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INNOVATIVE APPROACHES IN THE FORMATION OF COMPOUND FEED RECIPES FOR DECORATIVE BIRDS AND SINGING BIRDS AND TECHNOLOGY OF COMPOUND FEED PRODUCTION FOR THEM

Abstract

The share of compound feeds for unproductive pets in the compound feed markets of the world is growing every year. In Europe, decorative and songbird birds are the third largest pet population (cats and dogs being numbers one and two, pectively), according to FEDIAF data, with 51.87 million decorative birds in all of Europe (37.23 million of those in the European Union) in 2019.

Decorative and songbirds need complete feeding to maintain life and health. Today, owners of decorative and songbirds have a wide range of ready-made food, which allows them to make the right choice of appropriate feeding regime for their pets. Analyzing the market of feed for decorative and songbirds, we saw that a significant part of it is imported feed, while the range of domestic feed in the Ukrainian market is very small and does not always meet market requirements and can not compete. However, the presented compound feeds can hardly be called complete, as they are mainly different types of feed mixtures, which include, depending on the price category, different types of components: from cereals and ending with different nuts and dried fruits.

Compound feed should contain all the components necessary for energy production, growth, tissue regeneration, as well as to regulate metabolism. Complete feed for decorative and songbirds must contain a certain amount of all nutrients and biologically active substances. Factors such as age, general health, breeding season, growth, molting, housing conditions and even the season should also be considered.

To date, there are a number of issues that need to improve our knowledge of the nutrient and biologically active needs of each species of decorative and songbird, including the characteristics of feed materials, the amount of energy, digestibility of feed and the content of nutrients and biologically active substances.

In this regard, it is necessary to study each class of nutrients and biologically active substances and features of the formation of compound feed recipes, taking into account the need for decorative and songbirds. To study in detail the functional purpose of nutrients and biologically active substances, symptoms that occur in the body of decorative and songbirds in their absence or excess in the feed, as well as their sources and minimum needs of birds during reproduction, growth and maintenance of healthy birds.

To meet the forage needs of decorative and songbirds when kept in captivity, one of the most effective methods is to create complete feed by using innovative technologies (for example, in the form of crumbs or a blend of crumbs obtained by extrusion). This will provide an opportunity to meet both the behavioral and feeding needs of birds.

Keywords: decorative and songbirds, nutrients and biologically active substances, recipe, innovative technologies, extruded complete feed for decorative and songbirds.

Introduction

The share of compound feeds for unproductive pets in the compound feed markets of the world is growing every year. Finished industrial feeds become the only balanced source of nutrients and biologically active substances in their diet [1].

Petfood Industry 2019 estimated the global pet feed market at $ 91 billion (annual growth of 6.5 %). The world leader is the United States. Last year, American pets ate almost $ 37 billion worth of food and treats, which is 7.3 % more than in 2018. The appetites of European furriers are a bit more modest. According to analysts at European Pet Food Industry (the federation covers 18 countries in Western and Eastern Europe), feed sales in the region over the past three years increased by an average of 2.6 %, which in 2019 reached a level of € 21 billion. The Ukrainian market does not exceed UAH 6.0 – 6.5 billion, but grows by 20 – 30 % annually [2].

In Europe, decorative birds are the third largest pet population (cats and dogs being numbers one and two, pectively), according to FEDIAF data, with 51.87 million decorative and songbirds birds in all of Europe (37.23 million of those in the European Union) in 2019. 28.57 million small mammals (10.63 million in the EU), 15.54 million aquaria (10.63 million in the EU; overall equating to roughly 300 million ornamental fish) and 9.43 million reptiles (7.91 million in the EU) round out the top pet types in Europe [3, 4].

Like all living things, decorative and songbirds need complete food to maintain life and health. Compound feed should contain all the components necessary for energy production, growth, tissue regeneration, as well as to regulate metabolism. Components of feed that perform these functions are called nutrients, the main of which are proteins, fats, carbohydrates and biologically active substances (vitamins and minerals). Properly balanced feed for decorative and songbirds should contain a certain amount of all nutrients and biologically active substances. Factors such as age, general health, breeding season, growth, molting, housing conditions and even the season should also be considered [5, 6].

Today, owners of decorative and songbirds have a wide range of ready-made feed, which allows them to make the right choice of appropriate feeding regime for their pets [7]. Analyzing the market of feed for decorative and songbirds, we saw that a significant part of it is imported feed, while the range of domestic feed in the Ukrainian market is very small and does not always meet market requirements and can not compete [8]. However, the presented feed is difficult to call complete, as it is mainly different types of feed mixtures, which include, depending on the price category, different types of components: from cereals and ending with different nuts and dried fruits.

