THE ROLE OF CEREALS IN CARP FEEDING (SHORT REVIEW)

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Abstract. *In Central and Eastern Europe, carp are widely farmed and reared in fishpond conditions. The effectiveness of the activity is basically determined by the quality of the feeding. The type, content and preparation of the grains used show great diversity in practice, not to mention the growing popularity of grain-based by-products. The work was aimed at reviewing and processing the available, relevant literature in order to prepare research. The role of the cereals in the carp (Cyprinus carpio) feeding is presented in this work, in order to set a basis of planned future investigations relied on data previously published in the Hungarian and international scientific literature related to this topic. Use of the cereals in the feeding products designated for carp is highly important in a cereal-growing area such is the south-east part of Hungary. In Europe, as in Hungary, carp are extensively fed with fodder mixtures based on cereals, as supplementary feeding. The efficiency of use individual feeds is influenced significantly by many factors as: the species, chemical composition, digestibility, processing method and particle size, age of the fed animals, etc. Among the by-products from the mill industry, bran can only be used for carp feeding with limitations due to its high fibre content. The role of DDGS (Dried Distiller's Grain with Solubles) as a by-product from the ethanol production process, is increasing due to its favourable nutrient content and digestibility.*

Keywords*: carp feeding, cereals, aquaculture, nutrient requirement, supplementary feeding*

INTRODUCTION

The carp has become one of the most sought-after sport fish in Hungary and other European countries due to the constantly developing fishing industry and the growing fishing community (WOYNÁROVICH et al., 2019). According to FAO statistics, carp and carp type species are still the most widely produced fish species worldwide. Due to the above, quality fish is becoming more and more important, including the production of properly kept and fed quality carp, without which the expansion of the consumption of domestically produced fish in Hungary cannot be imagined, but without it, access to European markets and a permanent presence cannot be imagined either.

The aim of our work was to prepare and establish a research project in the field of fish feeding with different species of cereals.

MATERIAL AND METHODS

The important role of cereals in the feeding of carp (*Cyprinus carpio*) was presented in order to establish the basis of our planned investigations based on the data of the previously published Hungarian and international literature. The use of cereals in the composition of feed is particularly important in a grain-growing area such as the south-eastern part of Hungary, where the planned research will be carried out.

RESULTS AND DISCUSSIONS

In the case of fish (like other animals), the feed supply must be based on the nutritional requirements of the given species, age group, gender and direction of utilization.

Nutrient requirements

Since the metabolism is proportional to the body surface of living beings, the metabolizable energy requirement, i.e. the energy that can actually be used, is the so-called we must expect metabolic body weight (MBW):

MBW = W x 0.75, where W = body weight.

This means that a smaller organism represents a relatively larger "physiological body mass" than a larger one, which is well illustrated by the values in Table 1. This means that a kilogram of fry with an average weight of 10 grams represents more than three times the metabolic mass of a 1 kg fish. Taking this legality into account is absolutely necessary when determining the daily feed ration for fish of different ages and body weights, i.e. the intensity of feeding (HANCZ, 2007).

Table 1

Relationship between body weight and metabolic body weight

Individual body weight (kg)	Metabolic body weight (MBW/kg)
0.01	3.162
0.05	2.115
0.10	1.778
0.25	1.414
1.00	1.000
2.00	0.841

source: Based on HANCZ, 2007

The energy requirement of fish, as an extremely important parameter from the point of view of feeding, depends on: The temperature of the water (every 10 °C increase in the temperature of the water - until the optimum is reached - almost doubles the rate of metabolism and thus the energy requirement of the fish). From the size of the fish (the rate of metabolism increases in proportion to the surface of the body). From the composition of the food. From the physiological activity of the fish. The energy requirement for body maintenance and growth varies by fish species. Depending on the species, age group, water temperature, dissolved oxygen content and salinity, approximately 8.4-19.3 MJ is required to produce one kg of meat surplus, which in the case of carp corresponds to 11-13 MJ/kg of feed (WOYNÁROVICH et al., 2019). Like other fish species, carp can be used, i.e. metabolizable, and its energy needs are calculated based on metabolic body weight (Table 2).

