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EFFECT OF SUBSTITUTION OF SUNFLOWER MEAL WITH FLAXSEED MEAL ON THE GROWTH PERFORMANCE AND CHEMICAL COMPOSITION OF MEAT IN COMMON CARP (*CYPRINUS CARPIO* L.)

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Abstract

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The aim of the study is to investigate the effect of substitution of sunflower meal with flaxseed meal in pellets on the growth performance and chemical composition of meat in common carp (*Cyprinus carpio* L.), cultivated in recirculation system. Fish from both experimental variants with a started live weight 1058.38 ± 60.73 – 1077.13 ± 59.67 g were reared in concrete tanks, with effective water volume of 0.8 m^3, part of a recirculation system. The carps from experimental group (EG) were fed a diet, containing flaxseed meal, whereas fish from control group (CG) received feed, supplemented with sunflower meal. Pellets were 6 mm of size and crude protein content of 26.06% and 26.35%. The duration of the experiment was 60 days. To evaluate the effect of dietary flaxseed and sunflower meals on the weight gain (g) of carps, control catches were conducted at 15-day intervals. Live body weight (g) was determined by individual weighing of fish. The final body weight of fish from experimental groups was as followed: EG –1272.50 ± 74.54 g and CG – 1222.50 ± 70.51 g, without statistically significant differences ($P > 0.05$). With respect to weight gain, the differences between groups were also insignificant ($P > 0.05$). Feed conversion ratio of fish from CG was 2.29 ± 0.17, significantly higher by 19.27%, than this one of carp from control group ($P < 0.05$). There were no considerable differences in water content, as well as the proportions of protein, fat, dry matter and mineral substances of fish meat from two groups ($P > 0.05$).

*Key words***:** common carp (*Cyprinus carpio* L.*)*, flaxseed meal, sunflower meal, intensity of growth, feed conversion ratio, chemical composition of meat

Introduction

The global production of common carp in 2010, according to data, reported by FAO, was about 3.5 million tones, with a marked tendency towards increase during the last years. This is the commonest warm-water aquaculture species in Central and East Europe, as well as in many regions of Southeast Asia. In our country, this is a primary fish, farmed in earthen ponds of various sizes (Zaykov and Staykov, 2013).

The production of feed for aquaculture species is crucial for the industry (Ng et al., 2007). The main requirements are that feeds should meet the needs of fish from nutrients, to ensure fewer losses of nutrients if not consumed in time by grown hydrobionts (Staykov, 2001). The nutritional needs of fish could be completely satisfied by well-balanced pelleted feed, developed according to the respective species and age (Girginov, 2007).

The number of protein sources for fish feeds is limited. The pellets for common carp are not an exception. The main used for this purpose are fish meal, soybean and sunflower meals. According to Pillay (1983), feeds based on ingredients, available on local markets are essential for success-

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ful aquaculture. In Bulgaria flaxseed, rapeseed and other meals are available as by-products from the production of oils. They are rich in protein and with favorable amino acid profile (NRC, 1993), but according to some authors, contain also anti-nutritional factors (NRC, 1993; Hasan et al., 1997). The studies also prove that a mixture of various proteins of plant origin is more appropriate, than the inclusion of a single source (Watanabe et al., 1995; Regost et al., 1999).

The aim of the study is to investigate the effect of substitution of sunflower meal with flaxseed meal in pellets on the growth performance and chemical composition of meat in common carp (*Cyprinus carpio* L.), cultivated in recirculation system.

Material and Methods

Fish from both experimental variants with a started live weight 1058.38 ± 60.73 – 1077.13 ± 59.67 g were reared in concrete tanks, with effective water volume of 0.8 m^3, part of a recirculation system. The common carp from experimental group (EG) were fed a diet, containing flaxseed meal, whereas fish from control group (CG) received feed, supplemented with sunflower meal. Pellets were 6 mm of size and crude protein content of 26.06% and 26.35%. The nutrient content of the feed of the two groups is presented in Table 1. The trial continued 60 days.

Hydrochemical Analysis

The hydrochemical parameters in the recirculation system of the common carp (*Cyprinus carpio* L.) were determined, using methods adapted for fish farming (Bessonov and Privezentsev, 1987; Todorov and Ivancheva, 1992), as follows:

- Dissolved oxygen, $mg.l^{-1}$ – Multi LineP4;
- pH – Multi Line P4;
- Electrical conductivity, $\mu S.cm^{-1}$ – Multi Line P4 and BDS EN 27888;
- Nitrates, $mg.l^{-1}$ – BDS 17.1.4.12:1979;
- Nitrites, $mg.l^{-1}$ – BDS ISO 26777:1997.