To date, there are a number of issues that need to improve our knowledge of the nutrient and biologically active needs of each species of decorative and songbird, including feed characteristics, energy content, feed digestibility and nutrient and bioactive content. To meet the feeding needs of birds when kept in captivity, one of the most effective methods is to create a complete feed.

Purpose and objectives of the analysis

The aim was to study each class of nutrients and biologically active substances and features of the formation of compound feed recipes, based on needs of decorative birds and songbirds.

Results and its discussion

Consider the requirements for the amount of energy for decorative birds and songbirds when kept at home, during reproduction, during the growing season; needs of adult birds, during growth and molting in proteins and amino acids; needs for fats and essential fatty acids; carbohydrates; vitamins and minerals.

Energy needs when kept at home. The main source of energy in the diet of grain birds is carbohydrates, mainly in the form of starch. In addition, fats are a highly concentrated source of energy. For example, young squash pigeons meet their energy needs by consuming the fats contained in goiter's milk. If there are not enough carbohydrates or fats in the diet, proteins can be used as an energy source. The body of the bird regulates the consumption of food by providing the necessary amount of energy. Poultry studies have shown that if the energy content of the diet increases, for example, by increasing the fat content of the feed, the bird reduces feed intake to compensate for this. If no changes have been made to the other components, a nutrient deficiency develops. Conversely, when the energy value of the feed is reduced, its consumption increases, so that the bird meets its energy needs as needed. However, if the diet contains very little energy, the ability to regulate consumption can be neglected, as the limiting factor is the capacity of the gastrointestinal tract. In the table 1 shows the metabolic energy needs for some species of decorative and songbirds.

Table 1 – Metabolic energy needs for some species of decorative and songbirds

Birds	Weight range, g	Age requirement, kJ/day
Cockatoo Nymphicus hollandieus	80-100	110-130
Wavy parrot	50-70	78-100
Canary	20-30	40-55
Zebra amadin	15-20	32-40

Since the energy content of most cereal mixtures for budgies is about 1.75 MJ per 100 g, theoretically, the bird should eat about 4-6 g/day to meet their energy needs. It should also be borne in mind that the energy absorption of seeds is normally about 90 %. Studies have shown that the average budgerigar consumes 8 to 12 g of seeds per day, which is equivalent to 500-1000 individual seeds [5, 9, 10].

Energy needs during reproduction. The average weight of a budgerigar egg is 2.5 g, each gram contains about 5.5 kJ of energy. Therefore, one budgerigar egg contains approximately 16.5 kJ. If there are an average of five eggs in the clutch, the hatched male may need an additional 80 kJ of energy during the laying of eggs. In addition, because males need energy to form eggs, the amount of energy increases. Obviously, more food needs to be consumed to compensate for the increased needs. During the period of egg laying and hatching, energy consumption remains relatively constant: 231 – 252 kJ/day. However, when the chicks begin to hatch, there is a tremendous increase in energy needs of the parent pair. At peak joint feed intake, birds absorbed from 483 to 505 kJ per day (2 adult birds and 3 chicks) [5, 9, 10].

Energy needs for growth. At hatching from an egg the chick of a wavy parrot weighs approximately 1,5 g, and by the tenth day of life its weight makes already approximately 20 g. In order to gain this phenomenal growth rate, as well as for the full development of plumage, a young bird needs a lot of energy. The chicks spend most of the energy they consume to grow. This ranged from 62 to 73 % in chicks at the age of 1-3 days. This proportion gradually decreases as the chicks develop, but for the entire period from hatching until they become independent, an average of 11 % of the daily energy supply is spent on growth. Therefore, adult birds should receive additional food so that they can provide their chicks with the necessary nutrients. On average, the need for food during the rearing of chicks doubles, and will return to baseline only after the last chick leaves the nest [5, 9, 10].

Influence of temperature. Birds maintain a body temperature of 41-42 °C, which is usually much higher than the ambient temperature, which requires

energy. The energy needed to maintain a constant body temperature depends on the difference between normal body temperature and ambient temperature. This means that in a cold environment, birds must use an effective mechanism to conserve heat, and feed consumption will be maximum. Also, when the ambient temperature is high, more heat should be expended. Birds lower their body temperature by evaporating from the surface of the airways and skin. However, it is not very effective and in hot conditions the reduction of heat release is often achieved by reducing feed consumption. With increasing temperature, feed consumption decreases by about 1.5 % for each °C compared to normal temperature [5, 9].

