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SCIENTIFIC AND PRACTICAL FUNDAMENTALS OF PRODUCTION COMPOUND FEEDS FOR DECORATIVE AND SINGING BIRDS

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Abstract. *According to FEDIAF, decorative and singing birds are the third largest pet population in the world. Analyzing the feed market for decorative and singing birds in Ukraine, we saw that a significant part of it is occupied by imported feeds, while the assortment of domestic feeds on the market is very small and does not always meet the requirements and cannot withstand competition. However, it is difficult to call the presented feeds complete, since they are mainly different types of feed mixtures and molded treats, which, depending on the price category, include different types of components: starting with cereals and ending with various nuts, dried fruits, etc. This creates significant economic potential with the introduction of modern technologies for the production of competitive fodder for decorative and singing birds, which will allow to significantly diversify and expand their range.*

The paper substantiates the expediency of the production of compound feed for decorative and singing birds, the peculiarities of the digestion process and the role of the main nutrients for decorative and singing birds are studied, and the classification of feed is developed. The object, subject and research methods are selected. Recipes of compound feed are calculated and theoretical justification of the method of production of compound feed for decorative and singing birds is given. Experimental samples were obtained in laboratory conditions and the main quality indicators were studied. A comparative analysis of the obtained compound feed with industrial feed was carried out. It was established that these feeds meet the needs of poultry in terms of the main nutritional indicators and are not inferior to industrial analogues.

Keywords: *pet food market, decorative and singing birds, assortment, classification, fodder, compound feed, recipe, extrusion, quality indicators.*

I. INTRODUCTION

In the developed countries of the world, animal business is one of the most profitable and promising branches of production. Pet business includes the totality and interaction between enterprises engaged in the production and distribution of goods and services for pets, and consumers of these goods and services. The term "zoobusiness" used in Ukraine corresponds to the concept of "Pet industry". The prospects of activities that include pet business are due to the constant growth of the number of domestic animals around the world. The term "pets" usually includes cats, dogs, decorative and singing birds, rodents, aquarium fish, reptiles and amphibians, which are united by the word "pets" abroad. The structure of pet business is represented by pet products (feeds (compound feeds), medicines, care products and accessories), services and animals [1].

Today, the owners of decorative and singing birds do not have a wide range of ready-made feed at their disposal, compared to feed for cats and dogs. Analyzing the

feed market for decorative and singing birds, we saw that a significant part of it is occupied by imported feeds, while the assortment of domestic feeds on the Ukrainian market is not large and does not always meet market requirements and cannot withstand competition. However, it is difficult to call the presented feeds complete, since they are mainly different types of feed mixtures, which include, depending on the price category, different types of components: starting with cereals and ending with various nuts, dried fruits, etc.

Ready-made feeds in combination with a correctly selected feeding regime strengthen the health of birds, and also meet their expectations regarding taste qualities and the owner's expectations regarding the price and convenience of feeding. Careful observation of the appearance and behavior of birds allows you to establish the correct diet for your pet and determine his preferences for one or another type of feed.

This creates significant economic potential with the introduction of modern technologies for the production of competitive fodder for decorative and singing birds, which will allow to significantly diversify and expand their range.

The purpose of this work is to develop recipes, increase the feed value and expand the range of feed for decorative and songbirds by extruding the formed initial mixture with the inclusion of fruit and vegetable extracts with the subsequent production of grits. To achieve the set goal, it was necessary to solve the following tasks:

– conduct an analysis of the pet food market in Ukraine;

– to study the peculiarities of the digestive process of decorative and singing birds and the role of the main nutrients in the composition of feed;

– to develop a classification of fodder for decorative and singing birds and to analyze the methods and technologies of their production;

– calculate recipes of compound feed for decorative and singing birds;

– to improve the technological method of production of compound feed for decorative and singing birds;

– to evaluate the quality of experimental samples and industrially produced feeds according to organoleptic, physico-chemical and microbiological indicators.

II. LITERATURE ANALYSIS
Prospects for the production of compound fodder for decorative and singing birds in Ukraine

2.1. Analysis of the pet food market

The global pet food market was valued at USD 94.76 billion in 2021 and is expected to grow at a CAGR of 4.4% from 2022 to 2030. Increasing consumer awareness of natural and organic pet foods has forced manufacturers to shift their focus from synthetic to natural products, which has become one of the major forces influencing the global market today.