Grain-based supplementary feeding

In the case of carp produced in a lake environment, they can use complete feeds that satisfy the animal's needs in all aspects (which are rarely used from an economic point of view in Hungarian conditions), or supplemental feeding that also takes into account the natural nutrient supply capacity of the waters.

Energy-bearing feeds: these are the most common supplementary feeds of natural fish food, but because they are rich in carbohydrates, they can increase the fat content of fish meat. Maize and wheat: Feed wheat has a solidifying effect on fish fat, which makes it difficult to mobilize fat during wintering. Corn, on the other hand, softens fat and has a good effect on fat-forming and fat-mobilizing processes (BOGÁR et. al. 2017). Maize can often be infected with fusarium * or mouldy. Triticale: a hybrid of wheat and rye. Its nutritional value is similar to that of barley. It is only recommended to be fed raw due to an infection with erysipelas. The best grain of biological value. In pond farming, it is only used for feeding mother fish.

Sorghum and millet: their use in aquaculture is very rare in our country. Both seeds should only be fed ground, because the carp cannot crunch them, so they are practically

undigested/excreted. Rye: nowadays it is rarely fed in ponds. Sprouted rye is a good source of vitamin E for mother fish. It is easily infected with the fungus *Claviceps purpurea*, in which case it is only recommended to feed it as whole grain. Autumn barley: only this barley is used for feed, but it is also not common in pond farms. It is richer in protein than wheat, although it hardens fat. It is well used, but due to its high fibre content, it can cause intestinal inflammation. By-products of grain processing: The quality of the various brans depends on the type/type of grain. Due to their high fibre content, they cannot be fed on their own. In our country, 5-10% of the daily feed has a good dietary effect because it improves the consistency of the faecal sludge (Table 2).

Table 2

The minimum nutrient requirements of different age groups of carp

Contents	Unit	Offspring	Young fish	Market size	Breeding female
Dry matter	%	88	88	88	88
Crude protein	%	39	36	30	32
Digestible protein	%	37	33	27	29
Crude fat	%	8	7	7	7
Crude fibre	%	2	4	5	5
Crude ash	%	10	11	12	12
Metab. Energy	MJ/kg	13	12	11	11.5
Lysine	%	2.4	2.1	1.8	2
Methionine + Cysteine	%	1.5	1.3	1.1	1.2
• of which Methionine	%	1.2	1	0.9	0.9
Ca	%	0.5	0.5	0.5	0.5
P	%	1.2	1.1	1	1.1
Mg	%	0.14	0.15	0.15	0.15
Cl	max. %	1.2	1.2	1.2	1.2
(n-3) fatty acid	%	1.1	1	1	1.1
(n-6) fatty acid	%	1.1	1	1	1.1
Vitamin A	IU/kg	3000	2500	2500	2500
Vitamin D_3	IU/kg	3000	2000	2000	2000
Vitamin E	mg/kg	90	60	60	60
Vitamin K_3	mg/kg	36	24	24	40
Vitamin B_1	mg/kg	2	2	2	2
Vitamin B_2	mg/kg	4.5	3	3	3
Ca-pantothenate	mg/kg	40	40	30	30
Vitamin B_6	mg/kg	5	5	5	5
Vitamin B_{12}	mg/kg	0.01	0.01	0.01	0.01
Biotin	mg/kg	0.2	0.2	0.2	0.2
Niacin	mg/kg	15	10	10	10
Choline	mg/kg	1200	1000	750	750
Folic acid	mg/kg	3	3	2	2
Vitamin C	mg/kg	100	80	50	50
Fe	mg/kg	15	10	5	15
I	mg/kg	0.9	0.6	0.3	1
Co	mg/kg	0.45	0.35	0.15	0.3
Cu	mg/kg	4.5	3	1.5	4
Mn	mg/kg	45	30	15	45
Se	mg/kg	0.45	0.3	0.15	0.5
Zn	mg/kg	24	16	8	25

Source: Based on WOYNÁROVICH et al., 2019

Their relatively high vitamin and mineral content (mainly phosphorus) is another reason for feeding them in pond farms. Flours (feed flour): their quality depends on their contamination. Generally, it is recommended to be mixed with other feeds. It is not

recommended to feed seed cleaning waste or wheat mixed with weed seeds. If this does happen, then it should be done without grinding, so that the carp can select the parts that are suitable for it and are not dangerous.