Fats and essential fatty acids. Fats play two main roles in feeding birds: they are a concentrated source of energy and perform various metabolic functions, as well as promote the absorption of fat-soluble vitamins. Birds are sensitive to the level of fat in the feed and regulate their metabolism, preventing excess energy. This is achieved by maintaining a constant level of feed intake in order to meet the needs of other nutrients by metabolizing fats with less efficiency. Thus, the overall effect is expressed in maintaining a constant mass, not in building it. However, birds that receive diets high in fat are obese. In addition, the consumption of large amounts of fat can cause diarrhea, as well as the formation of insoluble soaps. This makes minerals such as calcium and iron inaccessible to birds. Some cockatoos, which consume only sunflower seeds, are obese and often have lipomas. This is observed in the pink-breasted cockatoo and emphasizes the importance of the diet based on mixtures of seeds.

It is generally believed that linolenic acid is the most essential fatty acid for decorative and songbirds, so it helps to eliminate all the symptoms of deficiency of essential fatty acids. The first sign of a deficiency of essential fatty acids in chicks is a slowdown in growth, which may occur during the first week of feeding a diet with this deficiency. This is accompanied by damage to membrane structures, leading to skin diseases [5, 11]. The skin becomes rough, scaly, its permeability increases, which leads to rapid water loss. If birds do not receive essential fatty acids, they are affected by plumage, reduced utilization of nutrients, reduced resistance to disease, and sometimes the bird dies. In adult birds, this is rare, so the bird's body has a high ability to maintain reserves of essential fatty acids. Studies in poultry suggest that approximately 2 % of metabolic energy should come in the form of linolenic acid. This corresponds to approximately 0.9 % of the diet containing 12.5 MJ/kg. It is possible that during molting periods in adult birds the need for feed fats increases significantly. The membranes of epithelial cells involved in the formation of feathers contain a large amount of fat component, which must come with food. One source of linolenic acid is flaxseed [5, 12, 13].

The needs of adult birds in protein. Birds need proteins to form and develop body tissues and to maintain its structure. In addition, birds utilize proteins to form and maintain a healthy plumage, claws and beak. Studies on budgies have shown that the minimum need for feed protein is 10 %. Work with birds of the rowan family (adult field sparrows) confirmed that the concentration of feed protein, equal to 8 – 9 %, is sufficient to maintain weight, nitrogen and energy balance. However, this figure is probably less than the need for optimal growth, development and tissue repair (eg, reproduction, development of chicks, molting process). The results of a study of pigeons showed that birds during the breeding season need a protein content in the diet, at the level of 18 %.

In addition, protein needs depend on feed intake. Thus, everything that affects feed intake, ie energy content in the diet or ambient temperature, has a side effect on the optimal level of protein in the diet. There is no advantage in the bird's consumption of high-protein feed, as the energy costs of deamination, uric acid formation and excretion are very high. Further, overload of the excretory capacity of the kidneys can lead to hyperuricemia. Further deposition of urate crystals in the kidneys can cause clinical symptoms and cause death. In addition, there may be an association between excessive protein content in the feed and hypertrophied growth of the beak and claws in birds with cellular retention [5, 11].

Protein needs have both quantitative and qualitative aspects. As for the first, the feed should contain a sufficient amount of protein to obtain replacement amino acids or nitrogen for their synthesis. From a qualitative point of view, feed proteins should be a source of amino acids that the bird's body can not synthesize at all or can not synthesize quickly enough – essential amino acids. In addition to the essential amino acids that mammals and chicks need, they probably need a feed source of glycine and proline needed to ensure maximum growth and development.

To effectively utilize dietary proteins, it is important to maintain an optimal balance between amino acids. Ideally, the diet should meet the need for all amino acids, not including excess protein or individual amino acids. When using a diet low in protein, which causes a moderate deficiency of all amino acids, there is an increase in feed intake. This is an attempt by the bird to compensate for the lack of diet, which leads to obesity. An even more noticeable reaction is observed if only one or two amino acids are present in the diet at abnormally low or high concentrations. Under natural conditions, deficiency of certain amino acids is rare. However, cage keeping of birds and feeding a narrow set of seeds or grains can cause a deficiency of some amino acids, in particular lysine and methionine, the content of which is low in some seeds, such as safflower seeds and peanuts [5, 12, 13].

