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COMPARISON OF SOY PROTEIN CONCENTRATE AS AN ALTERNATIVE TO FISH MEAL IN COMMON CARP (*CYPRINUS CARPIO* L.) DIETS

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Abstract: The aim of this study was to replace fish meal (FM) with soy protein concentrate (SPC) in carp diets. During a carp feeding trial, the replacement of FM with SPC in four diets 100% replacement (SPC100); 50% replacement (SPC50); 25% replacement (SPC25), and; 0% replacement (SPC0) had no negative effects on the feed conversion ratio or the feed efficiency ratio of the live carp. However, significant differences in the specific growth rate and condition factor were found. The data obtained showed the four different carp diets led to differences in the chemical composition of the resultant carp meat. Between dietary treatments, significant differences were seen in the level of saturated fatty acids (FAs) in carp meat ($P < 0.05$). The levels of monounsaturated FAs and polyunsaturated FAs in carp meat differed significantly between dietary treatments ($P < 0.05$). Pearson's correlation coefficient indicates a statistically significant correlation between the FA composition of the diet and the resultant carp meat.
It is possible to replace up to 25% of the FM with SPC. Diets SPC25 and SPC0 had no significant FA composition and had amino acid balances that, more than the other diets studied, closely met the requirements of the carp.

Keywords: soy protein concentrate, fish meal, growth, amino acids and fatty acids composition

Introduction

Soy protein is one of the most common plant proteins that can replace fish meal (FM) in fish diets. Although soy products have been studied for a long time *(Tacon, 1994)* and are nowadays routinely used in fish feeds (*Hendricks, 2003; Brezas and Hardy, 2020*), recommendations for their incorporation in salmonid

diets vary (*Kaushik, 2008*). Soy protein concentrate (SPC) is promising for fish nutrition. Although SPC contains anti-nutritional factors (lectins, protease inhibitors, oligosaccharides etc.), these can be eliminated or deactivated (*Sealey et al., 2009; Day and Plascenia González, 2000*), and for some fish species, the solubility of protein was similar in fish diets with SPC and those with FM (*Day and Plascenia González, 2000; Kissil et al., 2000*). Several studies have shown that SPC diets can be used in fish nutrition. In sea bream diets, SPC can be used to replace FM but with a limit of 30% (*Kissil et al., 2000*). In turbot diets, up to 25% of the FM can be replaced with SPC (*Day and Plascenia González, 2000*). In rainbow trout diets, SPC caused a decrease in fish growth, but substitution of up to 50% of the FM was possible when diets with SPC were supplemented with amino acids (AAs) (*Mambrini et al., 1999*). However, studies have shown great variability when using soy products (soybean meal, full-fat soybeans, soya isolates and concentrates) in fish diets (*Welker et al., 2021*), and this variability is related to the processing technologies. Nonetheless, cyprinidae are considered to be more tolerant to soybean anti-nutritional factors (*Escaffre et al., 1997*) if synthetic AAs are utilized (*Lemme, 2011*). The whole-body AA profile of carp is not affected by the age of fish (*Kaushik and Seiliez, 2010*).

The aims of this study were to determine for common carp (*Cyprinus carpio* L.) whether a SPC diet without AA supplementation is suitable and how this diet influences the growth, AA and fatty acid (FA) composition of the carp meat.

Materials and Methods

Fish sampling

The study was conducted in the Laboratory of Fish Nutrition, Faculty of Agriculture, University of Belgrade, Serbia. Fish (n=26) with average weight of 9.55 g (the fish density was 2.069 kg m^{-3}) were stocked in each tank. Over a period of 90 feeding days, the 26 fish in each tank were given one of the four types of fish diet, each diet in three replicates (4 diets x 3 replicates = 12 tanks). In each tank, 3% of the ichthyomass was fed to the fish daily. Feed distribution was carried out continuously on a daily basis using automatic feeders (AGK Kronawitter GmbH, Germany). The ingredients of the experimental diets are presented in Table 1.