Intensity of fish growth

To evaluate the effect of dietary flaxseed and sunflower meals on the weight gain (g) of carps, control catches were conducted at 15-day intervals. Live body weight (g) was determined by individual weighing of fish.

Proximate Analysis

After the end of the 60-day experimental period, six fish from each group were chosen for evaluation of the chemical composition of the fillet. The meat samples were prepared

Table 1

Nutrient content in the feed of the common carp (*Cyprinus carpio* L.)

Ingredients, %	Compound feed	
	CG	EG
Wheat	21.90	21.90
Corn	15.00	15.00
Wheat bran	10.00	10.00
Soybean meal, 44% CP	27.00	27.00
Fish meal, 67% CP	10.00	10.00
Sunflower meal, 34% CP	–	10.00
Flaxseed meal, 32.9% CP	10.00	–
Dicalcium phosphate	4.05	4.50
Limestone	1.40	1.40
Sodium chloride	0.50	0.50
Vanilla	0.01	0.01
Vitamin-mineral premix P 6001	0.40	0.40
Total:	100	100
Nutrient value of compound feed:		
Metabolisable energy, kcal/kg	2600	2613
Crude protein, %	26.35	26.06
Crude fat, %	3.60	3.52
Crude fibre, %	4.12	5.16
Calcium,%	2.31	2.30
Phosphorus, %	1,60	1.62
Available phosphorus, %	1.10	1.10
Lysine, %	1.81	1.80
Methionine + cysteine, %	1.42	1.42
Threonine, %	1.40	1.40
Tryptophan, %	0.39	0.39
Vitamin A, IE	8000	8000
Vitamin D, IE	1500	1500
Vitamin E, mg/kg	150	150
Vitamin B_1, mg/kg	5	5
Vitamin B_2, mg/kg	15	15
Vitamin B_6, mg/kg	8	8
Vitamin B_{12}, mcg/kg	20	20
Nicotinic acid, mg/kg	80	80
Panthotenic acid, mg/kg	40	40
Folic acid, mg/kg	5	5
Biotin, mg/kg	0.60	0.60
Iron, mg/kg	20	20
Manganese, mg/kg	25	25
Copper, mg/kg	2.50	2.50
Zinc, mg/kg	18	18
Iodine, mg/kg	1	1
Cobalt, mg/kg	0.48	0.48
Chlorine,%	0.58	0.58
Sodium,%	0.37	0.37

Table 2

Water chemical parameters in the recirculation system during the experiment with common carp

Parameter	n	Min.	Max.	Optimum values (Zaykov and Staykov, 2013)
Temperature, ºC	60	22.50	24.00	22.0–26.0
Dissolved oxygen, mg.l^{-1}	60	5.30	5.96	> 5
pH	60	7.55	7.72	6.5–8.5
Nitrates, mg.l^{-1}	60	0.54	0.60	< 2.0
Nitrites, mg.l^{-1}	60	0.025	0.033	< 0.05
Electric conductivity, µS.cm^{-1}	60	540.00	715.00	–

according to AOAC (2006; method 983.18) and subjected to determination of water content, using air drying (AOAC, 1997; method 950.46). Crude protein content was calculated by converting the nitrogen content, identified by Kjeldahl's method, using an automatic Kjeldahl system (Kjeltec 8400, FOSS, Sweden). Lipid content was determined by the method of Soxhlet, using an automatic system (Soxtec 2050, FOSS, Sweden). Ash content was investigated by incineration in a muffle furnace (MLW, Germany) at 550°C for 8 h. Crucibles were brought about the room temperature and weighed.

Statistical evaluation of the data was done by STATISTICA 6.0 software (StatSoft Inc., 2002).

Results

Water chemical parameters during the experiment are presented in Table 2.

Water temperature was 22.5–24.0°C. The dissolved oxygen during the experiment ranged between 5.30 mg.l^{-1} and 5.96 mg.l^{-1}. Water pH values in the recirculation system varied between 7.52 and 7.75. Nitrates concentration was from 0.54 mg.l^{-1} to 0.60 mg.l^{-1}, whereas nitrites concentrations ranged between 0.025 mg.l^{-1} and 0.033 mg.l^{-1} in the different experimental variants. Electric conductivity of water varied from 540.0 µS.cm^{-1} to 715.0 µS.cm^{-1}.

The analysis of hydrochemical data showed that during the experiment, they were optimum for the farmed species. This led to good results with respect to survival, weight gain and feed conversion ration in experimental carps.

