Original paper

PROTEIN LEVEL AND EFFICIENCY OF FEED MIXTURE FOR COMMON CARP (*Cyprinus carpio*)

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Abstract

The quality of fish feed and its nutritional value are important for fish production. From an economic point of view it is vital to ensure a cheaper final product while from the nutritional aspects it is essential to fulfill the requirements of fish. The aim of this study was to investigate the digestibility and effect of feed mixtures with different protein content on growth of carp fry. The experiment was carried out at the Laboratory for fish nutrition of the Faculty of Agriculture, University of Belgrade, for 90 days. Fish were fed with concentrate mixtures having 38% (A), 41% (B) and 44% (C) of proteins. The bigger share of the protein part in A were plant proteins (PP), in C fish meal (FM), while in B the share of FM and PP was approximately the same. Results showed significant differences between digestibility of different feed mixture. The digestibility of protein and fat were higher in fish fed diets with higher protein content. Digestibility of nitrogen-free extracts (NFE), energy and digestible energy was not statistically significant ($p > 0.05$) regardless of the level of protein in the diet. The results indicate that the increase in the digestibility of proteins is in accordance with the increase in protein content in the diet e.g. diets with higher content of FM.

Key words: *carp, digestibility, fish meal, plant proteins, protein levels*

Introduction

In fish, as in other domesticated animals, digestibility of feed is one of the most essential attributes in evaluating the efficiency of foodstuffs (Forster, 1999). Determination of apparent digestibility coefficient (ADC) of nutrients in fish feed is important for proper diet formulation (Salim et al., 2004). At the same time, analysis of this parameter helps in estimating the potential pollution of water by wastes produced by fish.

Digestibility of nutrients is variable and depends on a range of factors, where the level and origin of proteins in the diet is one of the most important. Since proteins are the most expensive part of feed mixtures (Wilson, 2003), by decreasing their content or by increasing the digestibility, the price of the final product, fish, can be decreased.

As the aquaculture is in continuous development, expanding and intensifying (Bostock et al., 2009), it is essential to involve different components in fish feed (Tacon, 2005) and provide their maximal utilization. Fishmeal (FM) is a major protein source in compound feeds for intensive fish farming. In an effort to reduce reliance on FM as the primary protein source, most aquaculture diets now use some plant protein ingredients (SOFIA,

2007). From the nutritional aspect, the best potential show components of animal origin, but are the most expensive, while components of plant origin have a lower nutritive value, but have moderate prices and are more available on the market (Storebakken et al., 2000). In order to create better production results, due to high prices of certain components (Aas et al., 2009), it is essential to know requirements of different fish species. In this sense the nutrition and preparation of fish feed is highly important.

Nutrient requirements for growth, reproduction and normal physiological functions are similar to other animals, but fish have much higher requirements in proteins, thus feed mixtures with 25 to 45% of raw proteins are mainly used (Davies and Gouveia, 2010; Firas and Ramadan, 2012). The various studies concluded that digestibility of nutrients and energy from various feedstuffs varies in different fish species (Salim et al., 2004).

From the economical, but also ecological point of view it is important to supply feed that will result in low feed conversion coefficient, high growth rate, good health condition, high quality of the final product – fish meat, and as low as possible load of the aquatic environment with organic matter, phosphorus, and nitrogen (Jahan et al., 2003).

The aim of this study was to determine the apparent digestibility coefficient of concentrate mixtures with different content and origin of proteins for carp yearlings.

Materials and methods

Experimental fish and culture system

Fingerlings of common carp (*Cyprinus carpio*) were obtained from the fish farm "Farmakom" from Dobrić, around Šabac, Serbia. The culture system was developed in the Laboratory for fish nutrition of the Faculty of Agriculture, University of Belgrade, Serbia. Prior to the experiment fingerlings were acclimatized for four weeks in plastics tanks. After acclimation, each tank was stocked with 24 yearlings, average weight 95.6 g.

We used a circulating system consisting of 9 independent tanks (three replicates per treatment), with 120 L of usable water volume and flow rate of 0.34 $Lmin^{1}$ .Water quality and environmental conditions (dissolved oxygen, water temperature, electroconductivity, and pH) were measured in each tank daily using MULTI 340i/SET (WTW, Weilheim, Germany). Air was supplied constantly by a blower to maintain the O_2 concentration around 6 mg/L. The water temperature (23±1°C) was controlled by a thermostat.

Feed ingredients and diet preparation

Fish were fed with concentrate mixtures having different amount of animal protein and plant origin. The bigger share of the protein part in A were plant proteins (PP), in C fish meal (FM), while in B the share of PP and FM was approximately the same (Table 1).

