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Manufacturing of Non-Traditional Foods: Problems and Prospects

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ABSTRACT

This article analyzes advanced approaches and development prospects in the research area of food production based on traditional and non-traditional sources. As well, It is described the uniqueness of insect-based feed preparation compared to traditional feed sources. Besides, there is reported the information about some insects such as *Hermetia illucens* L., *Tenebrio molitor* L., *Musca domestica* L. uses as sources in production conditions.

Introduction

In recent years, insects have been noted as a high quality, efficient and competitive non-conventional protein source. Organizing the production of food and feed products from insects is of great importance in preventing food shortages, which is one of the most global problems today.

Especially,, the Ministry of Economic of Netherlands began to implement large-scale projects in 2012 which focused on the issue of adding insects to food and feed

products since 2012. The main goal of this project is to determine the possibilities and limits of using insects as feed. For instance, it was noted that the production of animal feed worldwide was 870 million tons, and the trade turnover for the production and sale of animal feed was 350 billion dollars since 2011(<http://www.ifif.org/>).

It will be predicting by Food and Agriculture Organization (FAO) which is the organization of the UN in 2050 that animal protein will make up 70% of the present food production. The International Feed Industry Federation (IFIF) predicts that meat production (poultry/cattle/pig) will double. This creates a shortage of

a large amount of food base. For example, fish is used as the main ingredient of protein food. There is noted that there is a need for 16-17 million tons of products in one year over the World, are only been preparing 5-6 million tons of fishmeal (Wijkström, 2009).

One of the most urgent tasks today is to further expand the supply of feed, find non-traditional feed additives and master production processes. In particular, Nowadays, the quality of the main protein ingredients for animals is recognized as fish meal, animal protein and processed soybean meal (Mirzaeva *et al.*, 2020 a, b, c).

It is known that in EU (European Union) countries, the use of protein ingredients obtained by processing animals as feed additives is prohibited. In addition, the amount of land suitable for soybean cultivation and the fish stocks caught in the seas are decreasing year by year.

The demand for protein substances in feed is increasing year by year. In the last five years, due to the dwindling supplies for the production of the most necessary ingredients, one size of the product requires 60-70% of the cost of production.

The largest association of feed producers in the world is NEVEDI (Dutch Feed Industry Association). In 2009-2010, 72 companies within NEVEDI engaged in feed production. 60 percent of the total amount of feed produced was distributed to 5 companies with large production capacity, 10 percent to 18 companies with medium capacity, and 49 companies with small production capacity (Veldkamp *et al.*, 2012).

In 2009, The total of 13.3 million tons of feed was produced in Netherland, 26.5% for cattle, 45.2% for pigs, 25.0% for poultry and 3.3% for other types of consumption and illustrate in Table 1. In 2010, the total amount of food products was 21.5 million tons. Therefore, it can be seen that the annual production in the Netherlands alone has increased by almost 61.8%.

Therefore, it is important to find non-traditional protein sources for animal husbandry and fisheries and master the production of feed and feed additives based on them. One of the more untraditional food sources is insects (Table 2).

The production of protein and lipid feed and feed additives on the basis of insects is characterized by sufficient profitability compared to all types of

production. Besides, the cold-bloodedness of insects is also important in the processing of agricultural and household waste and the production of secondary products from it.

Table 2 demonstrates that *Musca domestica* and *Tenebrio molitor* flies can easily replace soybean meal and fish meal, in terms of protein storage. It can be seen that the fat storage (ranging from 4-47%) of these two insect species differs dramatically from other sources (Mirzaeva *et al.*, 2020a).

Currently, the use of these potentials of insects around the world is very low compared to traditional production. 18 companies are only engaged in the cultivation of insects in the Netherlands. It is considered promising to organize production based on *Hermetia illucens*, *Musca domestica*, and *Tenebrio molitor* flies in Western countries. It is also important that these species are propagated by recycling organic waste products. However, approximately 1.3 billion tons of organic waste products are generated annually worldwide.