Initial live body weight of carps from EG and CG are presented in Table 3. Average values for the two replications of each group were 1058.38 ± 60.73 g and 1077.13 ± 59.67 g, respectively, with insignificant differences (P > 0.05). This tendency was preserved by the end of the trial, when fish attained average final body weights as followed: EG – 1272.50 ± 70.51 g and CG – 1222.50 ± 74.54 g (Table 3).

Survival rates of common carp, fed feed, containing sunflower and flaxseed meal during the experiment were 100% for the two replications (Table 3).

By the end of the experiment, average individual weight gain of fish from CG was 164.13 ± 16.97 g, whereas that of individuals from EG was 195.38 ± 14.19 g, but the differences were not significant (P > 0.05) (Table 3).

Carps were fed three times per day throughout the experimental period. The daily feed consumption in both experimental groups was analyzed.

Feed conversion ratios are shown in Table 3. In the group, fed feed with sunflower meal it was 2.29 and for carps, fed flaxseed meal – 1.92, which is statistically lower (P < 0.05).

The content of water, crude protein, fat, dry matter and mineral substances of meat in fish, fed pellets with sunflower or flaxseed meal from both experimental variants was within the allowances for the species (Table 4).

Water content of carp meat in CG and EG was 76.89 ± 0.03% and 76.91 ± 0.05%, respectively, without statistically significant differences (P > 0.05). Meat protein of fish from both groups was 17.78 ± 0.02% and 17.73 ± 0.06%, respectively (P > 0.05). Fat content of meat from carps, fed flaxseed

Table 3

Fish production parameters

Parameter	n	CG	EG
		$\bar{x}$ ± SD	$\bar{x}$ ± SD
Initial body weight, g	24	1058.38 ± 60.73	1077.13 ± 59.67
Final body weight, g	24	1222.50 ± 74.54	1272.50 ± 70.51
Survival rate, %	24	100	100
Average individual weight gain, g	24	164.13 ± 16.97	195.38 ± 14.19
Feed conversion ratio	24	2.29 ± 0.17	1.92 ± 0.12

meal was 4.31 ± 0.06%, whereas from those, received pellets with sunflower meal – 4.27 ± 0.03% (P > 0.05). Average dry matter of meat from fish in CG was 23.11 ± 0.03% and from these ones from EG – 23.09 ± 0.05% (P > 0.05). Mineral content of carp meat from both groups was almost the same (1.05 ± 0.02% and 1.06 ± 0.02% respectively), indicating that the dietary supplement did not influence this trait (P > 0.05).

Discussion

The analysis of data from water chemical analysis (temperature, dissolved oxygen, pH and electric conductivity) throughout the experimental period showed that they were within the optimum values for carp farming. The same was valid for maximum nitrate and nitrite allowances in the water. For carp farms, these parameters should not exceed 2 mg/l and 0.05 mg/l, respectively, which values were substantially higher than actual values of water in experimental tanks (Regulation 4/20.10.2000; Zaykov and Staykov, 2013). The maintenance of these optimum water values in both experimental variants was due to the fact that carps were farmed under optimised technical and technological parameters of the production system. Tanks were cleaned three times per day, with addition of fresh water in amount of 10% from the total recirculation system volume. To maintain the optimum water chemical parameters during the experiment, the mechanical filter and the biofilter in particular was of major significance.

In the beginning of the experiment, carps were with similar live body weight and body size (P > 0.05). By the end, there was a tendency towards more intensive growth in fish, fed flaxseed meal. In this group, the average final body weight was 1272.50 ± 70.51 g i.e. by 4.09% higher than that of fish, fed sunflower meal (P > 0.05) (Table 3). This indicates that the supplementation of fattening carp feed with 10% flaxseed meal did not have a negative impact on fish growth, what is more, supplemented fish tended to grow at a faster rate. These results were comparable to those of other authors in other fish species. The supplementation of the feed of *Japanese flounder* with flaxseed meal did not influence growth rates (Wang et al., 2006). Similar data were reported in tilapia by Karapanagiotidis et al. (2007).

In the opinion of researchers, this could be attributed to the high content of linoleic acid (LA) and α-linolenic acid (ALA) in flaxseed meal. These fatty acids are essential for freshwater fish species and also, most of these fish are able to convert them to n-3 and n-6 PUFA with longer chain (Sargent et al., 1995). That is why vegetable meals with high LA and ALA are particularly important sources of dietary lipids for freshwater fish.