In the case of supplementary feeding of carp in fishpond production, the biological value of the feed protein, the essential amino and fatty acid content of the dry matter content of the feed, and the mineral and vitamin content do not need to be paid as much attention as when compiling biologically complete feeds. For this reason, in the case of supplementary feeding, it is not necessary to accurately count all the components of the fed feed, because the carp can absorb most of the necessary nutrients with natural food. However, the main parameters of supplementary feed (protein, fat, carbohydrate and energy content) must be taken into account (WOYNÁROVICH et al., 2019). We consider natural food and supplementary feed together as a kind of biologically complete food. According to the above, the calculation of the nutritional needs of carp by age group in Table 2 enables not only the selection and selection of the most suitable supplementary feeds, but also the composition of supplementary feed mixtures and even full-value carp feeds. In order to compile complete fish feeds, in addition to the nutrient requirements of the specific fish species, in our case carp, the digestibility of the nutrients must also be known. It also depends on the nutritional ingredients and their quality. Table 3 lists the recommended minimum and maximum proportions of the most important feed ingredients in carp feed.

Table 3.

Recommended mixing ratio of grains and grain products (%)

Feed ingredient	Minimum	Maximum
Wheat	30	80
Corn	10	26
Barley	-	40
Oats	-	20
Rye	-	20
Wheat bran	-	15
Wheat germ	-	5
Wheat starch	-	3
Rice bran	-	10

Source: Based on WOYNÁROVICH et al., 2019

Cereal seeds (wheat, corn, barley, rye, triticale) are the most important group of feeds used in fish ponds (ARRAINA, 2015). They are rich in energy-carrying carbohydrates (60-70%), their crude protein content is around 10%, but they are poor in essential amino acids (lysine). The amount of fat (oil) found mainly in the sprouts is 2-3%, and their fiber content is 1-5%. They are rich in phosphorus, but poor in calcium. They usually contain enough vitamins B_1, B_2 and E, but not vitamins C and D. The digestibility of cereals, including their starch content, is improved by soaking them before feeding. It is given in a ground state for fry, and germinated to mother fish selected for reproduction (TASNÁDI, 1983).

One of the most important and most frequently fed cereals is fodder wheat, whose low lysine and methionine content is worth mentioning, as well as its significant saturated fatty acid content, which is unfavourable in the overwintering. VIOLA and ARIELI (1983) investigated grains that can be used for feeding intensively reared carp and their nutritional effects. The fish that consumed wheat had the best production parameters, but the feeding of this group was also the most expensive. Corn was cheaper than this, but as a result, body fat increased to 15%. Corn is also an important fish feed, rich in starch, unsaturated fatty acids and colouring matter (xanthophyll).

Autumn barley is one of the most widely used carp feeds, and its fibre content is relatively high. Rye, although only found in small quantities, is also suitable for fish feed, but the dietary effect of freshly harvested rye is unfavourable. Triticale juice is becoming more and more widespread, its nutritional value is similar to that of barley, but it is prone to ryegrass infection. Oats are not usually fed to carp, but their meal is excellent for supplementary feeding of mother fish due to its high protein and unsaturated fatty acid (linoleic acid) content (MÉZES, 2012).

For several decades, lake supplementary feeding has been based on the use of different grains, which cover the carp's energy needs and result in market-sized fish (1.5-2 kg) in the three-year production cycle (WOYNÁROVICH et al., 2019). The use of complex, full-value mixed feeds is quite rare in domestic carp breeding, but it is more widespread in countries further south than us (RAJIĆ ET AL., 2016).

