ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LXI 142 Number 5, 2013

http://dx.doi.org/10.11118/actaun201361051289

THE UTILIZATION OF RAPESEED EXPELLER FOR CARP (*CYPRINUS CARPIO*) DIETS

Vladimír Kukačka, Jiří Jirásek, Radovan Kopp, Jan Mareš

Received: May 2, 2013

Abstract

KUKAČKA VLADIMÍR, JIRÁSEK JIŘÍ, KOPP RADOVAN, MAREŠ JAN: *The utilization of rapeseed expeller for carp (Cyprinus carpio) diets.* Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 2013, LXI, No. 5, pp. 1289–1295

Production effectiveness of rapeseed stamping in the common carp fodder was attested in the controlled conditions of recirculation system with the absence of natural food. 4 isonitrogenous (31.5% NS) and isoenergetic (17.3 MJ GE.kg^{-1}, resp. 13.5 MJ DE.kg^{-1}) diet with different (35 and 40%) unmodified (URS) and technologically modified (MRS) rapeseed expeller ratio were tested. During the sixty-day feeding trial, beneficial production effect of diet with modified stamping was proved. Diet MRS fish were characterized by significantly ($P < 0.05$) faster length growth. In comparison with fry of MRS variant, they have reached highly significantly ($P < 0.01$) the higher values of broad – backedness index and significantly ($P < 0.05$) higher values of body width. Significant values were not detected by individual weight and HSI. Except the haematocrit value, there were no hematologic and biochemical indices influenced by feed type. Higher content of fat in the URS was shown at fish variant URS/40 by higher fat deposition in hepatopancreas (averagely 30.31%), without statistically significant difference compared to other variants.

carp fry, growth intensity, feed conversion, haematological parameters

Climate changes in the global impact influence the sources of basic compound for fish feed production – the fish-flour. Also, they influence a crop structure of agriculture production with extension of foretime marginally grown crops. Regard to the availability, high consumption and price, there are possibilities of partial reduction of fish-flour in aquafeeds. Namely for the carnivore salmonids and fish of prey breeding, the nutrition identification of non-traditional protein sources suitability has prior breeding and economical intent. The development of productively effective and affordable diet is necessary even for juvenile omnivorous fish breeding, including carp. According to TACON and JACKSON (1985), the level of fish-flour substitution in aquafeed depends primarily on the essential fat acids balance and presence of antinutrition substances. In connection with biofuel using program under the EU, the significant growth of oilseed rape (*Brasicca napus* L.) arisen. Products obtained by industrial manufacturing can be considered as perspective feed ingredients and protein sources for fish, as well as the modern technological methods in the processing and the technique of feed production (extrusion).

For feeding purposes the oilseed rape is used mainly in extracted grout or stampings. THIELSSEN *et al.* (2004) added the rape protein concentrate (canola concentrate – CPC) into the feed for rainbow trout (*Onchorhynchus mykiss*). The best results were reached with 50% presence of CPC in dry matter of feed. The digestibility data of variously processed oilseed rape by see bass carried out in their works KISSIL *et al.* (2000), GLENCROSS *et al.* (2004) and ALLAN and BOOTH (2004). Whereas the positive production effect of rape seed grout using in the proportion up to 15% for salmonids and up to 30% for carp is known (SADOWSKI, 2005), the using of thermally non – processed stampings has not been verified. The aim of the experiment was to verify the possibility of variously processed rapeseed expeller in the diet for carp fry.

MATERIALS AND METHODS

For feed tests there was the carp fry with average initial weight of 15 g used. This originated in the Rybníkářství Pohořelice, a. s. breed. The combinations of mirror carp lines M72 (severský lysec) and Pohořelický lysec were used. We conducted an experiment at the absence of natural food in the 50l volume flow tanks. These were connected to the recirculation system which enabled the regulation of conditions at physiological optimum for carp fry.

The hydrochemical regime in the experimental tanks can be defined by these parameters:

- Water temperature: 22.0–24.3 °C
- Water saturation by oxygen: 77–99%
- pH of water: 7.38–8.00.
- Inflow / water exchange: 1.5 l.s^{-1}/1.5 – 2x.h^{-1}
- Photoperiod (light / dark): 14 hr./10 hr.

The production effect of four experimental diet was observed. Unmodified rape seed (URS) and technologically modified rape seed (MRS) in the amount of 35% and 40% of feed weight were used as non-traditional source of protein integrated in diets.

The producer (f. ZOD Žichlínek) developed the special technology for modifying the rape seed (MRS) which enabled the minimization of glucosinolates content (trade name PROENERGOL).

The analysis of amino acids was carried out at the Department of Animal Nutrition and Forage Production MENDELU in Brno. The liquid chromatography with ninhydrin reaction following the acid hydrolysis of HCl (c = 6 mol.l^{-1}) was used. In the case of sulphuric amino acids the ninhydrin reaction followed after the oxidativelly acidic hydrolysis (oxidation mixture – 1 part H_2O_2 + 9 parts formic acid (85% p.a.) and then acid hydrolysis HCl of (c = 6mol.l^{-1}). The hydrolyzed sample was evaporated at RVO at 55°C and then diluted by Trisodium citrate buffer solution pH 2.2. The amino acids establishing was carried out by Automatical amino acids analyzer AAA 400 (f. INGOS Praha).