For calculation of growth parameters: body weight gain (BWG), specific growth rate (SGR), feed conversion ratio (FCR) and condition factor (CF), the equations in *Shamna et al. (2017)* were utilized. At the end of the 90-day feeding trial, seven fish from each tank were chosen randomly and the fish were removed the dorsal side.

Table 1. Ingredients and chemical composition in experimental diets

Ingredients (%)	Diet 1 SPC100	Diet 2 SPC50	Diet 3 SPC25	Diet 4 SPC0
Fishmeal (FM)[1]	0	17.0	25.5	34.0
Soy protein concentrate (SPC)[2]	34.0	17.0	8.5	0
Soybean	28.3	28.3	28.3	28.3
Wheat	11.0	11.0	11.0	11.0
Soybean meal	10.0	10.0	10.0	10.0
Maize	10.0	10.0	10.0	10.0
Premix[3]	3.0	3.0	3.0	3.0
Monocalcium phosphate[4]	3.0	3.0	3.0	3.0
Chalk	0.7	0.7	0.7	0.7
Chemical composition (% on dry matter)				
Crude protein	41.83 ± 0.07^{a}	40.19 ± 0.66^{b}	40.44 ± 0.34^{ab}	39.54 ± 0.08^{b}
Crude fat	8.09 ± 0.11^{d}	10.25 ± 0.11^{c}	12.44 ± 0.10^{b}	14.11 ± 0.13^{a}
Crude ash	7.69 ± 0.01^{d}	8.93 ± 0.02^{c}	11.01 ± 0.02^{b}	13.05 ± 0.02^{a}
Fiber	2.52 ± 0.02^{a}	2.18 ± 0.02^{b}	1.67 ± 0.02^{c}	1.40 ± 0.02^{d}
NFE	39.87 ± 0.01^{a}	38.45 ± 0.79^{a}	34.44 ± 0.19^{b}	31.88 ± 0.05^{c}

Means in rows followed by different superscript letters are significantly different ($P < 0.05$); NFE – nitrogen free extract; number of samples n = 3

[1] Fishmeal contained 60% crude protein, 10% crude fat, 0.3 % crude fiber, 18% ash. Source of fishmeal was Apesabel Export S.A.C. Lima (Peru); [2]soy protein concentrate contained 65% crude protein, 0.3% crude fat, 4.5% crude fiber, 7.0% ash. SPC was sourced from Sojaprotein a.d. (Bečej, Serbia); [3]mineral vitamin mix contained (per kg of premix): potassium phosphate, 40 g; calcium phosphate, 5.5 g; magnesium sulfate, 6.1 g; sodium phosphate 2.5 g, vitamin A, 350 000 IU; vitamin D, 800 000 IU; vitamin E, 40 g; vitamin K, 15 g; vitamin B1, 20 g; vitamin B2, 15 g; vitamin B6, 20 g; vitamin B12, 10 mg; niacin, 40 g; pantothenic acid, 40 g; folic acid, 4 g; biotin, 400 mg; choline, 500 mg; inositol, 150 g (Veterinary Institute of Subotica, Serbia); [4] monocalcium phosphate (Veterinary Institute of Subotica, Serbia)

Chemical analysis

Analysis of the chemical composition of feed and carp meat was carried out using the following procedures: dry matter after drying in an oven at 105°C (*ISO 1442:1997, ISO 6496:1999*); ash by ashing in furnace at 550°C (*ISO 936:1998, ISO 5984:2002*); protein by Kjeldahl (N x 6.25) on a Kjeltec Auto 1030 analyzer (Manual Book, Tecator, Höganäs, Sweden); fat by petroleum ether extraction on a Soxhlet apparatus (*ISO 1443:1973, ISO 6492:1999*) and crude fiber using a standard method with intermediate filtration (*ISO 6865:2000*). Nitrogen-

free extract (NFE) was calculated by subtracting from 100 the percentages of moisture, crude protein, fat, crude fiber, and ash in the feed of carp. Chemical analyses of feed and carp meat were performed in triplicate.