Fish were fed with same percentage of feed depending on the total fish biomass in each tank, i.e. 3.5% of the ichthyomass, using semiautomatic feeders with pendulum. For daily measurements of feed quantity, as well as for control measurements every 30 days, a digital balance CASBEE, model MW 120; Casbee, Samsungm Korea, accuracy 0.01 g was used, while an ichthyometer was employed for length and height measurements.

Table 1. *Composition of experimental diets (% dry matter)*

Feed	A	B	C
Fish meal	26.0	30.0	32.0
Soybean meal	29.0	30.0	31.0
Yeast	2.0	6.0	8.0
Wheat gluten	5.0	5.0	5.0
Wheat	11.5	11.5	11.5
Corn	24.0	15.0	10.0
DCP	1.2	1.2	1.2
Calcium	0.3	0.3	0.3
Min. Vit. premix	1.0	1.0	1.0
Total	100.00	100.00	100.00

Growth and nutrient utilization parameters

Growth performance and diet nutrient utilization were assessed in terms of:

Body weight gain (BWG, g) = final weight (g) - initial weight (g), Buyukcapar and Kamalak, 2006;

Metabolic growth rate (MGR, $gkg^{0.8}day^{-1}$) = BWG_g / (((initial weight / 1000)$^{0.8}$ + (final weight / 1000)$^{0.8}$) / 2) / feeding days, Dabrowski et al., 1986;

Feed Intake (FI, %) = (daily feed intake (g) x 100) / biomass (g), Diler et al., 2007;

Digestibility

Samples of feces were taken daily from the plastic collectors located at the bottom of every fish tank. Protein, carbohydrate, fat, and total energy digestibility were measured using a natural indicator; the Acid-insoluble ash (AIA) method.

ADCs in experimental diets were calculated according to the formula from Maynard and Loosli (1969):

$$Digestibility\ (\%) = 100 - ((F / D) * (Dm / Fm) * 100)$$

Where: F= % nutrient in faeces, D= % nutrient in diet, Dm= % marker in diet, and Fm= % marker in faeces.

Chemical and Statistical analysis

The basal diet was analyzed for dry matter, nitrogen, crude lipid, crude fiber, and ash and the feces for dry matter, nitrogen and ash, using standard methods (AOAC - Association of Official Analytical Chemists, 1990).

Statistical analysis was done using one-factorial analysis of variance with factor type of feed. Individual comparison of average values was carried out using Tukey test.

Results and discussion

Levene's test of experimental data showed that variation in tanks was not significantly different for measured parameters pointing out that the experimental setup was correct and

that differences in growth and nutrient utilization parameters were the result of different feed quality.

During the experiment water temperature was 22.75±0.02°C, with minimal differences in measured values between tanks during the day. Electroconductivity was 524.35±0.48 μS/cm; dissolved oxygen was on average 6.41±0.04 mg/L, and pH value was 7.48±0.01. According to Marković (2010), Flajšhans and Hulata (2007), Hover (1976), all the values monitored were within the optimal range for carp growth.

Proximate composition of feed ingredients is shown in Table 2. Experimental diets contained from 38.10 (A) to 43.72% (C) crude protein and from 19.60 to 19.98 kJ/g of gross energy. Dry matter, crude lipid and ash were in the range of 89.20–93.70%, 8.54–9.64% and 9.50–10.76%, respectively.

Table 2. *Chemical composition of experimental diets (% dry matter)*

Feed	**A**	**B**	**C**
DM gkg^{-1}	937	937	892
Protein	38.10	41.52	43.72
Lipid	8.54	9.07	9.64
Ash	9.50	9.61	10.76
Fiber	2.03	2.45	2.02
[1]NFE	41.83	37.35	33.86
Total	100.00	100.00	100.00
[2]Gross energy	19.60	19.84	19.98
[3]P/E	19.44	20.93	21.88

[1]NFE= 100 –proteins (g) –fat (g) –ash (g) –cellulose (g)
*[2]Gross energy = protein (g) * 23.6 + fat (g) * 39.5 + NFE (g) *17.3*
[3]P/E = Protein-energy ratio (g proteins (kJ)$^{-1}$gross energy

Based on the visual observation during of the experiment, palatability or acceptability of feed was good and the behavior of fish was normal. Daily feed intake was not significantly different between treatments (F=0.812; p=0.497), and was around 1.55-1.65%. After 90 days of feeding, final weight and body weight gain was significantly higher in the fish group fed with C (Table 3).

