IMPORTANCE AND USE OF GRAINS IN FISH NUTRITION

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ZNAČAJ I UPOTREBA ŽITA U ISHRANI RIBA

Abstrakt

Proizvodnja hrane za ribe, poslednjih godina beleži najbrži rast u industrijskoj proizvodnji hrane za životinje (Jovanović i sar. 2006). Ukoliko sektor akvakulture nastavi sa dosadašnjim prosečnim rastom od 8-10% godišnje do 2025. godine, i proizvodnja hrane moraće da prati taj rast (Tacon,2010). Danas se u hranu za ribe uglavnom uključuju riblje brašno i riblje ulje zbog visoke nutritivne vrednosti. Zbog ograničenosti prirodnih resursa. nameće se potreba za značajnijim uključivanjem biljnih hraniva, pre svega žita u ishrani riba. Žita prvenstveno predstavljaju izvor energije i služe za prihranu riba, međutim, njihovom preradom mogu se dobiti koncentati proteina koji se mogu koristiti kao delimična zamena za proteine animalnog porekla. Žita kao energetska hraniva čine osnovni deo obroka u poluintenzivnom sistemu gajenja riba. Proteinski deo potreba obezbeđuje im fauna dna i zooplankton.

U našoj zemlji kukuruz je najvažnije žito koja se koristi u ishrani životinja. Visok sadržaj skroba, srazmerno velika zastupljenost ulja i malo celuloze, čini kukuruz izrazito energetskim hranivom (Đorđević i Dinić, 2007). Kukuruz karakteriše nizak sadržaj proteina sa nepovoljnim aminokiselinskim sastavom. Protein kukuruza pretežno čini zein koji ima nisku nutritivnu vrednost, pre svega usled deficita lizina i triptofana. Proteini ječma su niske biološke vrednosti, ali nešto bolji u odnosu na proteine kukuruza (Perović, Janković et al.,2009). Siromašni su u lizinu i metioninu, mada su selekcijom dobijene sorte sa većim sadržajem lizina. U poređenju sa kukuruzom, po hranljivoj vrednosti, pšenica sadrži više proteina, a manje masti. Sadržaj proteina kod različitih sorata pšenice varira od 10-14% (Protić, Janković,1998).

Proteini pšenice su siromašni lizinom, zatim metioninom, treoninom, leucinom i izoleucinom (Janković et al.,2008). Količina lizina, koji je prva limitirajuća aminokiselina, iznosi 0,3-0,37%. Tritikale je hibrid pšenice i raži, koji se zbog relativno visoke nutritivne vrednosti sve više se koristi u ishrani svih kategorija životinja, pa i riba. Tritikale sadrži 11-20% sirovih proteina. Sadržaj aminokiselina je sličan sadržaju aminokiselina pšenice. Najsavremeniju tehnološku operaciju u procesu proizvodnje hrane za ribe predstavlja proces ekstrudiranja. Ekstruzionim kuvanjem na principu «visoka temperatura-kratko vreme» postižu se veca svarljivosti skroba, veća nutritivna vrednost, plutanje ili sporo tonjenje sto omogucava vece učesće žita u hrani za ribe. (Jovanović et al.2006).. Žita kao komponente u kompletnim smešama za ribe u intenzivnom uzgoju imaju izuzetno veliki značaj, posebno u ishrani šarana koji značajan deo energetskih potreba može zadovoljiti iz skroba. Proteinska hraniva, uz dodatak sintetičkih aminokiselina dobijena preradom žita, poput kukuruznog, pšeničnog glutena, kao i proteina pirinča, u značajnoj meri mogu zameniti, riblje brašno kao najkvalitetnije hranivo u ishrani riba. Selekcijom i genetskim modofikacijama treba stvarati žita sa povoljnim nutritivnim svojstvima potrebnim za hranu za ribe.

Ključne reči: *žita, hrana za ribe, ekstrudiranje*

INTRODUCTION

In recent years, production of fish feed is registering the fastest growth in industrial production of animal feed (Jovanovic et al,2006). If the aquaculture sector continues its present average growth from 8-10% annually until 2025, feed production will also have to follow this growth (Tacon, 2010). This poses the need for significant inclusion of plant feeds, primarily cereals in fish nutrition. The most important cereals in our country used in fish nutrition are: maize, wheat, barley and triticale. Cereal proteins have low biological value, primarily due to lysine deficit, but contain sufficient methionine and cystine, while soya is a rich source of the essential amino acids. If fish were fed only cereals, a series of health disorders would occur. Cereals are primarily an source of energy and serve for additional nutrition of fish, however, their processing can produce protein concentrates that can be used to partially substitute animal proteins. The yield of carp in fertilized fishponds is 390 kg/ha; if cereals and their byproducts are added to rations, the yield of carp increases up to 3000 kg/ha (Lovell et al.,1978). High energy feed with insufficient protein content leads to increased fat content in tissues (Cirkovic et al.,2011).