Amino acid analysis

AAs of feed were analyzed according to the method in *Liu et al.* (1995). The AAs were analyzed by high pressure liquid chromatography (HPLC) (Waters, Milford, MA, USA) on a photodiode array detector (PDA) at 260 nm and fluorescence detector (FL) (all from Waters). An AccQ-Tag C-18 column (3.9 mm x150 mm x 4 μm) was used. Flow rate was 1.5 ml min^{-1}. The injected volume was 10 μL. Standard AAs were purchased from Supelco (Supelco, Bellefonte, USA). To control the HPLC system, data acquisition and data processing Empower Pro software was used.

Fatty acid analysis

The FA composition of feed and carp meat was determined by capillary gas chromatography, starting with accelerated solvent extraction (ASE) at 100°C at 10.3 MPa (Dionex, Sunnyvale, CA, USA). A solvent evaporator 500 (Sunnyvale, CA, USA) was used at 50°C until sample dryness was reached. Extracted lipids were dissolved in tert-butyl methyl ether. Furthermore, fatty acid methyl esters (FAMEs) were transesterificated using 0.25 M trimethylsulphonium hydroxide (TMSH) in methanol (*ISO 5509:2000*). FAMEs were determined by capillary gas chromatography on a Shimadzu 2010 gas chromatograph with a flame ionization detection (Kyoto, Japan) using a HP-88 capillary column (100 m × 0.25 mm × 0.20 μm, J&W Scientific, USA). The injector and detector temperatures were set at 250°C and 280ºC, respectively. Nitrogen was used as the carrier gas at a flow rate of 1.33 mL min^{1}. The injector split ratio was set at 1:50. Temperature program for oven starting at 125ºC and ending 230ºC, was applied. The chromatographic peaks in the extracts were identified by comparing peaks with peaks in Supelco 37 Component FAME mix standard (Supelco, Bellefonte, USA). Relative quantities were expressed as the weight percentage of the total content of FAs.

Statistical analysis

Data were analyzed by one-way analysis of variance (ANOVA) and Tukey-Kramer HSD test (JMP 10, SAS Institute, Inc.). Pearson's correlation with *t*-test was used to examine correlations between fish diet (SPC100, SPC50, SPC25 and SPC0) and the composition of resultant carp meat (carp meat 1-4), to evaluate the effects of dietary replacement of FM with SPC.

Results and Discussion

The effects of the four dietary regimes on growth parameters during the feeding trial are given in Table 2.

Table 2. The effects of dietary regimes on growth parameters of carp after the 90 day feeding trial (mean ± SD)

Diet	Diet 1 SPC100	Diet 2 SPC50	Diet 3 SPC25	Diet 4 SPC0
BWG[1]	196.71 ± 6.78^{NS}	199.68 ± 2.16^{NS}	183.73 ± 18.20^{NS}	168.25 ± 8.52^{NS}
SGR[2]	1.36 ± 0.02^{a}	1.13 ± 0.02^{b}	1.22 ± 0.06^{ab}	1.16 ± 0.07^{b}
FCR[3]	1.81 ± 0.11^{NS}	1.85 ± 0.12^{NS}	1.99 ± 0.14^{NS}	2.15 ± 0.11^{NS}
FER[4]	0.58 ± 0.04^{NS}	0.59 ± 0.02^{NS}	0.55 ± 0.04^{NS}	0.50 ± 0.03^{NS}
CF[5]	1.51 ± 0.03^{b}	1.61 ± 0.02^{ab}	1.60 ± 0.02^{ab}	1.63 ± 0.02^{a}

Means in rows followed by different superscript letters are significantly different ($P < 0.05$); NS – not significant; [1]BWG – body weight gain; [2]SGR – specific growth rate; [3]FCR – feed conversion ratio; [4]FER – feed efficiency ratio; [5]CF – condition factor; number of samples n = 6

