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CLASSIFICATION OF FEED USED IN DUCK NUTRITION

PODZIAŁ PASZ STOSOWANYCH W ŻYWIENIU KACZEK RZEŹNYCH

Summary: *Ducks belong to a group of omnivorous birds. In comparison to gallinaceous birds such as hens or turkeys, they are characterized by a greater voracity and smaller feed preference. They are also distinguished by a higher resistance to unfavorable environmental conditions and lower feed quality. The characteristic feature of duck is well-developed microbiota of blind guts (caecum) that enables the effective utilization of vegetal feed. At the same time, the construction of their alimentary tract does not allow to employ the feed mixtures destined for hens and turkeys in their nutrition.*
The system of duck utilization is the key element determining the way of their nutrition. In the intensive management system, the full-ration mixtures are the basic component of diet whereas in the semi-intensive and extensive systems, the main nutrition basis consists of farm feeds, enriched with feed concentrates.

Keywords: *duck nutrition, cereals, feed oils, protein feed*

Streszczenie: Kaczki należą do grupy ptaków wszystkożernych. W porównaniu z drobiem grzebiącym, takim jak kury czy indyki, cechują się większą żarłocznością oraz mniejszą wybrednością pokarmową. Wyróżniają się również wyższą odpornością na niekorzystne warunki środowiskowe oraz niższą jakość paszy. Charakterystyczną cechą kaczek jest dobrze rozwinięta mikrobiota jelit ślepych, która umożliwia efektywne wykorzystanie pasz roślinnych. Jednocześnie budowa ich układu pokarmowego uniemożliwia stosowanie w żywieniu mieszanek paszowych przeznaczonych dla kur i indyków.

Kluczowym czynnikiem determinującym sposób żywienia kaczek jest system ich użytkowania. W intensywnym systemie chowu podstawowym składnikiem diety są mieszanki pełnoporcjowe, natomiast w systemach półintensywnym i ekstensywnym główną bazę żywieniową stanowią pasze gospodarskie wzbogacane koncentratami paszowymi.

Słowa kluczowe: żywienie kaczek, zboża, oleje paszowe, pasze białkowe

Introduction

The main aim of meat-type ducks nutrition is to obtain the birds with a correct body conformation, with the preservation of optimum fattening level, musculature and good quality feathering. The duck broilers should have the ensured access to *ad libitum* feed during the whole rearing period. Due to the fact that the costs of nutrition constitute up to 68% of total production costs, the appropriate diet balancing plays a crucial role in the effectiveness of rearing. A short production cycle requires a precise choice of feed components in order to prevent the deficits, which may have a negative impact on a final effect of fattening [29].

The purpose of the present work is to submit the principles of duck nutrition, with the consideration of their unique feeding requirements and the in-the-market available raw feed components.

Cereals and feed oils

The concentrates with a high energetic value should constitute ca. 70% of feed ration for the ducks. Their basis includes the cheapest feed components, first of all, cereal grains. In Poland, corn, wheat and barley are used most frequently and oats is applied more rarely. Millet may be an alternative to the traditional cereals and in production of the feed mixtures for duck broilers, the additives of sorgo, triticale and rye are also allowed. Their presence requires, however, the constant monitoring. Apart from the cereals, fodder oils, brans and oily plant seeds are also used in duck nutrition.

Production and utilization of feeds by meat-type ducks

The intensive fattening of the meat-type ducks lasts usually for 7 weeks [8, 23]. During the mentioned period the birds obtain

body weight in the range of 2300–3100 g, according to the gender. Dressing percentage of the ducks is estimated at the level of 65–70% [8]. Body weight gains of Pekin ducks are similar as the discussed values obtained for broiler chickens and may amount to 45 g per each 100 g of the consumed feed [2].

During the first week of life, one day-old chicks consume about 350 g of feed, the composition of which not always covers their requirements of energy and protein [2]. The improper supplementation of the diet during the discussed period may lead to the nutritional deficits, resulting in production losses in the successive stages of rearing.