The protein level depends on the source and the quantity of energy in the ration. If these are fats, lower quantities of protein are required, than when energy is provided from carbohydrates. Protein digestibility is reduced when carbohydrate concentration grows (Smith and Lovell,1973). Carbohydrates contribute most to the nutritional value of cereal grains. Whole grains contain 62 to 72% of starch, digestible for warm water fish at a level of 60 do 70% (Cirkovic et al,2002), but much less for salmonids (Smith,1976). Starch from cereals is an important binding agent in pelleted and extruded fish feeds (Jovanovic et al.,2009; Cirkovic et al.,2010). Studies indicate that hormonal and metabolic carbohydrates regulation, as well as energy metabolism, vary in fish and can differ when compared to mammals (Cowey and Walton, 1989). California trout uses 30% glucose from 45% protein nutrition, while a 30% concentration of glucose in 30% protein nutrition has a negative effect on growth and efficiency of feed utilization (Bergot,1979). Fish do not secrete cellulase so, cellulose digestibility plays no significant role in their nutrition. Most fish can tolerate up to 8% fiber in rations, while concentrations from 8-30% decrease growth. High concentrations of digestible carbohydrates lead to liver enlargement and higher glycogen content in salmonids (Bergot,1979). Smith,1976 showed that for California trout only 49% of thermally unprocessed (raw) starch is digestible, while the carp family utilize over 70% of energy from raw starch.

Cereals in fish nutrition

Being energy feeds, cereals form the basic part of rations in a semi-intensive system of fish breeding. Protein requirements are provided by fauna populating the bottom and zooplankton.

In our country, maize (*Zea mays*) is the most important cereal used for animal nutrition. High starch content, a relatively high presence of oils and little cellulose, make maize a pronounced energy feed, with digestibility of organic matter of up to 90% due to poor utilization of starch in the diet, the share of cereals is expected to amount to 12% digestible carbohydrate The quantity of individual components varies depending on the type of hybrid and breeding conditions (Jelicic, Jankovic et al., 2009). The content of starch in maize is from 62-78%, raw protein from 7-14%, raw fat from 2.8-6% pentosanes from 4-5%, carbohydrates from 1-3% and cellulose from 1-3%. Maize is characterized by low protein content with an unfavorable amino acid composition. Maize protein is predominantly composed of zein, which has a low nutritional value. When fish are fed exclusively maize, the tryptophan deficit leads to niacin deficiency in the body. Geneticists have been trying for decades to create such forms that would have a better nutritional composition. Hybrids with increased oil and protein content and with altered starch composition were created.

Barley (*Hordeum vulgare*) is an important cereal in cold and humid areas and, after rice, it is the most widespread cultivated culture in the world. Barley proteins have low biological value, but they are better compared to maize proteins (Perovic, Jankovic et al.,2009). They are poor in lysine and methionine, although selection has created barley varieties with higher lysine content. Fat content in barley is around 2%, with a domination of palmitic and stearic acid. Raw fiber content is higher than in maize, wheat and rye, therefore its nutritional value is lower. Barley contains less starch then maize, and therefore it also has a lower energy content. Its vitamin content is similar as in other cereals.

Wheat (*Triticum sativum*) is primarily cultivated and used for human nutrition. Poorer quality wheat, as well as broken and inferior grain is used for nutrition of domestic animals when its price is lower than the price of maize. It is considered that of the total wheat production, 20-28% is used for nutrition of domestic animals. By its nutritive value, it is similar to maize. It has more protein, and less fat, as well as a somewhat lower level of digestible energy. Various wheat varieties contain from 10-14% of protein (Protic, Jankovic et al,1998). Wheat proteins are poor in lysine, methionine, threonine, leucine and isoleucine (Jankovic et al.,2008). The quantity of lysine, the first limiting amino acid, is 0.30-0.37%. It is poor in vitamins A and D, but contains high quantities of vitamins B1, B2, B6, nicotinic acid, pantothenic acid, folic acid and biotin. Wheat is poor in calcium, but contains more phosphorus (Prvulovic, Jankovic et al., 2009).

Triticale (*Triticale* sp.) is a hybrid between wheat and rye, which is due to its relatively high nutritional value used more and more in nutrition of animals, including fish. Its content of protein and lysine is higher compared to wheat and rye. Energy value is lower than for wheat and maize. Triticale contains 11-20% raw protein. Its amino acid content is similar to the amino acid content of wheat. Phosphorus utilization for triticale is much higher than for other cereals, owing to the presence of higher quantities of the enzyme phytase. A comparative review of cereal nutrients is presented in Table 1.

Complete mixtures, as additional feed in the form of pellets or granules, are becoming more and more important from the aspect of economically justifiable production, and are to a large extent replacing the traditional use of cereals in carp nutrition (Stankovic et al., 2011). In intensive forms of breeding, fish nutrition is supplemented by soya, peas, sunflower and synthetic amino acids, in pellet or extruded form. Intensive production, of over 3000 kg/ha, as well as production of noble predators, require the use of animal feeds.