Common carp grew well on diets with SPC. After the feeding trial, SPC had no negative effect on the BWG, FCR, or FER of the live carp. Some growth reduction was observed, although it was not statistically significant. The results were in agreement with those of another study (*Mambrini et al., 1999*). The SGR of carp on the SPC100 diet was 1.36 $g \cdot 100^{-1} \cdot day^{-1}$, while that of carp on the SPC0 diet (which contained FM but no SPC), was 1.16 $g \cdot 100^{-1} \cdot day^{-1}$. The values were statistically different ($P < 0.05$). The SGRs of carp fed on diets SPC50 and SPC25 were 1.13 $g \cdot 100^{-1} \cdot day^{-1}$ and 1.22 $g \cdot 100^{-1} \cdot day^{-1}$ respectively. These growth parameter results were in agreement with *Chen et al.* (*2019*). However, significant differences in the CF were found between carp fed on the SPC100 diet and those without any SPC in their diet (SPC0), so addition of FM to the diet led to the carp having better body condition at the end of the study.

The chemical composition of the experimental diets is given in Table 1.

Among the diets, the SPC100 diet had the highest protein content and the lowest crude fat content. Significant differences were observed, especially in regard to crude fat and ash contents, between the experimental diets, with FM having the highest crude fat content and ash content. Although the fiber content was highest in the SPC100 diet, as shown in Table 1, the SPC100 and SPC50 diets had larger fractions of nitrogen-free extract (NFE) than the SPC25 and SPC0 diets. The experimental diet in our study had similar chemical compositions to the diets fed to gilthead sea bream, cod, rainbow trout and common carp in other studies (*Francis et al., 2007; Palmegiano et al., 2006; Nasir et al., 2013*).

Table 3 presents the AA composition of the carp diets containing different levels of SPC.

Table 3. Amino acid composition (% dry weight) of the experimental carp diets

Amino acid	Diet 1 SPC100	Diet 2 SPC50	Diet 3 SPC25	Diet 4 SPC0
Cys + Met	4.8^{a}	4.3^{b}	3.9^{c}	3.6^{d}
Lys	3.5^{c}	3.6^{c}	6.1^{b}	7.7^{a}
Val	6.4^{a}	6.5^{a}	5.9^{b}	6.7^{a}
Leu	4.1^{c}	4.5^{b}	7.5^{a}	7.6^{a}
Ile	4.4^{c}	4.7^{bc}	4.8^{ab}	5.0^{a}
His	1.5^{c}	1.7^{bc}	1.9^{ab}	2.0^{a}
Arg	8.0^{a}	7.9^{a}	6.9^{b}	6.3^{c}
Thr	3.7^{NS}	3.6^{NS}	3.4^{NS}	3.6^{NS}
Phe + Tyr	9.2^{a}	8.9^{b}	7.6^{c}	6.6^{d}
Trp	4.2^{c}	4.4^{bc}	4.6^{ab}	4.8^{a}

Means in rows followed by different superscript letters are significantly different ($P < 0.05$); NS – not significant; number of samples n = 3

Both the SPC100 and SPC50 diets were deficient in lysine. The requirement of common carp for lysine is 5.7 % (*Hasan, 2000*). However, other AAs were within the described ranges suitable for carp. Both SPC25 and SPC0 had a balance of AAs that closely meets the requirement of these fish *(NRC, 2011)*. The AA compositions of the fish diets were in agreement with another study (*Chen et al.*, *2019)*.

Table 4 presents the chemical composition of carp meat from fish fed on diets containing different levels of SPC.

Table 4. Proximate composition of common carp meat from fish fed on diets containing various levels of SPC (mean ± SD)

Parameter	Carp meat 1, fish fed on SPC 100	Carp meat 2, fish fed on SPC 50	Carp meat 3, fish fed on SPC25	Carp meat 4, fish fed on SPC0
Protein, %	19.28 ± 0.23^{a}	17.80 ± 0.18^{b}	18.13 ± 0.28^{b}	17.80 ± 0.11^{b}
Moisture, %	74.30 ± 0.37^{NS}	71.80 ± 0.12^{NS}	73.14 ± 0.11^{NS}	73.06 ± 1.26^{NS}
Lipid, %	5.26 ± 0.10^{d}	8.46 ± 0.10^{a}	7.82 ± 0.11^{b}	7.72 ± 0.15^{c}
Ash, %	1.25 ± 0.02^{a}	1.12 ± 0.01^{b}	1.16 ± 0.02^{ab}	1.15 ± 0.02^{ab}