In EU countries alone, 90 million tons of food products are thrown away from houses, household service branches and production enterprises (Andreas Stamer, 2015). Also, on the basis of the "Ecodiptera" project funded by the European LIFE program, they are recommending the use of insects in the processing of pig manure, which is one of the biggest problems. As a result, the negative effects of pig manure on the environment are prevented, insect biomass is grown as a product and used as feed, and zoohumus is produced on the basis of processed manure as a by-product.

This technology has been put into practice in Slovakia to obtain products by processing pig manure and poultry manure. The below are some types of insects that are widely used in production conditions and brief information about them (Mirzaeva *et al.*, 2020b).

Black fly larvae (*Hermetia illucens* Linnaeus) contain a large amount of protein and lipids, so it can be used as a feed additive and shows in Fig.1. Black linca has been proven to be an effective protein source for raising pigs, broiler chickens (Newton, 1977) and several fish species (St-Hilaire *et al.*, 2007; Sheppard *et al.*, 2008).

In addition, they reduce environmental pollution with manure by 50-60%, and are of great importance in reducing the population of pathogenic bacteria and flies.

The use of housefly in the processing of pig manure is relatively ineffective because of the high water content of these manures, which has a negative effect on the development of housefly larvae and limits the laying of eggs by flies (Sheppard, 1983; Sheppard *et al.*, 1994).

Hermetia illucens is naturally found in poultry manure from domestic chickens, pigs and cattle, but can also be found in organic compost and fish waste. When the feed supplement made from *Hermetia illucens* larvae is added to fishmeal in the amount of 25%, it is recognized as a substitute for fishmeal due to the fact that the weight gain and the protein content of chickens significantly increased (Awoniyi and others, 2003, 2004; Mirzaeva *et al.*, 2020c) and the production of products based on it is technically and economically effective (Hwangbo and Hong, 2009).

The South American company Agroprotein Technologies launched multi-ton production based on *Hermetia illucens* for the first time. The production technological base of this company includes sterile insect breeding equipment, each of which has kept more than 750,000 insects.

Two types of waste products are used in the breeding and maintenance of insects: human feces and blood from cattle sheds. An average of 700 to 1000 eggs per week are taken from one female insect. After the hatched insect larvae have developed for 72 hours, they are separated without cocooning or left to cocoon.

The collected larvae are dried as a thin layer, then crushed and packed. This product contains 9 essential amino acids, especially cystine, lysine, methionine, threonine and tryptophan, which is comparable to sea fish flour.

The current technical capacity of this company is 2 tons per week. But the company has set itself the goal of preparing 100 tons of larvae per day. Such as large production enterprises are increasing in developed countries such as Germany, England, and the USA.

Yellow mealworm (*Tenebrio molitor*) is a source of highly nutritious and cost-effective feed supplement for African carp and broiler chicks in Fig.2.

They can be grown on dry or boiled fruits, vegetables and cereal crops of different composition. Haocheng Mealworms Inc. in China is a company that

manufactures a feed additive by rearing yellow mealworms on a large scale 15 companies within the company produce 50 tons of live yellow flour beetle (*Tenebrio molitor*) and zophobas (*Zophobas morio*) per month. This company sells live, dried, canned and dry powder products for livestock, fish and pets.

This company sells more than 200 tons of its products based on the yellow flour beetle to North America, Europe, Australia, and the countries of eastern and southern Asia. The protein storage and cost advantage of *Tenebrio molitor* compared to conventional protein sources is presented (Meuwissen, 2011) in Table 3.

Table 3 shows that although the protein content of the yellow mealworm product is not less than that of traditional sources, it is required to reduce its price by 95%. Under current small production conditions, the cultivation of *Tenebrio molitor* costs approximately €0.71 for space, €1.09 for feed, €2.14 for labor and €0.81 for other costs, in total €1 per size (kg) product. 4.75 will be spent. Therefore, if we take into account that these costs will be reduced by several tens of times when modern mechanized and automated large production enterprises are established, the production of products from *Tenebrio molitor* will become a profitable industry in the future.