The COVID-19 pandemic has had a negative impact on supply chains. The pet food sector has been affected in terms of supply and cash flow due to restrictions on the movement of raw materials. On the other hand, demand for pet food has grown steadily in many parts of the world as people get more pets in response to the growing

desire for company during the quarantine. To meet this demand, market players have shifted their focus from brick-and-mortar stores to e-commerce platforms [2, 3].

In Ukraine, in 2017–2021, the category "Animals – pets and feed for them" in the structure of retail turnover occupied a share of 0.3-0.5 %. The volume of retail turnover during this period increased 3.4 times, from 1,612.5 million UAH in 2017 to 5,468.6 million UAH in 2021 [4].

According to FEDIAF, decorative and singing birds are the third largest pet population (cats and dogs, respectively, numbers 1 and 2), with 51.87 million decorative and singing birds across Europe (37.23 million of them in the European Union) in in 2020.

Business activity related to the production of pet food in Ukraine has existed for about 20 years, while in the developed countries of Europe and the USA, similar products have been sold for more than 150 years. At the same time, according to analysts of the Euromonitor International company, the Ukrainian pet food market is characterized as a fast-growing one. It is believed that Ukraine is on the 8th place in the TOP-10 fastest growing pet food markets. However, the Ukrainian feed market is dominated by foreign producers, in particular from such countries as Hungary, the USA, France and others.

Today, the Ukrainian cat and dog food market is worth about 300 million dollars a year. For comparison, the European market for pet food is more than 22 billion dollars per year, in the USA more than 11 billion dollars of feed is sold per year, and in Poland they spend 1 billion dollars annually [5].

About 10-15 % of the profit from the total sale of pet food comes from decorative and songbirds, rodents, aquarium fish and other exotic animals. Currently, a large number of ready-made feeds, mainly in the form of feed mixtures and treats for various types of poultry, have appeared on sale. Currently, there are about 20 brands of fodder for decorative and singing birds. Most of the feed suppliers on the market are foreign countries, such as Hungary, Germany, Belgium, Italy, Poland, etc. Among the domestic manufacturers, TM "Pryroda", TM "Lori", Hobby meal and others are represented on the market. Feeds of domestic producers are generally not expensive and according to the price criterion belong to the "economy" and "business" classes [6].

Based on the analysis of the world and Ukrainian markets for pets, the following main factors that influence their development can be identified: demographic changes (population size, population urbanization, "population aging", increasing the level of education); psychological changes (change in the role of animals, change in approaches to feeding animals); change in management (intensification of competition due to the consolidation of individual companies in the industry, continuation of the offensive of global corporations, increased competition between specialized and non-specialized stores, increasing importance of an established delivery system, reducing the number of links in the producer-consumer chain, increasing the role of innovative developments, new methods of marketing, packaging technologies in the development of competitive advantages).

2.2. The role of the main nutrients in the composition of feed and features of rations for decorative and singing birds

Decorative and singing birds, like all living things, need full nutrition to maintain vital activity and body health. The feed must contain all the components that are necessary for energy production, growth, tissue regeneration, as well as for the regulation of metabolism. A well-balanced feed should contain all the nutrients in a certain amount, and depending on the need for these substances in the bird, their ratio may be different. Factors such as species, age of birds, general health, level of physical activity, physiological state, housing conditions and even season must also be taken into account. In this regard, it is necessary to carefully research each class of nutrients and especially the formation of compound feed recipes taking into account the need for them for decorative and singing birds.

Of all animals on earth, birds have the highest body temperature of 41-42 degrees. Therefore, the metabolism that determines their life activity is very fast. The daily metabolic energy requirement for budgies is 70 – 85 kcal, for nymphs and roselles – 115 – 160 kcal, for gray parrots and cockatoos – 140 – 175 kcal. Proteins play an important role in the vital activity of the bird's body. Coming with food, they go to the restoration of old cells, the formation of muscle tissue and the growth of feathers. A lack of protein or an imbalance in its amino acid composition in the diet can cause a delay in the development of chicks, the bird becomes thin, blood quality deteriorates, and reproductive function decreases. For example, budgerigars should receive 3.2-4.0 g of crude protein per head per day, nymphs, rosellas – 5.2-7.0, gray parrots, cockatoos – 7.0-8.5, respectively. Fats are an essential component of protoplasm and play an important role in cellular metabolism. They are the most concentrated source of energy for the bird's body. Fats are an important source of reserve energy and can accumulate in the body in significant quantities (excessive accumulation of fats leads to obesity and reduced activity of birds). Carbohydrates are necessary for the body to ensure the work of muscles and organs, to maintain body temperature. An excess of carbohydrates is deposited in the liver in the form of glycogen and goes to the formation of fat, which is broken down when there is a lack of carbohydrates. With its lack in the diet, the internal reserves of the liver are used up, and after them, the fats and proteins of the body are destroyed. Carbohydrates are accumulated in the bird's body to produce energy, maintain body temperature, and form adipose tissue.