The substitution of sunflower meal with flaxseed meal in pelleted feed for carps reared in recirculation system did not influence survival rates. Data, obtained by the end of the trial showed that in both replications, all fish survived (Table 3). This is due to the maintenance of the hydrochemical parameters within the range of the required for the carp species as well as to the application of optimized technological parameters – stocking density, daily diet, frequency of feeding.

The analysis of data for average individual weight gain in CG (164.13 ± 16.97 g) showed that it was lower for fish, fed flaxseed meal by 19.04%, but the differences between the groups were insignificant (P > 0.05) (Table 3).

By the end of the experiment, data for consumed feed showed that feed conversion ratio in carps, cultivated in recirculation system and fed flaxseed meal was 1.92 – by 19.27% lower than FCR of fish, fed with pellets, supplemented with sunflower meal (P < 0.05) (Table 3). Therefore, the inclusion of 10% flaxseed meal in the diet of fattening carps had no negative impact on growth rates and feed conversion ratio, on the contrary, resulted in higher weight gain in experimental carps. In this study, the results could be due to the improved metabolism of nutrients in fish, fed flaxseed meal consequently to the higher amount of two fatty acids essential for freshwater fish – linoleic (LA) and α-linolenic (ALA). This supports earlier data of many researchers, that these fatty acids increased the live weight of fish, fed the same amount of feed (Bieniarz et al., 2001; Hadzhinikolova, 2008; Epler et al., 2009; Epler et al., 2010).

A lot of evidence has been presented that fish are especially sensitive to the quality of feed and the presence of dietary anti-nutritional factors (NRC, 1993; Hasan et al., 1997; Mukhopadhyay and Ray, 1996, 1999). Organoleptic properties and palatability of each feed ingredient determine its potential use when formulating a diet. One of the most commonly encountered problems with alternative vegetable protein sources in aquaculture feeds is their palatability for fish. It is mainly related to feed taste. The determination of feed ingredients' taste is an important criterion for evaluation of their potential use in fish nutrition (Glencross et al., 2007). The results from the present study showed that the use of flaxseed meal in experimental fish diets did not result in lower growth rates and stunted growth, therefore it is a suitable feed component.

The analysis of data from the chemical composition of meat showed that replacement of dietary sunflower meal with flaxseed meal did not influence meat chemical parameters (Table 4). Similar results about the water, dry

Table 4

Chemical composition of carp meat

Parameter	n	CG	EG
		$\bar{x}$ ± SD	$\bar{x}$ ± SD
Water, %	6	76.89 ± 0.03	76.91 ± 0.05
Protein, %	6	17.78 ± 0.02	17.73 ± 0.06
Fat, %	6	4.27 ± 0.03	4.31 ± 0.06
Dry matter, %	6	23.11 ± 0.03	23.09 ± 0.05
Mineral substances, %	6	1.05 ± 0.02	1.06 ± 0.02

matter and ash content of meat were reported by Umer and Ali (2009) after replacement of fish meal with a combination of rapeseed meal and corn gluten in *Labeo rohita*, as well as by Bergamin et al. (2011) after using a variety of vegetable protein sources (rapeseed, flaxseed, sunflower and soybean meals) in common carp.

The same authors reported statistically significantly higher protein content of carp meat, fed diets, containing a mixture of plant and animal proteins. The established increased meat protein content in these fish was attributed to supplementation of amino acids, when using mixtures of various protein sources, resulting in a more complete utilization of feed proteins (Watanabe et al., 1995; Regost et al., 1999).

Carp meat is with average fat content (muscle fat content from 2 to 10%). Our data showing meat fat between 4.27–4.31% supported that statement. At the same time, data from the present experiment were significantly lower, than those reported by Bergamin et al. (2011) – 10.27–13.05%. In our opinion, the latter results for higher carp meat fat content were due to higher dietary fat and higher dietary energy value in the respective experiment.

The main purpose of experiments was to investigate the possibility for using flaxseed meal in carp feeds. These first results are promising and stimulate investigations in the field. To meet the needs of increasing aquaculture production, more and more authors focus their attention to seeking alternatives to rising costs of protein sources.

Conclusion

The utilization of flaxseed meal in pelleted feeds with sunflower meal for carps reared in recirculation system resulted in:

- Increased individual weight gain of fish by 4.09%;
- Lower feed conversion ratio by 19.26%;
- No influence on the survival rates of fish;
- No influence on the chemical composition of carp meat.

The present experiment showed that flaxseed meal could be successfully used for replacement of sunflower meal in carp feeds. Its inclusion influenced positively the growth, did not have a negative impact on fish survival, increased the weight gain, reduced the feed conversion ratio and did not have a negative effect on the chemical composition of carp meat.

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