Means in rows followed by different superscript letters are significantly different ($P < 0.05$); NS – not significant; number of samples n = 6

The data show the different types of feed affected the chemical composition of the carp meat. Significant differences ($P < 0.05$) in protein content existed between carp meat 1 (SPC100) and carp meats 2, 3 and 4 (SPC50, SPC25, SPC0 respectively). However, the protein content was higher in our study than in a

previous study (*Barakat et al., 2007*). The differences in lipid content in the carp meat from fish fed the different diets were statistically significant ($P < 0.05$). Regarding lipid content, according to some published data *(Ćirković et al., 2011*), carp meat from dietary treatments 2 (SPC50), 3 (SPC25), and 4 (SPC0) can be considered fatty fish meat (with >8% fat content), while carp meat from dietary treatment 1 (SPC100) can be considered moderately fatty fish meat (with fat content of 4-8%) *(Mráz et al., 2012*). The lipid contents established in this study were similar to those reported in other studies (*Trenovszki et al., 2011*). The ash contents differed significantly ($P < 0.05$) in the carp meat from the different dietary treatments (*Honzlova et al., 2021*).

Table 5 presents the FA compositions of the experimental diets and the resultant carp meat from the fish fed on the different diets (SPC100 to SPC0).

The levels of saturated fatty acid (SFAs) in the carp meat were similar between dietary treatments with significant differences ($P < 0.05$). The levels of SFA was similar as in a previous study (*Barakat et al., 2007*). The level of monounsaturated fatty acids (MUFAs) was significantly higher in carp meat 1 (fed on SPC100) than in carp meat 2 (SPC50) ($P < 0.05$). The lowest MUFA levels were in carp meat 3 (SPC25) and carp meat 4 (SPC0) ($P < 0.05$). The PUFA levels were significantly higher in carp meats 2 (SPC50), 3 (SPC25), and 4 (SPC0) than in carp meat 1 (SPC100) ($P < 0.05$). As for the n-6 series of FAs among PUFAs, higher levels were measured in carp meat 2 (SPC50), 3 (SPC25), and 4 (SPC0), while carp meat 1 (SPC100) had the lowest levels. With respect to the n-3 series FAs, higher levels were present in carp meat 2 (SPC50), 3 (SPC25), and 4 (SPC0), with the lowest level in carp meat 1 (SPC100). The PUFA level has been reported to vary over a wide range and was similar in another study (*Ćirković et al., 2011*).

The n-6/n-3 ratio was 11.63 in carp meat 1 (SPC100), much higher than the 5.59-6.18 ratios in carp meat 2 (SPC50), 3 (SPC25), and 4 (SPC0). Also, different values of the n-3/n-6 ratio correlated with feed composition were observed by other investigators in freshwater fish such as carp (*Ćirković et al., 2011; Mráz et al., 2012; Trenovszki et al., 2011; Honzlova et al., 2021*).

Using correlation analysis of the FA composition of the four diets and resultant carp meat, we calculated Pearson's correlation coefficient between diet 4 (SPC0) and carp meat 4 (SPC0) and between diet 3 (SPC25) and carp meat 3 (SPC25) were r = 0.864 and r = 0.862, respectively. The *t*-test values were 10.38 and 10.30 (t_{crit} = 2.10) for pair 3 and pair 4, respectively, which means both correlation coefficients were statistically significant at a significance level of $P = 0.05$. The Pearson's correlation coefficient for diet 2 (SPC50) and carp meat 2 (SPC50) was r = 0.821, while that for diet 1 (SPC100) and carp meat 1 (SPC100) was r = 0.718.