Vitamins are necessary for the normal functioning of the bird's body. With their lack or excess, the body's metabolism is disturbed, its resistance to diseases, reproductive capacity, etc., decreases. The need for vitamins especially increases during the molting and nesting period, as well as in the winter and spring period. After all, the egg laid by the female contains the entire complex of vitamins necessary for the further growth and development of the chick. If there is an insufficient amount of vitamins and other nutrients in the egg, then the chick either dies at a certain stage of development, or grows up weakened, prone to various diseases. The body of the female, having used the appropriate supply of vitamins for the formation of an egg, also needs to replenish this supply for the next egg-laying and normal functioning in the future. Some vitamins can accumulate in tissues and organs (for example, vitamin A – in the liver) and be used by the body from these reserves, and some, especially those vitamins that cannot be synthesized in the bird's body, must be supplied regularly with feed. Unlike proteins, fats, and carbohydrates, minerals have no nutritional value,

but they are extremely necessary for the bird's body as a plastic material (bone tissue) and as a regulator of metabolic processes involved in maintaining the appropriate level of osmotic pressure, acid-alkaline balance, as a structural element of enzyme systems, etc. Some of them are necessary in relatively large quantities, because they participate in the construction of various tissues of the body, for example, calcium, which is found in bones. Others, involved in chemical processes of metabolism, are needed in minimal quantities. The daily requirement of calcium for budgies is 120-160 mg, phosphorus – 120-140 mg, sodium – 50-60 mg.

Thus, a competently developed recipe for decorative and singing birds, taking into account the species, age of birds, physiological characteristics, conditions of keeping will be a guarantee of their health and longevity [7-9].

2.3. Classification and characteristics of fodder for decorative and singing birds

Taking into account the market analysis, as well as based on the study and generalization of literary and Internet sources, we propose to classify feed for decorative and singing birds by bird species, purpose, form of release, price, physiological features and age, as well as by type of packaging [10].

All domestic birds that are kept as pets can be divided into three varieties: singing (having a melodious voice), decorative (with original coloring), and parrots, which are a kind of hybrid of the first two species.

According to their purpose, complete ration feeds and grain feed mixes, treats and feeds fed for medi.al purposes are distinguished. Complete feed contains all nutrients and biologically active substances and is intended for everyday use. Manufacturers of grain feed mixtures also position them as complete ration feed. However, this is a mixture where it is possible to selectively eat feed components, which does not give it the right to be called complete nutrition. Medicinal feed is used for various poultry diseases. This feed has appropriate labeling and is prescribed on the recommendation of a veterinarian and is sold only in veterinary pharmacies. Treats (crackers, sticks for additional feeding, etc.) should be given infrequently and only from proven manufacturers of well-known brands. The glue with which the grain and nuts are attached to the base can contain a large amount of animal protein and, as a result, provoke a surge of sexual activity, and the grain in crackers and sticks is often expired or of low quality.

According to the form of release, loose fodder mixtures and molded fodder are presented on the market. The composition of fodder mixtures includes various types of components, starting with cereals, and ending with various nuts, dried fruits, etc. Formed, represented by a small amount of granulated feed and with a partial inclusion in the composition of the mixture of extruded additives in the form of balls, etc. The use of molded feeds causes a number of disputes among the owners of decorative and singing birds. Some bird owners refuse them, while others, on the contrary, cannot imagine the existence of their pets without them. In this case, it is necessary to take into account that the transition of birds, which have been used to eating mixtures of nuts and grains all their lives, to pellets and extrudates, may turn out to be an overwhelming task. Therefore, this process should be gradual and long-term, with

partial addition of new feed to the main habitual diet. Today, mainly granulated fodder is used in feeding macaws, gray parrots and cockatoos. It should be noted that in order to meet the feed needs of decorative and singing birds when they are kept in captivity, one of the most effective methods is the creation of complete ration compound feed through the use of innovative technologies. For example, in the form of grits or a mixture of grits obtained by extrusion. This will make it possible to diversify the diet, to ensure the satisfaction of both behavioral and feed needs of birds.