The need for protein for growth. Requirements for rapid growth and development mean that young birds have increased protein needs. If we take into account the growth rate, we see that the protein needs of chicks are much higher than those of adult birds. Newly hatched budgerigar chicks double in weight in two days and then continue to grow rapidly until they are thirty days old. In addition to the huge weight gain, birds develop full plumage. However, the optimal level of protein in the diet has yet to be established. When the protein content is at least 25 %, the chick develops much better. The fluid formed in the goiter of budgerigars,

which is intended for feeding chicks, contains from 24 to 26 % protein relative to dry matter, which leads to the conclusion that this level is optimal for budgies that have just hatched. After a few days, protein requirements are reduced, and studies in squash pigeons have shown that at this stage the conditions for optimal growth and development are achieved when the protein content in the diet is 18 %. Studies of chicks of small Australian crested cockatoos (Nymphicus hollandicus) have shown that to maintain maximum growth, the diet should contain 20 % protein. Subsequent studies have suggested that the minimum lysine requirements are 0.8 %. Modern research on canary chicks leads to the conclusion that the protein content in the feed should be 16.5 – 21.9 %. Excess protein in the diet (23 %) inhibited the growth of older chicks mentioned by the Australian cockatoo, so it would be unwise to overload the diet.

The amino acid needs of developing chicks are different from the needs of adult birds. In addition to 10 essential amino acids, decorative birds and songbirds need glycine and proline for optimal development. Glycine is an integral precursor of uric acid this is one of the reasons why the bird has high requirements for the content of this amino acid in the diet. In addition, glycine is the main component of collagen and feathers (table 2). Thus, a deficiency of this amino acid immediately affects the development of chicks. If to get the right amount of glycine you have to give the chicks an increased amount of food, the serine in the liver can be converted into glycine. However, since the rate at which the chick synthesizes glycine is less than the rate at which it is used, it is useful to introduce appropriate supplements into the diet. A similar situation occurs in the case of proline. This is the main component of collagen and feathers, which explains the importance it has for the development of chicks. Glutamate is a common precursor of proline, and therefore it is often called a "semi-essential" component of the diet of chicks [5, 12, 13].

Table 2 – The main amino acid protein of budgerigar feathers

Amino acid	Content in protein, %
Glutamic acid	7,72
Cystine	7,45
Proline	7,26
Valine	5,41
Leucine	5,30
Glycine	4,60
Aspartic acid	4,54
Arginine	4,27
Serine	4,12
Alanine	4,07

The need for protein and amino acids during molting. The plumage creates a heat-insulated layer in birds, and also acts as a water-repellent coating and promotes flight. The formation of follicles is observed during the development of the embryo, but later the feathers of birds more than once during life fall out and recover. At the age of four months, the budgie experiences its first moult. In Western Europe, the main annual moult occurs in autumn. It begins when the temperature drops and usually lasts six to eight weeks. The pattern of molting is the same as that of canaries and finches.

Feathers 85 – 97 % consists of protein, and almost all protein is represented by keratin. Thus, the amino acids of the diet play an important role in the development of plumage. The main amino acids involved in the synthesis of keratin are methionine and cystine.

Cystine is a component of keratin, methionine is important as a precursor to cystine. Studies have shown that during the period of rapid development of plumage, the maximum feeding efficiency is achieved if cystine is at least half of the sulfur-containing amino acids in the diet. As the feathers grow, the nutritional value of cystine decreases. Thus, during the molting period it is reasonable to include in the diet of both rapeseed and white millet, which contain many of these amino acids. There are other amino acids that are important for healthy plumage, including lysine and arginine. Lysine is also required for pigmentation, which is probably due to its role in the formation of melanin. In addition, there is evidence of a link between the lack of feed arginine and the plucking of feathers by birds.

Birds that lose their feathers either due to disease or plucking have higher feed needs, which allows them to compensate for this effect. In addition to the need for amino acids for the growth of new feathers in birds with incomplete plumage, there is increased heat loss. This leads to an increase in metabolic rate by more than 60 % with an even increase in energy needs for heat generation and plumage recovery. Energy consumption by birds that have lost their plumage is more than 85 % higher than that of birds with normal plumage (at 22 °C). It should be noted that at this time the birds should be fed mainly grain with high energy value, such as oats or oilseeds [5, 12, 13].

Interaction of amino acids. The interaction of glycine – serine and glutamate – proline reveal the importance of analyzing the role of amino acid needs in the diet. For adult birds, the interaction between sulfur-containing amino acids, which are integral components of feathers, is important. Thus, given the interactions between methionine and cystine, the minimum feed requirement for methionine is expressed as the need for both of these amino acids. Also for chicks feed need for glycine is determined by the total content of glycine and serine in the diet. The situation is complicated by the fact that the need for feed glycine increases under the influence of low concentrations of methionine, arginine or B vitamins [5, 12, 13].