Table 5. Fatty acid composition of experimental diets containing various levels of SPC (diets 1-4) and meat from common carp fed those diets (carp meat 1-4)

Fatty acids	Diet 1 SPC100	Diet 2 SPC50	Diet 3 SPC25	Diet 4 SPC0	Carp meat 1 fish fed on SPC100	Carp meat 2 fish fed on SPC50	Carp meat 3 fish fed on SPC25	Carp meat 4 fish fed on SPC0
C14:0	0.08^{c}	0.72^{b}	0.85^{a}	0.85^{a}	0.38^{y}	0.66^{x}	0.63^{x}	0.66^{x}
C15:0	nd	0.11^{b}	0.13^{a}	0.14^{a}	0.05^{y}	0.10^{x}	0.09^{x}	0.11^{x}
C16:0	10.51^{c}	13.01^{b}	13.90^{a}	14.09^{a}	14.19^{x}	14.64^{x}	15.02^{x}	14.94^{x}
C16:1	0.09^{b}	1.22^{a}	1.19^{a}	1.12^{a}	3.04^{y}	3.51^{x}	3.19^{y}	3.11^{y}
C17:0	0.08^{d}	0.26^{c}	0.45^{a}	0.49^{a}	0.10^{y}	0.21^{x}	0.23^{x}	0.24^{x}
C18:0	5.50^{a}	4.87^{a}	5.96^{a}	6.54^{a}	5.53^{x}	4.47^{x}	4.80^{x}	4.98^{x}
C18:1n-9	28.32^{a}	28.11^{a}	27.65^{b}	27.14^{b}	42.02^{x}	39.69^{x}	38.52^{y}	38.04^{y}
C18:2n-6	50.35^{a}	43.33^{b}	40.68^{c}	39.64^{c}	25.71^{y}	27.00^{x}	27.74^{x}	27.40^{x}
C20:0	0.40^{a}	0.39^{a}	0.40^{a}	0.38^{a}	0.16^{x}	0.13^{y}	0.13^{y}	0.13^{y}
C18:3n-6	nd	0.03^{b}	nd	0.07^{a}	0.74^{x}	0.38^{z}	0.42^{y}	0.45^{y}
C18:3n-3	4.64^{a}	4.81^{a}	3.99^{b}	4.02^{b}	1.53^{y}	2.09^{x}	2.22^{x}	2.24^{x}
C20:1	nd	nd	1.24^{b}	1.43^{a}	2.12^{y}	2.29^{y}	2.19^{y}	2.40^{x}
C20:2n-6	0.03^{a}	0.10^{a}	0.15^{a}	0.08^{a}	0.53^{x}	0.51^{xy}	0.49^{y}	0.44^{z}
C20:3n-6	nd	0.06^{c}	0.19^{a}	0.09^{b}	1.03^{x}	0.77^{y}	0.74^{y}	0.74^{y}
C20:3n-3	nd	0.27^{c}	1.21^{b}	1.55^{a}	nd	0.31^{y}	0.35^{x}	0.40^{x}
C20:4n-6	nd	0.23	nd	nd	1.99^{x}	0.99^{z}	1.07^{yz}	1.15^{y}
C20:5n-3	nd	0.85^{a}	0.59^{b}	0.59^{b}	0.07^{y}	0.34^{x}	0.33^{x}	0.35^{x}
C22:5n-3	nd	0.10^{b}	0.10^{b}	0.23^{a}	0.11^{y}	0.26^{x}	0.26^{x}	0.27^{x}
C22:6n-3	nd	1.53^{a}	1.31^{b}	1.53^{a}	0.71^{y}	1.63^{x}	1.81^{x}	1.93^{x}
SFA	16.56^{c}	19.36^{b}	21.69^{a}	22.50^{a}	20.41^{x}	20.22^{x}	20.86^{x}	21.07^{x}
MUFA	28.41^{c}	29.34^{b}	30.08^{a}	29.70^{a}	47.18^{x}	45.49^{y}	43.81^{z}	43.55^{z}
PUFA	55.03^{a}	51.07^{b}	48.23^{c}	47.80^{c}	30.42^{y}	33.30^{x}	34.27^{x}	34.23^{x}
n-6	50.38^{a}	43.52^{b}	41.02^{c}	39.88^{c}	28.01^{y}	28.67^{x}	29.32^{x}	29.04^{x}
n-3	4.64^{d}	7.56^{b}	7.21^{c}	7.93^{a}	2.41^{y}	4.64^{x}	4.95^{x}	5.20^{x}
n-6/n-3	10.85^{a}	5.76^{b}	5.69^{b}	5.03^{c}	11.63^{x}	6.18^{y}	5.92^{y}	5.59^{y}