By price, fodder for decorative and singing birds is divided into three price categories: economy, business and premium classes. This formation of classes was developed based on the income of the population. Economy class includes consumers who can afford to buy food for their pets at a price of UAH 70 to 100 per kilogram, business class – UAH 101-250/kg, premium class - consumers who can buy food for of their pets is higher than UAH 251/kg. On the market, these classes can include the following feeds: economy class – "Bird", "Fruit-Menu", "LORIvit", etc.; business class – "Papuzhka", "Vitapol KARMEO", "RIO", "Padovan", Versele-Laga, etc.; premium class: "Fiori", "LoLo Pets", "Prestige", "VitaKraft", etc. Among the domestic manufacturers, TM "Pryroda", TM "Lori", Hobby meal are widely represented on the market. Feeds of domestic manufacturers are generally not expensive and according to the price characteristics, they belong to the economy and business class feeds.

Economy-class fodder is mainly domestically produced fodder. In their composition, they mainly contain various types of seeds of grain and oil crops, seeds of meadow grasses, etc. The assortment of business-class feeds includes both domestic and foreign manufacturers. It also contains various types of grain and oil seeds, as well as dried fruits, vegetables, peanuts, etc. Premium-class fodder – fodder enriched with various natural flavor additives, mainly imported. The composition may additionally contain flakes, extruded balls, mineral substances, oils and fats, honey, yeast, algae, etc. The difference between these feeds depends on their composition and nutrition.

By physiological characteristics and age, feed can be divided into feed for adult birds at rest, in the period before nesting, for females in the feeding period, for chicks and in the molting period. These feeds should contain the necessary amount of nutrients and biologically active substances in accordance with the norms and needs of poultry feeding in different periods of its life.

For example, in the period before nesting, i.e., the period when the female "fixes" her nest and when she lays eggs, the feed should be enriched, first of all, with calcium, vitamins and other mineral substances. During the nesting (egg hatching) period, the female almost does not get up from the nest, only when necessary, and she eats everything that the male brings her, therefore, this feed should meet the minimum requirements for nutrients and biologically active substances. During the period of feeding chicks and for chicks, feed should be enriched with proteins, fats, vitamins, amino acids and minerals, these feeds should be in an easily digestible form. During the molting period, feed should contain an increased content of protein and amino acids.

Depending on the type of packaging, feed for decorative and singing birds is currently offered in natural (cardboard), soft polymer and combined (based on cardboard and polyethylene) packages.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The object of the research is the technological process of extruding loose starting mixtures. The subject of the research is extruded compound feed in the form of grits for decorative and singing birds and feed for industrial production.

The described physico-chemical and microbiological research methods in accordance with the direction of the experiments are given in the table 3.1. For ease of use, all methods are systematized in accordance with research directions.

Table 3.1. Research methods used in experiments [11-13]

№	Name of indicatots	Principle of the method and its specifics	Regulatory and technical documentation (RTD)
Physical and chemical indicators			
1.	Mass fraction of moisture	Drying a test product weight to a constant mass at a temperature (130±2) ˚C	The State Standard DSTU ISO 6496:2005
2.	Volumetric mass	With the use of a liter powder (mass of raw maerials in one liter)	The State Standard GOST 28254-89
3.	Natural slope angle	On Zenkov's equipment by pouring from a watering can	The State Standard GOST 28254-89
4.	Fluidity	The flow rate if the product through an opening of a certain diameter	[13]
5.	Weighted average particle size	Sievsng a sample of bulk product on a set of sieves with holes of different diameters	The State Standard GOST 13496.8-96
6.	Crude protein	According to Kendall's method	The State Standard DSTU ISO 5983:2003
7.	Raw fat	By the Soxhlet method	The State Standard GOST 13496.15-97
8.	Crude fiber	Treatment of a sample of the experimental product with a mixture of concentrated nitric and acetic acids	The State Standard GOST 13496.4-93
9.	Raw ash	Incineration of a sample of the experimental product with subsequent calcinations of the mineral residue at a 500-600°C	The State Standard GOST 13496.14-87
10.	Calcium	Complex metric method	The State Standard GOST 26928-86
11.	Phosphorus	By the molybdenum-vanadium method	The State Standard GOST 26928-86

To assess the quantitative and qualitative composition of the microbiota, samples were taken in sterile dishes in aseptic conditions, which exclude microbial contamination of the samples from the environment. The composition of the microbiota of the samples was determined by microbiological and sanitary indicators, which include the number of mesophilic aerobic and facultatively anaerobic microorganisms (MAFAnM), micromycetes (mold fungi and yeast), bacteria of the group of Escherichia coli followed by the identification of opportunistic Escherichia coli and Staphylococcus; aureus pathogenic microorganisms, including salmonella, sulfite-reducing clostridia. Determination was carried out by sowing on special nutrient media with subsequent cultivation and characterization according to RTD [14, 15].