Adequate particle size adjustment of cereals increases feed efficiency (nutritional value, acceptability and digestibility) and thus fish growth. In fish farming, new methods are being developed to increase the digestive efficiency of cereals by mechanical chopping: pressing or grinding (URBÁNEK, 2009). The way feed is processed affects the availability of nutrients (TABACHEK, 1985). According to current practice, cereal grains are crushed in a roller mill to improve digestibility.

The production efficiency of farmed carp can be increased by supplementing cracked rye or barley instead of unpressed cereals. During feeding with cracked grain, the different rate of growth was smaller, which is an economic advantage, and thanks to the homogeneous herd, less sorting causes less stress for the animals (MÁSILKO et al., 2014).

The results of Przybyl and Mazurkiewicz (2004) confirmed the higher efficiency of feeds containing extruded wheat, barley, triticale or rye in intensive carp production. The lack of significant differences between each extruded cereal indicates that they are equally beneficial for carp. In the case of feeding feed with a balanced nutrient content, it may happen that the type of cereal used does not significantly influence the production results, because the lack of nutrients in one component is compensated by a higher amount in the others.

One of the by-products of bioethanol production, corn pomace (DDGS - Dried Distiller's Grain with Solubles), is well suited for feeding various farm animals and its use has also come to the fore in fish aquaculture production (GATLIN et al., 2007). DDGS is produced from corn, wheat, sorghum or barley (LIM and YILDRIM-AKSOY, 2008).

The dry matter (spirit wash) is produced as a by-product after the distillation step and drying, which is a suitable raw material for the feed industry because it has a moderately high crude protein (30%), crude fat (10%), low carbohydrate (<10%) and easily usable phosphorus content (0.75%) has (BELYEA et al., 2004). The advantage of DDGS compared to other plant-based feed materials is that it does not contain anti-nutritional substances, its phytin-phosphorus content is low and during the technological process it is enriched with yeast (4-7%), which is known to have a beta-glucan content (7.6%), it has an immune-stimulating effect in fish (MAKKAR, 2012). At the same time, it contains a low proportion of essential amino acids, and we must also expect contamination from mycotoxins, mainly aflatoxins, which are considered common in grains. Mycotoxins in corn are not broken-down during fermentation, so they are also found in DDGS, and their amount increases approximately threefold as a result of starch fermentation (PINOTTI et al., 2016).

Based on the apparent digestibility values of DDGS as a feed material, it can be said that DDGS is well digestible for carp fry, as the apparent digestibility of crude protein is 86.1%, and that of dry matter is 47.0%. Compared to the digestibility data of other plants determined for carp, the value measured for DDGS is close to that of corn (DEGANI and

YEHIDA, 1997), which is 81% for crude protein, but lower than that of wheat (91.9%). However, the phosphorus digestibility of DDGS is favourable for carp, its apparent digestibility was 82.9%. Some plants have a high phytin-phosphorus content, which is considered up to 80% indigestible phosphorus in the case of agastric fish species (KUMAR et al., 2012). Based on a feeding experiment, it was determined that in the case of carp, DDGS can be used in the feed at up to 40% with amino acid supplementation, as it has a favourable effect on growth, the utilization of protein and feed is significantly better compared to the control, and there is no negative effect on the health of the fish and metabolic processes. The easily digestible phosphorus reduces the amount of phosphorus released into the runoff water (JAKABNÉ SÁNDOR, 2020). The protein digestibility of DDGS as a feed ingredient was determined to be around 86% at both temperatures (20 and 30°C). Values between 45-50% and 81-83% were determined for the apparent digestibility coefficient of dry matter and phosphorus by RÉVÉSZ (2021).

CONCLUSIONS

In Hungary, as in other European countries, carp are extensively fed with various cereals, which are primarily used not for the production of complete feeds, but for supplementary feeding. The effective use of individual feeds is significantly influenced by their species, content, digestibility, processing method and particle size, age of the fed animals, etc. Among the by-products of the mill industry, bran can only be fed with limits due to its high fiber content. The role of DDGS as a by-product of ethanol production is also increasing due to its favorable nutrient content and digestibility.

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