The house fly (*Musca domestica L.*) is widespread in all regions of the globe and is inextricably linked with the life of humans and animals in Fig.3. One female insect lays an average of 100-150 eggs under natural conditions, egg-laying lasts 2-4 days. On average, up to 600 eggs can be laid. In hot regions, up to 2,000 eggs have been laid in a natural state.

However, studies have shown that under controlled conditions, it is possible to obtain up to 1200-1800 healthy eggs. They can give 10-15 generations during one cycle, and up to 20 generations in tropical and subtropical regions. Generally, during the life of one female insect, 5 billion. is estimated to lay eggs.

As a result of research carried out by scientists, it was observed that in different conditions and regions, the protein storage of the housefly compared to dry biomass and its amino acid content are different in Table 4. In particular, it is noted that the protein content of dry biomass is 47-63.95. Linoleic acid, which is the most important of the non-exchangeable amino acids, was found to be 26.25% in larvae and 36.27% in mushroom, compared to the total fat content.

Table.1 The amount of feed where produced in the Netherlands in 2010 [NEVEDI, 2012]

Food	Amount (mln.t)
Feed production	14.3
food as substitution milk	0.7
Products as substitution milk	1.5
Liquid feeds	5.0

Table.2 Protein and fat storage relative to dry matter of tradational and non-tradational protein sources

Protein source	Protein (%)	fat (%)
<i>Hermetia illucens</i> (black fly larva)	35-57	35
<i>Musca domestica</i> (housefly larva)	43-68	4-32
<i>Tenebrio molitor</i> (yellow flour beetle)	44-69	23-47
Fish meal	61-77	11-17
Soybean meal (defatted)	49-56	3

Table.3 Variety of protein sources which is consisting of 88% dry matter

Protein source	Protein storage (%)	Price/kg product (€)
Flour beetle	50	15.80 31.70
Fish meal	60	1.24 1.91
Wheat	12	0.14 1.17
Soya meal	45	0.28 0.62

Table.4 Nutrient composition of *Musca domestica* larvae

Nutrients, %	Aniebo <i>et al.</i> , 2008	Hwangbo <i>et al.</i> , 2009	Atteh <i>et al.</i> , 1993
Dry matter	92,7	94,78	91,34
Protein	47,1	63,99	39,16
Fiber	7,5	-	8,25
As matter	6,25	5,16	6,15
Ether extract	25,3	24,31	20,76

Figure.1 There are: A-Mature fly, B-larva and S-pupa of *Hermetia illucens* L.



A



B



S

Figure.2 There are: A-Mature beetle, B-larva and S-pupa of *Tenebrio molitor* L.

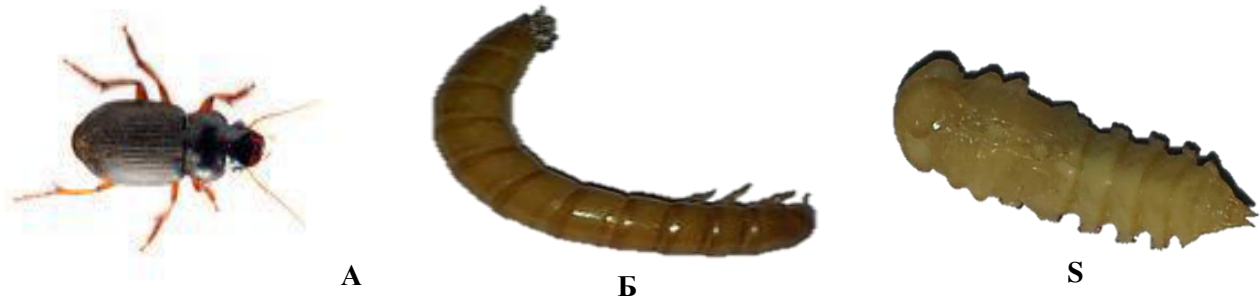
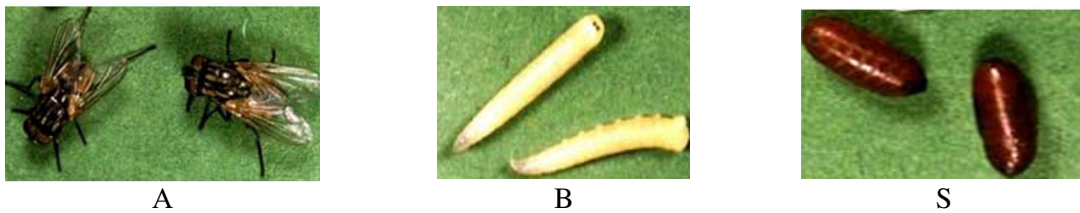