The above-mentioned agents of poisoning can cause serious diseases in decorative and singing birds, which can lead to death. Therefore, according to modern

requirements, the presence of these microorganisms in compound feed makes it possible to judge their sanitary condition.

IV. RESULTS

4.1. Optimizing the composition of feed for decorative and singing birds

The optimal composition of compound feed recipes was calculated using a software complex, which is based on the principles of calculating the minimum cost, taking into account the limitations of the input of each component and the nutritional value of the finished product using linear programming [16, 17].

In the table 4.1. gives recipes of compound feed for decorative and singing birds (budgies – №1 (CF №140-1), amadins – №2 (CF №140-1) and canaries – №3 (CF №140-1)) and their indicators quality.

Table 4.1. Composition of feed recipes for decorative and singing birds

Raw	CF №140-1	CF №140-2	CF №140-3
Peeled millet	43,0	24,0	29,3
Peeled oats	25,0	25,7	23,9
Sorgum	10,0	8,6	7,0
Wheat	–	10,0	6,0
Flax oil	3,0	5,3	4,0
Sunflower cake	7,2	8,1	–
Sunflower seeds	–	3,9	–
Sunflower meal	–	–	7,5
Rapeseed cake	–	–	4,5
Fodder yeast	1,0	3,0	3,0
Dry milk	–	–	2,7
Beets pulp	4,0	–	–
Apples pulp	4,0	4,0	–
Carrots pulp	–	–	4,0
Vineyards pulp	–	4,0	–
Pumpkin pulp	–	–	4,0
Monocalciumphosphate	0,4	1,4	1,3
Feed chalk	1,2	0,8	1,6
Kitchen salt	0,2	0,2	0,2
Premix	1,0	1,0	1,0
Everything	100,0	100,0	100,0
Quality indicators			
Exchange energy, kcal/100 r	272	287	310
Mass fraction of, %: crude protein	12,50	15,80	18,30
raw fat	5,40	6,50	8,10
raw ash	3,90	5,20	5,90
crude fiber	3,30	4,90	4,20
lysine	0,70	0,74	0,79
methionine	0,32	0,42	0,47
calcium	0,90	0,90	1,18
phosphorus	0,68	0,70	0,75
sodium	0,11	0,15	0,17

The calculated recipes correspond to the nutritional standards for decorative and singing birds.

4.2. Development of a method of production of compound feed for decorative and singing birds

We have proposed a method for the production of compound feed for decorative and singing birds in the form of extruded grits or a mixture of grits, which provides for the preparation of the initial components with subsequent dosing, mixing, extrusion, cooling, grinding and fractionation, with the aim of obtaining grits or a mixture of grits of different colors (dosing, mixing grits) and packaging.

Prepared (cleaned) grain raw materials (wheat, corn, etc.) that do not require husking and lump raw materials (cake, meal) are submitted for dosing. Oats and millet are cleaned of metallomagnetic impurities, husked and separated. Hulled millet and oats are served and dosage. In order to prevent regrinding, these types of raw materials are submitted for fractionation. The fine fraction passes through the sieve and is fed into the mixer, and the large fraction is cleaned of metallomagnetic impurities and subjected to grinding, and then enters the mixer.

Mineral, protein, non-traditional raw materials and premix come in packaged form. After grinding, the raw material is fed for dosing and, for the formation of a homogeneous mixture of a stable composition, mixing. At the exit from the mixer, we get loose compound feed, which we send to extrusion. Bulk compound feed is pre-controlled for the content of metal-magnetic impurities and served for mixing with pre-dosed wet components (fruit and vegetable pomace: it is provided that wet raw materials enter a hopper with a mixing device). The homogeneous mixture is submitted for extrusion at a temperature of 110-130°C and a pressure of 2-3 MPa.

The hot extrudate is cooled to a temperature that does not exceed the ambient temperature by more than 10°C. In order to obtain a grain, the extrudate is sent for grinding, the gap between the rolls is 0.4 – 0.5. In the machine for controlling the grain size, the upper sieves LC №30 and the lower one – LC № 10 are installed. After that, the small fractions (the passage of the lower sieve) are sent for reextrusion, the large fraction (the exit of the upper sieve) is submitted for grinding. The passage of the upper and the exit of the lower sieve is a finished grain, which is fed to the warehouse of finished products or to the hopper for the formation of a mixture of grains. Next, the extruded compound feed is sent to storage, packaging and release. To form a mixture of grains, different types of grains are dosed, mixed, packed and served for the release of finished products.