Carbohydrates. The main function of all carbohydrates consumed by decorative birds and songbirds is a direct source of energy. The enzymes of the digestive tract of birds are as effective in breaking down starch as the enzymes of other animals. However, birds have a more limited ability to digest polysaccharides of non-starchy nature, in particular, in birds that have a rudimentary cecum or do not have it at all [5, 12, 13].

Water. Physiologically, birds are less dependent on drinking water than mammals because they excrete nitrogenous excrement in the form of insoluble uric acid rather than urea. As a result, their excrement contains very little water, an average of 32.8 – 6.5 %. However, water remains the most important component of feeding. It plays the role of a transport medium, an environment in which metabolic reactions take place and which is vital for the regulation of the body temperature of birds. Species of birds for which water is of paramount importance are those species whose main part of the diet is dry seeds. Decorative birds and songbirds birds such as budgies, canaries and finches are in constant need of fresh water. Wavy parrots, receiving a diet based on seeds with supplements, consume 3 to 5 ml of water daily. Of all the birds kept in cages, canaries are the most sensitive to the presence of water and in its absence can die in 48 hours. On the other hand, budgies in the process of evolution have the ability to survive in minimal water content, but they also need to give fresh water daily. If the bird does not consume enough water, its manure is meager. In addition, the proportion of fecal masses in the manure increases so much that the manure becomes dark green [5, 13].

Vitamins.

Vitamin A deficiency is commonly found in captive parrots, and most commonly in African grays and Amazons. Clinical symptoms include increased susceptibility to respiratory infections, kidney disease, oral abscesses, reduced hatching and high mortality of chicks at hatching. Birds are able to convert β-carotene feed to vitamin A, but most seeds contain very little. Most of the diseases associated with vitamin A deficiency are caused by the use of unbalanced diets and, especially in parrots, overeating sunflower seeds. Fish oil is a good source of vitamin A as well as iodine, and is often used by poultry farmers as a dietary supplement. However, the use of excessive amounts of additives can lead to a toxic dose of vitamin A, so it is necessary to exercise caution and caution in assessing the proposed amount of vitamin A bird.

The effectiveness of ***vitamin D*** for birds is only one-thirtieth of the effectiveness of vitamin D_3 (cholicalciferol). Vitamin D is essential for the absorption of calcium in the digestive tract and for calcium metabolism in the bones. Insufficient intake of vitamin D with food or UV light for the synthesis of vitamin D from steroids in the skin leads to metabolic bone disease. Symptoms of calcium deficiency the inability of bones and beak to calcify during growth and demineralization of bones in adult birds. In addition, the plumage may be damaged, and with a certain color of the feathers may develop abnormal blackening. During the breeding season, vitamin D deficiency leads to thinning of the egg shell. Hatching of chicks from eggs decreases, embryos have deformed or only partially formed beaks.

Vitamin E deficiency in poultry leads to encephalopathy, exudative diathesis or muscular dystrophy. Symptoms of encephalopathy include loss of coordination, throwing the head, stretching the legs and squeezing the toes. Exudative diathesis is caused by increased permeability of capillaries due to the accumulation under the skin in the chest exudate, which is a derivative of hemoglobin. This exudate has a characteristic green color. Feeding-related muscular dystrophy, especially of pectoral muscles, is observed in combination with vitamin E and selenium deficiency. With vitamin E deficiency, selenium can prevent both exudative diathesis and muscular dystrophy. Small Australian cockatoos with varying degrees of paralysis responded to the addition of vitamin E and selenium. Whole grains contain a sufficient amount of vitamin E, so when keeping birds on a normal diet based on seeds, vitamin E deficiency is rare. Alfalfa and seed germ oils contain a particularly high level of vitamin E, so if necessary can be used as additional sources of this vitamin.

Vitamin K is found in most green leaves and herbs. In addition, intestinal bacteria synthesize vitamin K, which can then be absorbed. Only when antibiotics are used does this non-feed source of vitamin K become unavailable. As a result, vitamin K deficiency is rare.

We do not have published data on the needs of decorative birds and songbirds species in ***B vitamins***. Thus, our knowledge of these needs is based on the results of work performed on poultry and on the symptoms observed in keeping birds on B-deficient diets.

Thiamine (B_1) is found in grains, although pathogens caused by some fungal infections can reduce its amount. Deficiency can occur when infected with specific intestinal bacteria that produce thiaminase, which destroys thiamine before it is absorbed by the bird. Manifestations of deficiency include loss of appetite, general weakness and polyneuritis. The latter symptom develops in chicks at a rapid pace, accompanied by drowsiness, tremor of the head, and in more advanced cases throwing his head back.