Energetic raw feed materials employed in production of mixtures for the meat-type ducks

Concentrates are the basic component used in duck nutrition. Their participation in feed mixtures is equal to 60–80%. The discussed group includes:

- Cereals (50–80% of the feed mixture) (Table 2);
- Products coming from cereals' processing (e.g. brans, fodder meals);
- Seeds of oily plants;
- Feed oils (5–10% of the feed mixture).

Table 1. The examples of the formulations of feed mixtures type starter and grower for duck broilers [2]

Feed component	Type of feed	
	starter	grower
Corn	57%	73.4%
Extraction soy meal (protein content at the level of 48%)	36%	20.5%
Soy oil	3%	2.5%
Feed calcium carbonate ($CaCo_3$)	1.6%	1.4%
Calcium phosphate ($Ca_3(Po_4)_2$)	1.4%	1.2%
Animal feed salt (NaCl)	0.4%	0.4%
Mineral-vitamin premix	0.3%	0.3%
Methionine	0.3%	0.2%
Lysine	-	0.1%

Table 2. The contents of nutritional components in kg of different cereals and brans according to the National Research Institute of Animal Production – Balice (2010)

Raw material	Nutrients				
	Total protein	Crude fat	Crude fiber	Nitrogen-free extractives	Crude ash
	%				
Corn (grain)	10.2	4.7	2.6	80.6	1.9
Wheat (grain)	13.7	1.9	3.5	78.9	2.0
Wheat (brans)	16.6	3.9	9.0	65.7	4.8
Barley (grain)	12.6	2.1	5.3	77.3	2.7
Naked barley (grain)	13.1	2.4	1.5	80.6	2.4
Barley (brans)	14.0	4.6	12.6	64.2	4.6
Oats (grain)	12.3	4.1	12.7	68.0	2.9
Triticale (grain)	13.0	1.6	2.9	80.5	2.0
Rye (grain)	10.3	1.7	2.3	83.8	1.9
Rye (brans)	15.5	2.9	5.3	72.2	4.1

The cereals being most often used in the feed mixture are corn, wheat, barley and oats, and, also, millet, sorgo, triticale and rye. Additionally, the seeds of oily plants and feed fats are employed.

Nutritional suitability of the particular energetic raw materials:

- **Corn** – corn (maize) is distinguished by the highest energetic value from among all cereals; at the same time it is characterized by one of the lowest crude fiber content. The content of starch in corn grain is equal to 68%–74% whereas that of crude fat is 4%–5.5 % of grain weight [35]. Lipid content of corn includes oleic acid (19.5 – 30.5%), linoleic acid 953 – 65.3%) and palmitic acid (9.2–12.1%) and also, ß-carotene and other carotenoids, including zeaxanthin, kryptoxanthin and lutein [14]. Digestibility of corn is estimated at the level of 85%. As compared to other cereals, corn contains less protein which is characterized by a lower biological value. It is mainly composed of glutelin and zein and is poor in exogenous aminoacids such as lysine and tryptophan which play a crucial role in animal nutrition. Owing to high digestibility and lack of antinutritive compounds, corn meal may be used as feed component in the mixtures intended for all production groups of the ducks. It is important to remember to keep a constant check on the raw material being sourced, as maize purchased or used in the production of finished feed may be infected with mycotoxins – the secondary metabolites of fungi which are developing in the conditions of the increased humidity e.g. in the case of the insufficient drying of the grain or its storage in the warehouses with the improper microclimate conditions (high humidity and air temperature) [4, 17, 18]. The main mycotoxins occurring in corn are fumonisin B1 [41] and aflatoxin B1 [17, 18]. Aflatoxins in feeds may lead to the decrease of the body weight gains, permanent damage of liver of the ducks and, also, to the increase mortality in the flock. To limit partially a negative impact of the mentioned toxins, it is recommended to increase the supplementation of selenium and vitamin E [17, 18]. In order to limit a harmful effect of mycotoxins in feeds, the detoxicants such as active carbon and active aluminosilicates are employed; the mentioned compounds reveal the capability of adsorbing the mycotoxins, restricting their negative impact on the animal organism.
- **Wheat** is a cereal, the cultivation area of which in Poland is constantly increasing. When cultivating the wheat on the more fertile soil of I – III class , we may obtain even 80–100 dt of yield from 1 ha for winter wheat [31] and 50–70 dt/ha for spring wheat [37]. The yield of wheat grain is found on the second place, directly after corn which gives the performance equal to 100–125 dt/ha [34]. A high energy concentration together with the considerable level of total protein and a low content of crude fiber make that the wheat is characterized by a high feeding suitability. In combination with the high yielding, it causes that it is one of the major feed components in the mixtures for poultry. The studies of Kokoszyński et al (2017) [23] revealed that the replacement of 15% commercial mixture by wheat in fattening of Pekin ducks did not affect negatively production parameters (final weight, dressing percentage, feed conversion ratio (FCR). Introduction of the full wheat grain to the diet of poultry may favorably affect the functioning of alimentary tract, mainly due to the lower passage of the intestinal contents. Moreover, the full wheat grain causes the increase of muscular and glandular stomach what improves the excretion of enzymes and intestinal peristalsis.
- **Barley** is one of the main feed cereals cultivated in Europe, with the average yielding at the level of 51dt/ha–75dt/ha [37]. Similarly as oats, it is classified as hulled cereal what results in higher content of crude fiber in the grain, lowering the feeding value of the raw material. Nevertheless, barley is characterized by a smaller amount of hulls as compared to oats. On the market, there are also available "naked" varieties of barley and oats, deprived of hulls but their application is limited due to higher production costs. In duck nutrition, a high level of antinutritive substances in the grain of barley is a challenge; it refers especially to non-starch polysaccharides (NSP) such as arabinose, xylose, fucose, mannose, and glucans. Although the ducks digest barley starch effectively at the level of ca. 99%, their capability to digest NSP is considerably lower, amounting only to ca. 20% [20]. The presence of NSP in the diet may lead to increase of the viscosity of intestinal contents, what has a negative impact on digestion and absorption of nutrients. In order to minimize the mentioned unfavorable defects, it is recommended to employ enzymatic additives such as xylanases and ß-glucanases, which decompose NSP, improving the digestibility of nutrients and total feeding effectiveness of ducks. Introduction of enzymes to feeds for poultry is a common practice, aiming at the increase of the availability of nutrients and improvement of production parameters. The studies indicate that the addition of the enzymes of bacterial origin may effectively reduce the negative effects of the soluble NSP activity in alimentary tract of young chicken broilers what suggests similar effects in the nutrition of ducks[19]. Moreover, the appropriately balancing of diet and observing the recommendations concerning the participation of the particular cereals in the feed mixtures are crucial for optimization of production results and health state of the ducks [19].
- **Oats** is characterized by the highest content of crude fiber, exceeding 10% what limits its energy value. The protein content in the oats is equal to ca. 11%. In spite of the mentioned above properties, oats could be a valuable component in the feed mixtures for the ducks. However, due to a relatively low yielding, amounting to 41 dt/ha–70 dt/ha [37], its application in the greater scale is limited. Introduction of oats to the diet of the ducks may bring the profits such as the supply of indispensable aminoacids and improvement of intestinal peristalsis owing to a high fiber content. Due to a lower energy content and higher level of fiber, it is however recommended to use oats in combination with other cereals such as wheat or corn (maize) in order to ensure the correct balance of nutrients. It is important to monitor the quality of oats as to avoid the presence of antinutritive substances which may affect negatively the health and performance of the ducks.
- Triticale is a cereal which is characterized by the most variable content of total protein from among all cereals (9–16%). Protein

concentration in triticale is dependent on the soil [13] and climate conditions [10]. The digestibility of triticale is similar as that of wheat.

- **Rye** – unfortunately, the grain of the mentioned cereal is not readily consumed by the birds and is characterized by a relatively low digestibility. It contains antinutritive substances from the non-starch polysaccharides group, and in particular, pentosanes (arabinoxylans) which are harmful to the poultry. The content of pentosanes in the rye grain is estimated at ca. 10% [7]. The application of rye in the feed mixture requires a constant control because the excessive amount of the discussed cereal may lead to impairment of the growing processes of the birds. Due to the presence of the antinutritive substances, rye should not be combined with triticale or other cereals which may contain the similar substances.
- **Millet** is a cereal with a high tolerance to water deficits what makes it especially popular in the regions suffering from deserts and draughts, mainly in Africa and Asia. In the nutrition of ducks, millet may be an alternative to corn. The studies revealed that the complete replacement of corn by the millet did not have any negative influence on the body gains, feed intake or feed conversion coefficient of the ducks [2].
- **Feed oils** are utilized with the aim to balance correctly the energy in the feed mixtures for the poultry. Additionally, feed fats play a role of solvents and vectors for vitamins A, D3, E and K and, also, reduce the dustability of the feed. It was revealed that the 4%-addition of rape, soy, palmitic or coconut oils did not cause any differences in the body weight gains of the young ducks [15].