The appearance of fodder for decorative and singing birds is of great importance both for the bird and for its owners. Modern technologies of the feed industry can significantly change the natural color of products. Decorative and singing birds have well-developed organs of vision. It has the ability to distinguish colors – red, green, yellow, etc. Therefore, the technology provides for the introduction of natural dyes (extracts of red beets, carrots, pumpkins, apples, grapes of dark varieties) into the composition of fodder to achieve marketable and consumer appearance.

4.3. Characteristics of the quality indicators of compound feed for decorative and singing birds

In accordance with the developed recipes (Table 4.1) and improved technology for the production of compound feed for decorative and singing birds, test samples of compound feed in the form of extruded grain were obtained in laboratory conditions, in which physico-chemical and microbiological quality indicators were determined. The possibility of giving the extruded compound feed various shades – red (beet pulp), yellow (carrot and pumpkin pulp), purple (blue grape pulp) due to the inclusion of natural dyes – was investigated. We suggest introducing 8 % of wet components, which will allow to effectively moisten the starting mixture before extrusion due to the moisture contained in the starting raw materials.

Experimental samples of compound feed were obtained in laboratory conditions (№ 1, № 1a – compound feed before and after extrusion with the addition of beet pomace; № 2, № 2a – compound feed before and after extrusion with the addition of grape pomace; № 3, № 3a – compound feed before and after extrusion with the addition of carrot and pumpkin extracts) and organoleptic, physico-chemical and microbiological quality indicators were determined, which are listed in table. 4.2 and 4.3 and in fig. 4.2, 4.3 respectively.

As shown by the results (Table 4.2.), during the extrusion process, the moisture content decreases, which is positive from the point of view of further storage, as well as the volumetric weight decreases, other indicators change slightly.

In the extrusion process, protein denaturation occurs, which leads to an increase in the number of peptides and free amino acids. The result of this process is an increase in digestibility of proteins. Thus, extrusion processing, which causes starch gelatinization, destruction of cellulose-lignin complexes, and protein denaturation, significantly increases the feed value of mixtures of grain components. At the same time, the increased feed value, which is due to the high degree of digestibility and assimilation of nutrients, determines the high efficiency of the extruded mixture of grain components in the production of compound feed.

Table 4.2. Physical properties of test samples

Indicators	Indicators of experimental samples					
	For budgies CF №140-1		For amadins CF №140-2		For canaries CF №140-3	
	№1	№1a	№2	№2a	№3	№3a
Mass fraction of moisture, %	17,2	12,8	16,8	11,6	17,4	13,0
Volumetric mass, kg/m^3	714	610	722	558	728	575
Natural slope angle, grad	32	40	30	41	34	43
Fluidity, cm/s	9,1	10,8	8,9	10,5	9,0	10,3

In the process of extrusion, the components of compound feed are subjected to such processing stages as heat treatment, sterilization, disinfection, volume increase, grinding, mixing, dehydration, stabilization. As a result, there are significant changes in raw materials, starting with changes in physical properties, improvement of fodder qualities, increase of fodder value and ending with sterilization of compound feed.

As evidenced by the obtained data (Table 4.3.), according to organoleptic indicators, compound feed is characterized by an attractive appearance and smell

characteristic of a set of components and an increased content of nutrients and biologically active substances.

Table 4.3. Indicators of the quality of compound feed for decorative and singing birds

Indicators	Characteristic		
	For budgies CF №140-1	For amadins CF №140-2	For canaries CF №140-3
Organoleptic indicators			
Color	light pink	Light purple	yellow
Scent	Characteristic og the set of components included in the product, without extraneous odors		
Physical and chemical indicators			
Mass fraction of moisture, %	12,80	11,60	13,00
Mass fraction of crude protein, %	12,44	15,91	18,24
Mass fraction of crude fat, %	5,32	6,48	7,88
Mass fraction of crude fiber, %	3,41	3,89	3,94
Mass fraction of ash insoluble in hydrochloric acid, %	3,88	5,29	5,75
Mass fraction of calcium, %	0,90	0,90	1,11
Mass fraction of phosphorus, %	0,67	0,70	0,74

In the course of the conducted research (Table 4.4.), a comparison of experimental results of physical and chemical parameters of commercial feed and data printed on the packaging was also carried out. Where we can see that the data specified by the manufacturer do not correspond to reality, and are somewhat different.