The use of deficient rations in the feeding of chicks ***riboflavin (B_2)*** leads to growth retardation and paralysis (with wrapping of the fingers). In cases of minor deficiency, spontaneous recovery may occur. Curable and early stages of the disease. Moderate deficiency can lead to the death of embryos in the middle of hatching and to a reduction in hatching.

Pyridoxine (B_6) and related compounds (*pyridoxal and pyridoxamine*) are common in cereals, so cases of deficiency are rare.

Biotin is also abundant in cereals, so the likelihood of deficiency of this vitamin in birds eating normal diets is low. In birds kept on an experimental diet, specific symptoms of biotin deficiency include foot dermatitis and lesions in the submandibular and eye area. It is unclear whether birds are able to utilize biotin, which is synthesized by the intestinal microflora.

Vitamin B_{12} is not found in plants, but is present in meat, milk and yeast. Birds receive some amount of vitamin B_{12} by absorbing vitamin synthesized by bacterial microflora in the intestine or by ingesting feces (coprophagy). Vitamin B_{12} deficiency leads to anemia and erosion of the muscular stomach, as well as has a devastating effect on the skin and plumage. The process of hatching chicks in conditions of insufficient reserves of vitamin B_{12} may be accompanied by a high mortality rate.

Niacin (*nicotinic acid*) deficiency results in stunted growth, poor plumage, and stomatitis. In chickens, this disease is known as "black tongue", and progressive inflammation of the tongue and esophagus leads to reduced feed intake. Most seeds contain enough niacin, except corn. Because corn also has a low tryptophan concentration, diets high in corn should be supplemented with sources of potential niacin precursors.

Pantothenic acid is important for the growth and integrity of plumage in chickens. In chickens, signs of its deficiency include slow growth, the appearance of "snacks" in the corners of the beak and nostrils, as well as dermatitis of the fingers (biotin deficiency affects primarily the pads on the soles and toes). Wheat and oat grains give a sufficient amount of pantothenic acid.

Choline is found in many feeds and is present in the seeds in an amount sufficient to prevent symptoms of deficiency. Symptoms of deficiency in poultry include growth retardation and limb structure abnormalities. Adult birds are likely to be able to synthesize enough choline to meet their needs, but growing birds and birds need breeding choline sources during the breeding season. As a complicating factor, the need for choline may depend on the level of vitamin B_{12} in the diet.

In birds with ***folic acid*** deficiency there is a growth retardation, poor plumage, loss of feather pigmentation and the appearance of characteristic anemia. The specificity of anemia caused by folic acid deficiency is expressed in a decrease in the number of erythrocytes, which increase in size, their deformation, the content of increased amounts of hemoglobin.

In general, birds do not need feed ***vitamin C***, although there are exceptions to this rule: the Asian bulb Pycnonotus cafer and one species of nectar Aethopyga siparaja. Vitamin C supplements can have a positive effect during physiological stress, for example, during reproduction, molting or growth [5, 11, 14].

Minerals.

Calcium and ***phosphorus*** are important for the development and maintenance of the skeletal structures of birds. In the body of a growing bird, most of the calcium contained in the diet is used to form bones, while in the reproduction of birds, most of the calcium will be used by the female to form the eggshell, which is 98 % calcium carbonate. Partly due to the high growth rate of captive birds, calcium and phosphorus requirements are high. The ideal ratio of calcium and phosphorus (Ca:P) compared to most mammals is also very large (approximately 2:1).

Imbalance in the absorption of calcium and phosphorus (or lack of vitamin D in the diet) in domestic parrots is common and leads to a variety of diseases. Rickets is most often observed. Rickets usually occurs as a result of feeding birds only seeds with a high fat content and low mineral content, and at a low ratio of Ca:P. When feeding seeds with a high oil content, insoluble calcium soaps can interfere with the absorption of calcium in the intestine and further exacerbate the absolute and relative calcium deficiency. To maintain a normal level of calcium in the blood, the calcium contained in the bones of the skeleton goes into a soluble state, which leads to osteomalacia. he result of chronic calcium deficiency is usually secondary forage hyper-parathyroidism, a fairly common disease of parrots. In birds that received a diet with moderate calcium deficiency, clinical symptoms of the disease can develop over years. They usually manifest themselves in the form of loss of appetite, plucking of feathers, weakness and drowsiness. In more severe cases, bone fractures may occur, and some individuals may develop hypocalcemic tetany and convulsions. There is evidence that some species of parrots are more sensitive to calcium deficiency than others. For example, in African gray parrots, hypocalcemia is common.