Figure.3 (A)-Mature fly, (B)-larva, and(S)- pupa of *Musca domestica* L.



Dried *Musca domestica* is made by larvae, it is widely used as a feed additive. This feed supplement is important due to its nutritional value and easy digestibility in the animal and poultry body. For example, it is noted in scientific sources that protein feed made from house fly larvae is absorbed up to 69% in the gastrointestinal system of birds, and protein feed made from mushrooms is up to 79%. It was found that the metabolic value of the food prepared from the larvae was 14.23 mDj/kg, and 15.15 mDj/kg when it was prepared from the mushroom. When the feed is prepared from the larva, It was found that the oil content of the fly is up to 94%, and the fat is up to 72%, and when it is prepared from the mushroom, the same indicators are 98% and 68%. Therefore, the production of fodder based on *Musca domestica* is very important for livestock and poultry farming.

Organization of production based on the functional characteristics of insects, i.e. simultaneously feed, feed additives, zoohumus, biologically active substances, pharmaceutical drugs, antifungals from cultivated insects and we believe that establishing directions such as obtaining antibacterial agents can reduce the cost of finished products.

Furthermore, the following are the main factors affecting the decrease in the cost of finished products: increasing the biological value of feed prepared on the basis of insects and breeding insects using residual products with

organic content; reduction of workforce through mechanization, automation and logistics of production; increasing the amount of land for breeding insects by increasing the number of insect breeding enterprises; use of new energy-efficient technologies for electricity, heat exchange and ventilation processes; increasing production capacity by modernizing insect breeding and cultivation; reducing the cost of biomass processing processes (separation, drying).

Insect-based marketing scientist [De Vor \(2011\)](#) said that in order to reach the level of competitive feed, insect-based products should contain at least 35% dry matter and cost an average of €0.40-€0.60. Generally, since the protein content of insect feed (50%) is equal to the protein content of fishmeal (60%), insects can only be a competitive protein source if the cost per kilogram of the finished product is around €1.00-€1.50.

Currently, the price of 1 kg of fishmeal is €1.24, but considering that its price is increasing day by day, the cost of insect based feed will be one of the cheapest products in the future. Scientific analyzes show that there are opportunities to reduce the cost of insect products based on ongoing scientific research.

Since great attention is paid to livestock and fish farming in our country, the issue of ensuring their nutritional reserves is one of the most urgent tasks.

We believe that the future use of insects as a source of protein will be of great economic, ecological and social importance in solving this problem.

For this, it is important to have a favorable geographical climate in our country. In this case, the cost of making products based on insects is relatively cheap (a large amount of residual products with organic content, a lot of sunny and hot days, etc.) and creates a basis for an increase in the range of products.

Author Contributions

T. O. Ikromov: Investigation, formal analysis, writing—original draft. U. A. Kuzimurodov: Validation, methodology, writing—reviewing. Kh. Kh. Abdinazarov:—Formal analysis, writing—review and editing. D. Kh. Kuchkarova: Investigation, writing—reviewing. N. A. Khujamshukurov: Resources, investigation writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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