Table 4.4. Physico-chemical indicators of the quality of industrial feed

Indicators	Industrial feed					
	Special One (for budgies)		Padovan (for exotic birds – amadines)		Nature (for canaries)	
	research	on the package	research	on the package	research	on the package
The mass fraction: moisture, %	12,40	13,00	10,90	13,00	10,50	13,00
crude protein, %	11,34	12,00	12,70	13,10	17,10	19,30
raw ash, %	3,42	3,40	3,75	2,80	5,20	4,40
crude fat, %	5,87	4,00	5,53	7,20	8,57	16,20
crude fiber, %	9,10	8,00	7,32	8,30	9,24	10,00
phosphorus, %	0,22	0,10	0,41	–	0,52	–
calcium, %	0,58	0,20	0,68	–	0,73	–

It is very important that compound feed is not only balanced in terms of nutrition, energy, and amino acid composition, but also meets the hygienic requirements for safe and high-quality feed. The purity of feed is the absence of pathogenic bacteria, mold and toxins in it, which pose a significant threat to the health decorative and singing birds.

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and high-quality feed. The purity of feed is the absence of pathogenic bacteria, mold and toxins in it, which pose a significant threat to the health and productivity of poultry.

The quality of fodder is determined by the quality of the initial components. Meanwhile, a large part of feed raw materials is exposed to risk factors that significantly affect the productivity and safety of livestock and poultry farming. Such risk factors include, first of all, mold, contamination of grain and feed during storage, and pathogenic microorganisms that, entering the body of animals with feed, multiply and cause disorders of the gastrointestinal tract.

To prevent the negative factors listed above, the extrusion process is provided for in this technology. So, the health of the bird depends not only on the quantity and quality of feed, but also on its sanitary quality. The sanitary quality of feed is the absence of pathogenic bacteria, mold and toxins in it, which pose a great threat to the health and productivity of animals. Therefore, the study of the qualitative and quantitative composition of the microflora is of great importance for the development and practical application of various processing methods in order to improve the stability and prolong the shelf life of compound feed for its further use in the compound feed industry.

The indicator of the number of mesophilic aerobic and facultatively anaerobic microorganisms (MAFAnM) is the most widespread microbiological indicator. It is used in the food and compound feed industry as an indicator of the sanitary state of production. Identification of the qualitative composition of the microflora is an indicator of safety, since the presence of pathogenic microorganisms or an increased content of opportunistic pathogens compared to the permissible norm can be the cause of poisoning.

The following types of compound feed were selected as objects of research: № 1, № 1a – compound feed before and after extrusion with the addition of beet pulp; № 2, № 2a – compound feed before and after extrusion with the addition of grape pomace; № 3, № 3a – compound feed before and after extrusion with the addition of carrot and pumpkin extracts; № 4 – TM "Special One" (for budgies); № 5 – TM "Padovan" (for exotic birds – amadines); № 6 – TM "Nature" (for canaries).

All samples in the amount of 1 kg were stored in paper bags for 3 months in the laboratory of the Department of Grain and Compound Feed Technology at a temperature of +6...+18 °C. The relative humidity of the air during the storage period fluctuated between 60...75 %. The insemination analysis of the samples was carried out before storage, as well as after 3 months of storage.

The analysis of the obtained results (Fig. 4.1.) showed that in the majority of samples, the component of the bacterial microflora is the non-spore-bearing bacillus Erwinia herbicola – a typical companion of grain compound feed when stored under standard conditions (representative of epiphytic microflora). The percentage of Erwinia herbicola bacteria from the total number of all bacteria in samples of non-extruded compound feed is about 70 %, the share of coliform bacteria and micrococci is 11 %. Among the spore-forming bacteria, bacterial groups Bacillus subtilis – licheniformis were found, the relative number of which was 1.4 % of the total number of bacteria in all samples. Among the micromycetes, field mold fungi such as:

Cladosporium, Alternaria and a small number of unidentified fungi were found before storage.

As research has shown, no growth of microorganisms was detected in all samples. On the contrary, the initial number of bacteria and micromycetes decreased during storage. The decrease occurred due to the death of non-spore-forming bacteria Erwinia herbicola, which is natural. Due to the fact that Erwinia herbicola is dying out, the composition of the bacterial microflora is regrouping – the relative content of non-spore-forming forms and micrococci decreases, and spore-forming ones increases. This is a consequence of the unequal degree of survival of different bacteria.

A different picture is observed when analyzing micromycetes (Fig. 4.2.). Micromycetes practically did not develop, but a change in their qualitative composition was observed. The number of field molds of the genera Alternaria, Cladosporium and others has significantly decreased. Mold fungi of the genera Aspergillus and Penicillium became permanent representatives of the fungal microflora of the studied compound feeds.