In practice, a sufficient concentration of calcium in the diet can be ensured by giving the birds shellfish, limestone gravel, cuttlefish shells, as well as direct addition of calcium to the diet. High concentrations of calcium carbonate or calcium phosphate in the diet can give the feed an unpleasant taste, so you need to be careful in dosages. Studies of diets containing 1 % calcium have shown that this amount is sufficient for reproduction in some large species of parrots, the same level is recommended for turnips, to prevent calcium deficiency. On the contrary, it is shown that the content of 0.35 % of calcium is sufficient to ensure the thickness of the eggshell and its conductivity in Australian cockatoos during the breeding season. Some studies have shown that 0.8 % of calcium is a sufficient concentration for budgies during breeding and growth, the real needs may be lower. Usually phosphorus is abundant in the seeds, but only 30 – 40 % is contained in non-phytate form and can be considered as available to the body of birds. If there is a deficiency of phosphorus in the diet, the needs for phosphorus in nervous tissue, cellular structures and enzyme synthesis take precedence over the needs for bone formation. Thus, deficiency always affects the skeleton [5, 11].

Interactions occur between different *trace elements*, which can lead to bioavailability problems (for example, between copper and molybdenum, calcium and zinc, manganese and iodine, mercury and selenium). Therefore, any feed additive must be made taking into account these interactions, otherwise excessive concentrations of one mineral may lead to a deficiency of another.

Minerals can also be used in the body of birds to form colored pigments of plumage and skin. *Copper,* for example, is found in turacin, a pigment that gives feathers a blue color. Hypopigmentation of the plumage can occur with *iron* deficiency.

Iodine deficiency was often observed in budgies when kept on cereals without additives. The result was a decrease in the production of thyroid hormones with an increase in its volume (goiter, current), which, in turn, could lead to difficulty breathing, belching food and loss of activity. Symptoms of deficiency are more common in areas far from the sea, even drinking water contains little natural iodine. Scientists recommend to add 2 μg of iodine to the diet twice a week to prevent thyroid dysplasia in budgies or add 1 % fish oil to the standard diet. Some feeds may contain goitrogenic substances. For example, peanuts contained in peanuts affect the utilization of iodine. High levels of calcium can also exacerbate iodine deficiency by reducing absorption.

Table 3 – The needs of budgies in basic nutrients and biologically active substances

Indicator	Mass fraction
Protein, %	10 – 17
Fat, %	6 – 9
Saccharose, %	3 – 4,6
Cellulose, %	3,5 – 7
Essential amino acids, mg/100 g:	
lysine	1,02
threonine	1,20
methionine	0,80
cystine	0,40
phenylalanine	1,20
tyrosine	1,00
valine	1,50
leucine	0,80
arginine	1,90
histidine	0,70
tryptophan	0,30
Vitamins:	
A, IU/kg	200 – 500
D_3, IU/kg	500 – 800
E	0,20 – 0,60
K	0,20 – 0,40
B_1	0,20 – 0,40
B_2	0,12 – 0,50
PP	0,15 – 0,60
B_6	0,40 – 0,60
B_8	0,10 – 0,24
B_{12}, μg/kg	0,24 – 0,50
Minerals:	
Ca, %	0,90 – 1,30
P, %	0,68 – 0,75
Mg, %	0,015 – 0,02
K, %	0,20 – 0,30
Mn, mg/kg	0,80 – 0,90
Se, mg/kg	0,75 – 1,00
I, mg/kg	0,30 – 0,40
Zn, mg/kg	0,40 – 0,65
Fe, mg/kg	0,78 – 0,85
Cu, mg/kg	0,80 – 1,00

Manganese deficiency causes perose in poultry. Hock joints swell and become denser, the Achilles tendon is displaced relative to the normal state. Peroz was observed in keelless birds and cranes, but there is no data on its presence in rowans and parrots. This is probably due to the fact that they have shorter limbs and less body weight compared to birds that move mainly on land. However, although rowans and parrots do not show clinical signs of manganese deficiency, this does not necessarily mean that their needs are different from those of other birds. Since the seeds have been shown to be low in manganese, it probably makes sense to use appropriate dietary supplements.

Zinc is usually found in excess in most feeds, particularly in seed germs. However, zinc of plant origin is less available to the body of poultry than zinc of animal origin, due to the formation of insoluble zinc-phytate complexes. In addition, the availability of zinc is reduced by calcium, by forming the most insoluble mixed zinc calcium-phytate complex. Signs of marginal or chronic zinc deficiency include anorexia, poor wound healing, skin diseases, scaly paws, and decreased reproductive capacity. Excess zinc can also be dangerous, inhibiting growth and causing anemia. Very high concentrations of zinc are toxic [5, 11].