Table 1. Chemical composition of triticale, maize, barley and wheat (Đorđević and Dinić, 2007)

Parameters	Triticale	Maize	Barley	Wheat
Raw protein,%	15.8	8.5	11.5	12.6
Lysine,%	0.52	0.25	0.40	0.40
Methionine,%	0.50	0.40	0.37	0.52
Threonine,%	0.51	0.36	0.36	0.46
Tryptophan,%	0.18	0.09	0.15	0.17
Raw cellulose,%	4.0	2.3	5.0	2.6
Oil, %	1.5	3.6	1.7	1.6
Calcium,%	0.05	0.03	0.05	0.04
Phosphorus,%	0.30	0.28	0.34	0.37
Digestible energy, DE MJ/kg	3299	3530	3120	3402
Metabolic energy, ME MJ/kg	3050	3420	3040	3300

Fish feed and the use of cereals

Intensive fish breeding, in addition to economy of nutrition, also poses strict requirements for the composition and physical characteristics of fish feed in order to minimize water pollution by remnants of unconsumed and/or undigested feed (Kiang, 2001). During the processing of fish feed, starch and proteins are exposed to chemical modifications, which include changes of molecular structure via starch gelatinization. By extrusion cooking based on the "high temperature – short duration" principle better digestibility of starch is achieved, higher nutritional value, as well as desirable physical characteristics – floating or slow sinking, which allows greater participation of cereal in fish feed (Jovanovic et al., 2006).

The additional feed for carp (*Cyprinus carpio*), in earlier times was to the highest extent or fully grainy feed, and to a high extent maize, wheat, barley, triticale. Today, more and more industrially produced pelleted or extruded feed containing required ingredients in accordance with nutritional requirements for certain ages of carp, is used. The diameter of pellets or granules depends on the age of fish, i.e. on the possibility to be consumed. Thus, literature mentions that a grain of maize can be consumed only when carp reaches 300 g (Đorđević and Dinić, 2007). Production of pelleted or extruded feed is desirable, to enable inclusion of cereals in nutrition for all categories of fish. In our country, mercantile carp is usually produced under semi-intensive conditions. For additional feeding of carp, until the first half of August, wheat (barley, triticale) is usually used, while maize is used in September and October. The feed conversion coefficient in a semi-intensive system is from 2.5 to over 6 kg. According to the statements of Mitrovic-Tutundzic et al., 1988, inadequate nutrition with maize, when natural food is lacking, can lead to a fatty degradation of the liver in carp and the depositing of fatty tissue of a soft consistency in subcutaneous connective tissue and in the stomach, as well as to degenerative lesions of the gonads.

From the aspect of nutrition, California trout is a carnivore. Trout are fed pelleted or extruded feed, prepared from flour type feeds originating from animals, and to a much lesser degree cereals (wheat and maize meal). Due to poor utilization of starch in the diet, the share of cereals should be up to 12% in the form of digestible carbohydrates (Đorđević and Dinić, 2007). When producing trout feed that should contain a high level of fats in granules, the problem of adding large quantities of fats is resolved using a vacuum device which enables distribution of oil throughout the entire volume of the pellet (Jovanovic et al., 2005). In the extrusion process, the share of carbohydrate feeds, (wheat or maize meal), enables the formation of puffy spaces within the granule into which oil is subsequently included by way of vacuum.

Expansion of starch simultaneously helps to obtain a physical structure slow to sink, which is decisive for adequate consumption by the trout. Cirkovic et al., 2005 stated that the density at which the extruded product 100% floats is below 550 g/l, while the density at which the extruded product 100% sinks is over 620 g/l, where the difference in water is only 8 liters. Fish meal is an adequate fish feed due to its high protein content, excellent amino acid profile, high digestibility. It is expected that in the near future the demand for protein feeds will exceed the annual offer of fish meal and induce greater use of plant proteins and protein isolates from plant feeds, protein from cereals, such as corn and wheat gluten and use of synthetic amino acids. Maize gluten meal is broadly used in fish feeds and the usual percent of in feeds is from 10-15%. Selection could create varieties and hybrids of cereals with favorable nutritional characteristics for use in fish feed. One of the most modern methods for achieving this goal is also genetic modification, but in this case the potential risks its entails must be taken into consideration.

CONCLUSION

The use of cereal grains in semi-intensive carp breeding systems is a realistic option in fish breeding in Serbia, because it simulates organic production. Cereals, as components in complete mixtures for fish under intensive breeding are very important, especially in the nutrition of carp, which is able to satisfy a significant portion of its energy needs from starch. By extrusion, as the most modern technological procedure for producing fish feed, starch is gelatinized, making cereal utilization much more efficient. Protein feeds, with the addition of synthetic amino acids obtained by processing cereals, such as maize and wheat gluten, as well as rice protein, can to a significant level substitute fish meal as the highest quality feed in fish nutrition. The process of selection and genetic modifications should be used to create cereals with favorable nutritive characteristics for fish feed.

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