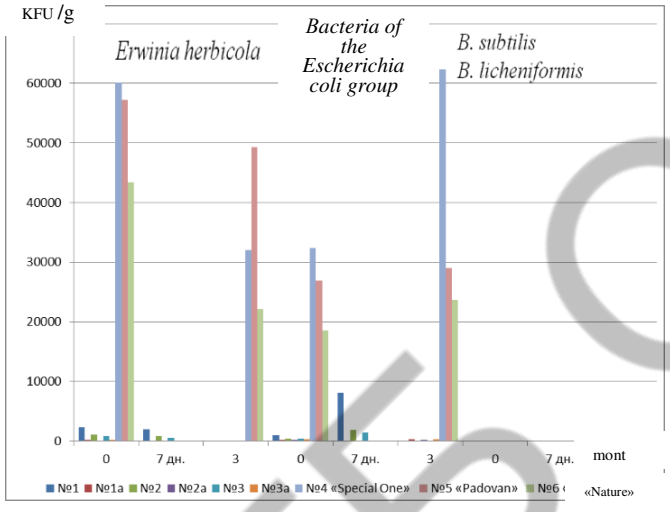

Fig. 4.1. Change in the number of bacteria during storage: № 1 – loose compound feed for extrusion; № 1a – compound feed after extrusion; №2 – loose compound feed for extrusion; № 2a – compound feed after extrusion; № 3 – loose compound feed for extrusion; №3a – compound feed after extrusion; № 4 – TM "Special One" (for budgies); № 5 – TM "Padovan" (for exotic birds - amadines); № 6 – TM "Nature" (for canaries)

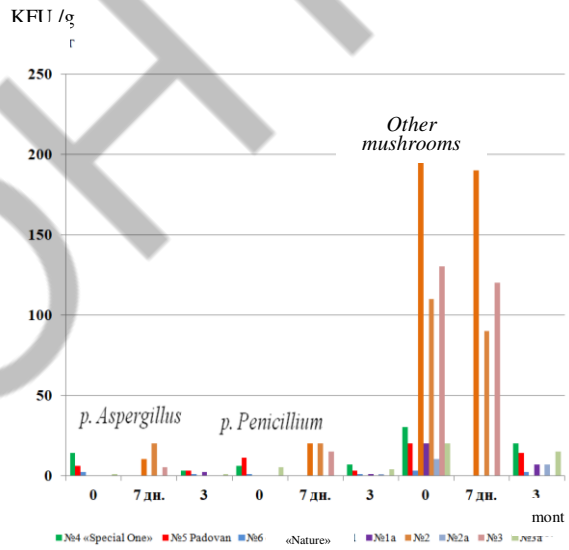

Fig. 4.2. Change in the number of micromycetes during storage: № 1 – loose compound feed for extrusion; № 1a – compound feed after extrusion; № 2 – loose compound feed for extrusion; № 2a – compound feed after extrusion; № 3 – loose compound feed for extrusion; № 3a – compound feed after extrusion; № 4 – TM "Special One" (for budgies); № 5 – TM "Padovan" (for exotic birds - amadines); № 6 – TM "Nature" (for canaries)

Escherichia coli, salmonella, staphylococcus, proteus, and sulfide-reducing clostridia were not detected in all tested samples of compound feed. This testifies to the provision of appropriate standards of sanitary and hygienic conditions during the production and storage of compound feed.

V. CONCLUSIONS

The following conclusions were drawn on the basis of the conducted research:

1. In order to meet the feed needs of decorative and singing birds when they are kept in captivity, one of the most effective methods is the creation of complete ration compound feed by using innovative technologies (in the form of grits or a mixture of grits obtained by extrusion). This will make it possible to satisfy both behavioral and feed needs.

2. Taking into account the market analysis, as well as based on the study and generalization of literary and Internet sources, we proposed a classification of feed for decorative and singing birds by bird species, purpose, form of release, price, physiological features and age, as well as by type of packaging.

3. A method for the production of compound feed for decorative and singing birds in the form of extruded grits or a mixture of grits is proposed, which provides for the preparation of the initial components with subsequent dosing, mixing, extrusion, cooling, grinding and fractionation, with the aim of obtaining grits or a mixture of grits of different colors (dosing, mixing of grains) and packaging.

4. The quality of experimental samples and industrially produced feeds was evaluated according to organoleptic, physico-chemical and microbiological indicators and it was established that these combined feeds meet the needs of poultry in terms of the main nutritional indicators and are not inferior to industrial analogues.

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