Protein feeds

Protein feeds are the key element in the duck nutrition as they have a direct impact on their growth, development and production profitability. The main source of protein in the feed mixtures for poultry are protein concentrates the nutritional value of which is greatly dependent on the quality of the discussed component. The quality of the protein feeds used in the ducks' nutrition is dependent on the content of antinutritive substances, crude fiber, composition of aminoacids and digestibility and assimilability of protein. Protein is one of the feed components which has a direct effect on production profitability.

In the nutrition of ducks, protein feeds deriving from different sources, are applied. By-products of oil industry such as extraction meals, oil cakes and expellers have the most important economic meaning. The extraction meals are especially valuable in the traditional systems of poultry management; however, in the organic system, their application is not allowed. In feed industry, there are also utilized the by-products of starch industry such as cereal gluten and cereal and potato protein; it also includes brewery by-products such as e.g. dried distillers with solubles (DDGS). Distilled by-products such as dried distiller's grains and brewery yeasts find also application in the feeds intended for ducks.

The by-products of the dairy industry such as dried whey or milk powder are expensive feeds of animal origin, the utilization of which is limited due to the presence of lactose. Since August 2021, it has been possible to employ insect powder and meat-bone meals in the poultry nutrition, with the preservation of the principle of cross-feeding. Meals obtained from fish and marine invertebrates have been for the years used in feeding industry. The seeds of legumes are promoted in Poland as a domestic source of protein, but in spite of agricultural payments, their cultivation is not popular.

The examples of the particular raw materials, used in production of protein feeds:

- Seeds of legumes (being once named as *Leguminosae*) are obtained from the plants belonging to *Fabaceae* family. Owing to the symbiosis with the diazotrophic bacteria, the species

Table 3. The contents of chemical components (% dry matter) in the seeds of leguminous plants according to the National Research Institute of Animal Production – Balice (2010)

Raw material	Nutrients				
	Total protein	Crude fat	Crude fiber	Nitrogen-free extractives (sugars)	Crude ash
	%				
Field pea	23.8	1.3	6.5	65.0	3.4
Field bean	29.8	1.3	9.3	55.7	4.0
White lupine	40.3	6.4	16.3	32.4	4.7
Blue lupine	33.8	5.7	14.9	41.1	4.5
Yellow lupine	43.0	5.3	15.1	31.5	5.2
Common vetch	33.9	0.8	4.9	56.7	3.7
Soy	34.6	19.9	7.4	14.2	6.5
Grass pea (*Lathyrus sativus*)	32.2	1.0	6.7	17.7	4.0

of the plants belonging to the mentioned family acquire the capacity to fix nitrogen gas from the atmosphere [1]. A close relation between the roots of *Fabaceae* plants and *Rhizobia* bacteria contributes, *inter alia*, to obtaining better yields with the increased level of total protein in the seeds [22]. The main species of leguminous plants, the seeds of which are used as feed components in production of feed mixtures for the poultry include field pea, field bean, common and winter vetch, yellow, white and blue lupine, soy and grass pea (*Lathyrus sativus*) (Table 3).

The seeds of leguminous seeds contain 23%–43% of total protein which is poor in sulphur aminoacids and tryptophane [33]. From among the mentioned plants, the seeds of yellow lupine have the highest level of protein; it exceeds 43% what causes that they are comparable with extraction soy meal in respect of the protein content. On the other hand, the lowest level of total protein was found in the seeds of field pea.

We should, however, pay attention to the presence of antinutritive substances in the seeds of leguminous plants such as:

- Tannins, saponins, trypsin and chymotrypsin inhibitors [33];
- Lupinins (alkaloids), cyanogenic glycosides, oxalyldiaminopropionic (ODAP) acid [38];
- Phytic acid.