Fish fed with feed mixture C had a significantly higher (p<0.001) final weight (200.18 ± 6.19 g), BWG (104.60 ± 3.84) and MGR (11.04 ± 0.38) compared to fish fed mixture A and B (Table 3).

Table 3. - *Initial weight (IW), final weight (FW), body weight gain (BWG), metabolic growth rate (MGR), feed intake (FI) in common carp fed experimental diets*

Parameter	**A (***mean±SE)*	**B (***mean±SE)*	**C (***mean±SE)*	ANOVA	
				F	p
IW	95.59 ± 3.80^{NS}	95.33 ± 3.44^{NS}	95.23 ± 2.95^{NS}	0.016	$\approx 1.000^{NS}$
FW	149.79 ± 5.50^{a}	173.56 ± 6.78^{b}	200.18 ± 6.19^{c}	24.031	**<0.001****
BWG	54.64 ± 2.62^{a}	78.07 ± 1.20^{b}	104.60 ± 3.84^{c}	61.027	**<0.001****
MGR	6.29 ± 0.24^{a}	8.52 ± 0.12^{b}	11.04 ± 0.38^{c}	32.893	**<0.001****
FI	1.55 ± 0.05^{NS}	1.57 ± 0.03^{NS}	1.65 ± 0.13^{NS}	0.812	0.497^{NS}

Small letters indicate significant differences (p<0.05) across rows

Table 4. - *Apparent digestibility coefficient of experimental diets*

Ingredients	**A (***mean±SE)*	**B (***mean±SE)*	**C (***mean±SE)*	ANOVA	
				F	p
Protein	60.02 ± 0.89^{a}	69.31 ± 4.20^{ab}	74.66 ± 3.18^{b}	5.856	**0.020***
Lipid	74.86 ± 2.86^{a}	80.26 ± 1.07^{ab}	84.76 ± 2.27^{b}	4.854	**0.033***
NFE	66.22 ± 1.70^{NS}	74.74 ± 5.14^{NS}	67.50 ± 9.07^{NS}	0.903	0.481^{NS}
Gross energy	64.86 ± 1.33^{NS}	73.22 ± 3.81^{NS}	74.50 ± 4.44^{NS}	2.929	0.100^{NS}
DE	14.37 ± 0.42^{NS}	14.82 ± 0.58^{NS}	13.30 ± 1.09^{NS}	0.934	0.468^{NS}

Small letters indicate significant differences ($p<0.05$) across rows

The results of feces analysis (Table 4) showed significantly higher ($p \geq 0.020$) values of apparent digestibility coefficient of proteins (74.66%) and lipids (84.76%) in fish fed with mixture C compared to fish fed with A. The digestibility of NFE-nitrogen free extracts (from 66.22% to 67.50%), energy (from 64.86% to 74.50%) and digested energy (from 14.37% to 13.30%), did not differ significantly ($p>0.05$) in fish fed mixtures with different protein content.

The average values of ADC of proteins from different mixtures increased with the increase of the protein content 60.02% (A), 69.31% (B) and 74.66% (C). This resulted in a significant difference ($p<0.01$) between protein ADC in feed C and A. The analysis of ADC of fat (74.86% in feed A, 80.26% in feed B and 84.76% in feed C) resulted in significant difference between feed A and C. The average value for ADC BEM was 66.22% (A), 74.74% (B) and 67.50% in feed C. ADC energy was on average 64.86% in feed A, 73.22% in feed B and 74.50% in feed C. Digestibility DE was 14.37% (A), 14.82% (B) to 13.30% (C). Analysis of variance for average values of ADC BEM, energy and DE showed no significant differences regardless of the level of proteins in different feed mixtures.

Salim et al. (2004) confirmed that the digestibility coefficient in feed of animal origin is higher that feed of plant origin. Additionally, Kumar et al. (2010) pointed out that higher utilization of proteins is provided by their higher availability. Having in mind that feed C had the highest level of proteins and highest content of FM, the best protein source with good palatability, the highest digestibility was achieved with this feed mixture. Hossain and Jauncey (2003) emphasize that the results of ADC of proteins are actually the effect of amino acid digestibility, thus the results of this study show the precision in feed formulation.

Conclusion

The results suggest that with the increase of proteins in mixtures, their digestibility increases. A higher content of fish meal in C mixture provided significantly higher digestibility of proteins compared to mixture A with higher content of plant proteins. It is known that the utilization, digestibility and availability of plant proteins are lower than in proteins of animal origin.

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