In the table 3 the needs of budgies in the main nutrients and biologically active substances are given [5, 10-13].

Based on the above, taking into account the needs of decorative and songbirds in nutrients and biologically active substances, recipes for complete feed were calculated. A method of production of compound feeds for decorative birds and songbirds in the form in the form of crumbs or a blend of crumbs obtained by extrusion [15]. This will allow them to meet both behavioral and feed needs.

Conclusions

On the basis of the conducted scientific researches the requirements concerning quantity of energy for an decorative and songbirds at the maintenance in house conditions, at reproduction, in the period of growth are studied; needs of adult birds, during growth and molting in proteins and amino acids; needs for fats and essential fatty acids; carbohydrates; vitamins and minerals.

The functional purpose of nutrients and biologically active substances, symptoms that occur in the body of decorative and songbirds in their absence or excess in the feed, as well as their sources and minimum needs of birds during breeding, growth and maintenance of healthy birds.

To meet the forage needs of decorative and songbirds when kept in captivity, one of the most effective methods is to create complete feed by using innovative technologies (for example, in the form of crumbs or a blend of crumbs obtained by extrusion). This will provide an opportunity to meet both the behavioral and feeding needs of birds.

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ІННОВАЦІЙНІ ПІДХОДИ ПРИ ФОРМУВАННІ РЕЦЕПТІВ КОМБІКОРМІВ ДЛЯ ДЕКОРАТИВНОЇ ТА СПІВУЧОЇ ПТИЦІ І ТЕХНОЛОГІЇ ЇХ ВИРОБНИЦТВА

Анотація

З кожним роком зростає частка комбікормів для непродуктивних домашніх тварин на комбікормових ринках світу. Згідно з даними FEDIAF, декоративна та співуча птиця є третьою за величиною популяцією домашніх улюбленців (коти і собаки, відповідно, номери 1 і 2), 51,87 млн декоративних птахів у всій Європі (37,23 млн з них в Європейському Союзі) у 2019 році.

Декоративна та співуча птиця потребує повноцінної годівлі для підтримки життя та здоров'я. На сьогоднішній день власники декоративної та співучої птиці в своєму розпорядженні мають широкий асортимент готових кормів, що дозволяє їм зробити правильний вибір відповідного режиму годівлі їх улюбленців. Аналізуючи ринок комбікормів для декоративної та співучої птиці, побачили, що суттєву його частину займають комбікорми імпортного виробництва, в той час як асортимент вітчизняних комбікормів на ринку України дуже малий і не завжди відповідає вимогам ринку та не витримує конкуренції. Проте, представлені комбікорми важко назвати повнораціонними, так як це в основному різні види кормових сумішей, до складу яких входять, у залежності від цінової категорії, різні види компонентів: починаючи із зернових – і закінчуючи різними горіхами та сухофруктами. Комбікорм повинен містити всі компоненти, необхідні для вироблення енергії, росту, регенерації тканин, а також для регулювання обміну речовин. Повнораціонний комбікорм для декоративної та співучої птиці повинен містити у визначеній кількості всі поживні та біологічно активні речовини. Слід також враховувати такі фактори, як вік, загальний стан здоров'я, період розмноження, росту, линьки, умови утримання і навіть пору року.На сьогоднішній день є ряд питань, які потребують удосконалення наших знань про потреби у поживних та біологічно активних речовинах для кожного виду декоративних та співучих пта-

хів, включаючи особливості кормової сировини, кількості енергії, перетравності корму і вмісту в ньому поживних та біологічно активних речовин.

У зв'язку з цим необхідно вивчити кожен клас поживних та біологічно активних речовин і особливості формування рецептів комбікормів з урахуванням потреби в них декоративної та співучої птиці. Детально вивчити функціональне призначення поживних та біологічно активних речовин, симптоми, які виникають в організмі декоративної та співучої птиці при їх недостачі або надлишку в кормі, а також їх джерела і мінімальні потреби птиці у період розмноження, росту та підтримання організму здорової птиці.

Щоб задовольнити кормові потреби декоративної та співучої птиці при їх утриманні в неволі, одним з найефективніших методів є створення повнораціонних комбікормів шляхом застосування інноваційних технологій (наприклад, у вигляді крупки або суміші крупок, одержаної шляхом екструдування). Це дасть можливість забезпечити задоволення як поведінкових так і кормових потреб птахів.

Ключові слова: декоративна та співуча птиця, поживні та біологічно активні речовини, рецепт, інноваційні технології, екструдований повнораціонний комбікорм для декоративної та співучої птиці.

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