Most of the mentioned substances is thermolabile what means that their activity may be reduced or neutralized during the heat treatment such as extrusion or micronation. The additional methods such as dehulling of the seeds and the appropriate breeding work may also contribute to the reduction of the discussed substances.

Due to a high content of protein and lowered level of antinutritive substances, the processed seeds of the newest varieties of lupines may become – up to 60% – the replacer of extraction soy meals in the feed mixtures for the meat-type ducks [26]. In the nutrition of the meat-type poultry, it is recommended to have the participation of the seeds of the leguminous plants in the feeds at the level of 5% during rearing period and ca. 10% for the older birds [12, 36].

- **Extraction meals** are the by-products of oil industry that are obtained during the extraction of oil from oil cake, with the application of chemical solvents e.g. hexane. The basic property, differentiating the extraction meals and oil cakes and expellers consists in the level of fat (ca. 1–5% for extraction meals (Table 4), ca. 8–10% for the expellers and ca. 10–19% for the cakes). Another meaningful aspect differentiating the extraction meals and oil cakes and the seeds of leguminous plants includes a lowered level or the complete neutralization of antinutritive substances as a result of expanding and extruding processes. In the market, there are available extraction meals, derived from the treatment of the seeds of soy, rape, sunflower, peanuts, Elaeis guineensis (palm seed extraction meal), less often from copra (obtained as a result of extraction of dried white flesh of coconut and external hull of the coconut palm seeds), cotton or alga meal.

Soy extraction meal is one of the most frequently used sources of protein in feeds for monogastric animals what results from its high digestibility and favourable amino acid composition, in particular the content of exogenous aminoacids. Moreover, it is characterized by a lower level of crude fiber and antinutritive substances what makes that it is especially effective in the nutrition of monogastric animals [43]. According to the estimates, production of soy protein satisfies ca. 45% of the world demand on feed protein [30] and in Poland the mentioned value is equal to ca. 62% [21, 45].

The rape extraction meal is the alternative to soy extraction meal; it is characterized by a high content of total protein and sulphuric aminoacids, especially the exogenous ones. In spite of this fact, the complete replacement of the soy extraction meal by the rape meal in the feeds for the young poultry may be difficult due to the higher level of crude fiber in the second discussed product [33]. In turn, the studies conducted by Fazhi et al. (2011) [46] indicate that the meat-type ducks, fed with the mixture, containing fermented rape extraction meal and blood meal reached better production results as compared to the birds fed exclusively the soy extraction meal what may suggest the possibility of the complete

Table 4. Contents of chemical substances (% dry matter) in extraction meals of soy, rape and peanut according to National Research Institute of Animal Production – Balice (2010) of cotton [28] and palm [11]

Type of meal	Chemical components				
	Total protein	Crude fat	Crude fiber	Nitrogen-free extractives (sugars)	Crude ash
	%				
Soy extraction meal	50.6	2.0	5.6	34.4	7.4
Rape extraction meal	37.4	4.1	14.6	36.3	7.6
Sunflower extraction meal	32.3	5.8	16.3	9.1	7.5
Peanut extraction meal	50.8	1.3	16.7	24.7	6.5
Cotton extraction meal	47.3	3.0	12.9	29.4	7.4
Palm extraction meal	18.7	2.8	20.2	53.7	4.6

Table 5. The contents of chemical components (% dry matter) in the rape and sunflower cakes according to National Research Institute of Animal Production – Balice (2010), and in sesame [27], hemp [5] and palm oil cakes [11]

Type of oil cake	Chemical components				
	Total protein	Crude fat	Crude fiber	Nitrogen-free extractives (sugars)	Crude ash
	%				
Rape oil cake	35.5	15.9	11.4	30.7	6.5
Sunflower oil cake	30.2	11.9	22.9	27.5	7.5
Sesame oil cake	44.6	11.3	7.3	24.9	11.9
Hemp oil cake	31.9	11.5	30.3	10.0	7.2
Palm oil cake	18.7	2.8	20.2	53.7	4.6

replacing of soy meal by the rape meal. Nevertheless, as it was indicated by Kowalska et al. (2020) [26], the soy extraction meal may be replaced by the rape extraction meal only in 14% what indicates a limited possibility of the complete exchanging the discussed components in the feeds for the poultry.