All values are reported as mean; nd = not detected; $^{a, b, c,}$ Diet - Means followed by different superscript letters are significantly different ($P < 0.05$); $^{x, y, z}$ Carp meat- Means followed by different superscript letters are significantly different ($P < 0.05$); SFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acid; number of samples for feed n= 3 for carp meat n = 6

The *t*-test values were 8.84 and 6.58 for pair 2 and pair 1, respectively, also indicating a statistically significant correlation between the FA composition of the diet and the FA composition of the resultant carp meat. Statistical analysis (ANOVA) showed there were no statistical differences in the FA composition of diet 3 (SPC25) and diet 4 (SPC0), and our results were in agreement with those obtained by other studies (*Nasir et al., 2013; Barakat et al., 2007; Ćirković et al., 2011; Mráz et al., 2012*).

Conclusion

There were small differences in the chemical composition of the fish diets, but they did not influence FCR and FER but they influence SGR and CF. Diets 3 (SPC25) and Diet 4 (SPC0) were very similar in regard to proximate and FA composition. The n-6/n-3 ratio was 5.59-5.92 in carp meat 3 (SPC25) and 4 (SPC0). These values are close to the dietary optimal n-6/n-3 ratio, which is between 1:1 and 4:1 and is desirable for reducing the risk of many diseases in humans. Therefore, we conclude that up to 25% of the FM in carp diet can be replaced with SPC, but we strongly caution against complete replacement because carp diet without FM would have an adverse effect on the FA composition of the resultant carp meat. Further studies are needed to evaluate the use of SPC in carp feed that is supplemented with synthetic AAs.

Poređenje koncentrata sojinih proteina kao alternativa ribljem brašnu u ishrani šarana (*Ciprinus carpio* L.)

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Rezime

Cilj ovog rada je bio da se ispita mogućnost zamene ribljeg brašna (RB) sa koncentratom sojinih proteina (SPK) u ishrani šarana. Tokom ogleda ishrana šarana po grupama bila je sa jednom od četiri hrane u kojoj je RB zamenjeno sa SPK: 100% (SPK100); 50% (SPK50); 25% (SPK25), odnosno, 0% (SPK0). Ishrana šarana sa četiri različite hrane nije imala negativan uticaj na konverziju hrane ili na koeficijent efikasnosti. Međutim, nađene su statistički značajne razlike u specifičnoj stopi rasta i kondicionom faktoru. Dobijeni podaci su pokazali da ishrana šarana sa četiri različite hrane dovode do razlika u hemijskom sastavu dobijenog mesa šarana. Uočene su značajne razlike u nivou zasićenih masnih kiselina (MK) u mesu šarana ($P < 0,05$). Nivoi mononezasićenih MK i polinezasićenih MK u mesu šarana značajno su se razlikovali između ishrane

šarana sa četiri različite hrane (P < 0,05). Pirsonov koeficijent korelacije ukazuje na statistički značajnu korelaciju između sastava MK u ishrani i mesa šarana. Moguće je zameniti do 25% RB sa SPK. Različite hrane za šarana sa SPK25 i SPK0 nisu imale značajno različit MK sastav i imale su balans aminokiselina koje su, više od drugih proučavanih hrana, u potpunosti ispunjavale zahteve šarana.

Ključne reči: koncentrat sojinih proteina, riblje brašno, rast, sastav aminokiselina i masnih kiselina

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