14.0	15.3
Volumetric mass, kg/m^3	315	580	429
Thickness, mm	12	3 mm, l = 4 mm	2.1
Angle of natural slope, degree.	48	40	41
Flowability, cm/s	1.75	4.2	3.54
Brittleness of granules, %	-	9.8	-

Table 3 – Recipes of whole grain feed for laying hens

Ingredient	% complete ration compound feed		
	№-1-1	№-2-2	№-3-3
Wheat	31.00	28.00	36.70
Corn	24.00	16.00	
Barley	-	13.23	15.00
Bran	-	-	2.60
Millet without films	-	-	25.10
Soy meal SP46%	-	11.30	-
Sunflower SP36%	13.00	10.50	5.00
Black Lioness	19.00	15.00	12.24
Monocalciumphosphate	8.00		
Fodder chalk	2.00	-	-
Limestone flour	1.56	3.90	1.90
Kitchen salt	0.25	0.10	0.26
Baking soda	-	0.70	-
Lysine 98%	0.13	0.10	0.10
Dl-Methionine 98.5%	0.06	0.17	0.10
P1-1	1.00	1.00	1.00

characterized by significant fragility and fatness and required an additional drying operation, which would significantly increase the cost of the finished compound feed.

Taking into account the chemical composition of the larvae of the Black lioness, we calculated recipes for adult laying hens using larvae up to 20% of the input, which are presented in the Table. 3, which made it possible to eliminate expensive feed of animal origin (fish meal, meat and bone meal) and partially replace soybean meal (up to 12%), which significantly reduced the cost of ready-made compound feed.

The obtained extruded/granulated mixture can be used in the future for the production of complete ration compound feed with increased fat content, with lines for the preparation of grain raw materials, preparation of FPFI, Black Lion, and other mineral raw materials, the main mixing and forming line, size control and packaging of finished products.

Conclusions

The technology of organic waste processing by black lioness fly larvae is a natural and innovative method of obtaining natural and complete feeds and their components, quick replenishment of soil fertility, as well as effective methods of fighting for environmental safety and improving green technologies.

The fodder market of vermiculture (insects, larvae) is at the initial stage. Based on the literature review and the results of experimental studies, it is advisable to use the larvae of the Black Lioness insect as an alternative to proteins of animal origin and vegetable crops (cakes, meal). A method of introducing the larvae of the Black Lioness into compound feed as part of grain raw materials has been developed.

The appearance of black lionfish larvae on the feed market of Ukraine makes it necessary to evaluate the biological effectiveness of this feed product as part of compound feed for poultry, pigs, fish and domestic animals.

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КОМАХИ – ВИРІШЕННЯ ПРОБЛЕМИ БІЛКОВОГО ЗАБЕЗПЕЧЕННЯ КОМБІКОРМІВ

Анотація.

В матеріалах статі розглянуті проблеми білкового дефіциту при виробництві комбікормів, та шляхи їх вирішення за рахунок використання альтернативних, нетрадиційних білкових компонентів – комах, які володіють високими пожив-ними властивостями, забезпечують швидке накопичення біомаси, служать джерелами біологічно активних речовин і є безпечними з точки зору питань ветеринарії та екології. Наведено прогноз забезпечення до 15 % додаткового білка у 2050 році за рахунок комах, а їх ринок буде оцінюватися в 1,2 млрд. $. Представлено характеристику мухи Чорна левина (Hermetia illucens) та її личинки, особливості вирощування та хімічного складу. Личинки в більшій мірі складаються з білка і жиру, також містять 7,0 % хітину, 5,0 % кальцію, 1,5 % фосфору і заліза. Амінокислотний склад білка демонструє при-сутність широкого спектра амінокислот і відносно високий вміст лізину, що дає можливість їх використання при розробці нових компонентів повнораціонних комбікормів для сільськогосподарських тварин і птиці. Розроблено способи введення сухих личинок мухи Чорна левина до складу комбікормів через гранульовані та екструдовані суміші з масовою часткою личинок від 10 до 50 %. Представлено структурну схему введення личинок при виробництві комбікормів, яка включає очис-тку зернової сировини, подрібнення, просіювання, змішування проходової фракції сита з сухими личинками у певному спів-відношенні та послідуюче гранулювання і екструдування суміші. Наведено результати дослідження фізичних властивостей зразків формованих сумішей, встановлено, що найкращі фізичні властивості у зразка з 15 % сухої личинки. Зі збільшенням вмісту сухої личинки у складі суміші понад 25 % зразки на виході характеризувалися значною крихкістю та жирністю і потребували додаткової операції сушіння, що значно підвищило б вартість готового комбікорму. Розраховані рецепти повнораціонних комбікормів для дорослих курей-несучок з використанням личинки від 15 до 20 %, що дозволило виключити дорогі корми тваринного походження (рибну муку, м'ясо-кісткову муку) та частково замінити соєвий шрот (до 12%), що значно зменшило вартість готових комбікормів.

Ключові слова: комбікорми, личинка Чорної левини, рецепт, фізичні властивості, гранулювання, екструдування, технологія.

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