- Oilcakes are by-products of oil industry, obtained as a result of mechanical extrusion of raw oily materials. They contain 10–19% of fat (Table 5) what makes that they may become a raw material for production of the extraction meals. As compared to extraction meals or expellers, the higher fat content in the oil cake contributes to the increase of its energy value. In Poland, the oil cakes are produced mainly from rape, linen and sunflower whereas at the international market, there are also available soy, sesame, hemp, palm and coconut cakes.
- Dried distiller's grains with solubles (DDGS) is a by-product of edible or industrial (fuel) ethanol production. Its manufacturing process is commenced from the distillation of wet grains (WDG) to which fraction of corn syrup (CCDS) is added what results in production of wet distillers grains with solubles (WDGS) with the dry matter content equal to 40%. Then, the mentioned product is subjected to drying, reaching a dry form (DDGS) with the dry matter content amounting to 90%. DDGS contains 30–35% of total protein and 8–10% of crude fiber. The studies show that the application of 25% of dried corn grain in feed rations for Pekin ducks allows the reduction of the demand on soy extraction meal by 8% and on wheat by ca. 18% without negative health and production consequences [25].
- Gluten is a protein which consists mainly of glutenin and gliadin, playing a crucial role in regulation of energetic processes during the growth of the young cereal seedling. In feed industry, feed gluten is obtained by the wet cereal grinding in the process of starch production. The total content of protein in feed gluten varies from 70% to 80% and its application in the feeds for duck is usually equal to ca. 8% of the ration [16].
- Animal meals – it is a group of feed by-products of animal origin; they include meat-bone meals, fish meals, the meals obtained from feathers, krill, and insects. Animal meals (excluding krill, insect and fish meals) are manufactured during the management of such by-products as feathers, bones, cartilages and fishbones which after combustion contain total protein in the quantities comparable to soy extraction meal. Until now, only the application of fish, krill and feathers' meals was admitted in the nutrition of ducks. According to the Commission Regulation (EU) 2021/1372 of 17 August 2021, it is allowed to use the farmed insect meals and meat, bone

Table 6. The contents of chemical components (% dry matter) in animal meals: meat-bone, feathers, fish according to National Research Institute of Animal Production – Balice (2010) and insect meal (produced from black soldier fly Hermetia illucens)

Type of oil cake	Chemical components				
	Total protein	Crude fat	Crude fiber	Nitrogen-free extractives (sugars)	Crude ash
	%				
Meat-bone meal	45.1	10.7	-	-	40.7
Feather meal	86.5	8.8	0.4	1.5	2.8
Fish meal	73.5	8.1	2.4	0.2	15.8
Meal from black soldier fly (*H. illucens*)	60.8	14.1	7.5	6.7	10.9

and bone-meat meals in feeds for poultry. The application of meat-bone meals in the feeds is limited to the so-called cross-feeding; it means that the meals produced from the waste coming from pork production may be employed in the feeds for the poultry and the meals produced from the poultry meat production may be used in the feeds for pigs. The insect meals must be produced in conformity with the specified sanitary standards and may derive from such species as black soldier fly (*Hermetia illucens*), the house fly (*Musca domestica)*, flour beetle (*Tenebrio molitor*), darkling beetle (*Alphitobius*), house cricket (*Acheta domesticus*), banana cricket (*Grillodes sigillatus*), and Jamaican field cricket, silent cricket (*Grillus assimilis*).

Protein concentrates in nutrition of meat-type ducks should constitute ca. 20–25% of the complete feed mixture. In Poland, soy is the main source of feed protein and, more precisely, soy extraction meal which is most frequently imported from Argentina. It is estimated that the imported soy meal covers ca. 70% of the national requirements for feed protein [9]. Such relationship creates a risk connected with the dependence on the foreign supplies what may affect the food safety. One of the solutions which might help in minimization of the mentioned risk is greater utilization of protein sources for feeds such as meal from yellow lupine, fermented blood meal, mixture with the rape extraction meal and animal meals.

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