The dry matter was established by drying of sample at 105 °C until the constant weight. The protein was established by method according to Kjeldal – establishing of the nitrogen content in sample and multiply by the coefficient for animal tissues 6.25. The fat was extracted by Soxhlet's method with dietyl ether for 10 hours. The content of ash was established gravimetrically after the annealing in the electrical furnace by the 550 °C till the constant weight.

The tested diets were compiled as a isonitrogenous (31.5% NS) and isoenergetic (17.3 MJ BE.kg^{-1}, resp. 13.5 MJ DE.kg^{-1}).

Diets were prepared by laboratory way and shaped to 2.5 mm size particles. All of the experimental variants were tested by double repeating. The feed were served to fish three times a day in during the period of ten hours (7.00–17.00) in the daily amount

I: *The content of glucosinolates in the rape seed stampings (% of dry matter) according to POUL et al. (2002)*

The kind of stampings	URS	MRS
Dry matter	91,44	90.45
Protein	28.79	26.48
Fibre	8.81	6.46
Ash	5.53	13.29
Fat	14.28	12.8
NFE	34.03	31.42
Glucosinolates[mmol.kg^{-1}]	19.5	1.00

II: *The content of chosen essential amino acids in stampings (g.16 g N-1)*

AC	URS	MRS
arg	4.366	4.100
his	1.399	2.309
ile	3.629	3.974
leu	7.150	7.785
lys	6.421	5.115
met + cys	1.553	1.805
thr	6.117	6.274

III: *The component and chemical composition of used diets (%)*

Component	Experimental diet - indication			
	URS/35	MRS/35	URS/40	MRS/40
Fish-flour	15	15	15	15
Soya extracted grout extrah. šrot	12	12	12	12
Yaeast VITEX	3	5	-	3
URS	35	-	40	-
MRS	-	35	-	40
Wheat flour	35	33	33	30
Dry matter	90	90	90	90
Proteins	31.77	31.55	31.50	31.51
Fat	7.87	7.42	8.52	7.90
NFE	38.57	37.70	38.03	36.10
DE [MJ.kg^{-1}]	13.64	13.24	13.74	13.25

corresponding with 4% of actual weight of tank stocks. The feeding rations were corrected each week according to the results of growth control. Test was carried out for 60 days.

We have used the following parameters for the assessment of the productive feeds, assessment of exterior and fish condition: SL (Standard Length); H (height); W (wide), w_0 (weight of mass at the beginning of test), w_t (weight of fish mass at the end of the test), w (weight of fish) w_x (weight of fish without visceral complex) w_h (weight of hepatopancreas), P (protein content in feed in %), t (time of the test in days), FCR (Food Conversion Ratio), FCE (Food Conversion Efficiency), SGR (Specific Growth Rate) = $[(\ln w_0 - \ln w_t).t^{-1}\ 100$, RGR (Relative Growth Rate) = $100.(w_t - w_0).w_0^{-1}$, 100% = $100.(RGR.t^{-1})^{-1}$(time necessary for reaching the 100% of the fish stock growth), PER (Protein Efficiency Ratio) = $100.(FCR.P)^{-1}$, I_H (high – backedness index) = $SL.H^{-1}$, I_w (broad – backedness index) = $(W.SL^{-1}).100$, Kf (Fulton's coefficient) = $(w.100).SL^{-3}$, Kc (Clark's coefficient) = $(w_x.100).SL^{-3}$, HSI (HepatoSomatic Index) = $w_h.w_x^{-1}$. For the assessment of inner conditions we have carried out the haematological examination and the fish blood plasma analysis of each variants at the end of the observation. Blood was taken by cardio puncture method (JIRÁSEK *et al.*, 1980) and processed immediately according to SVOBODOVÁ *et al.* (1986) methods. For variation provability testing there was ANOVA with following multiply comparison by Scheffe's method used. The significance of differences was tested by at the significance level P = 0.05 and P = 0.01. In the particular indicator tabs there are significances of differences in the upper index behind the current value stated. For the significance level $P < 0.05$ there is used small letter (X^a) and for the significance $P < 0.01$ there is used capital letter (X^A). In the case of values marked by the same letters or unmarked, there were no significant differences figured out.

RESULTS AND DISCUSSION

The average values of observed length-weight, fitness and production indicators reached with the particular experimental variants are stated in the Tab. IV. and V.

The values of length indicators were significantly higher ($P < 0.05$) with the fish variant MRS/40 comparing with variant URS/40. The values of body height figured out by the fish variant MRS/35 were significantly higher and with the fish variant MRS/40 highly significantly higher ($P < 0.01$) comparing with variant URS/40. There was statistically highly significant difference in favor of fish variant MRS/40 comparing with variant URS/40 figured out at the body wide values and high – backedness index. The differences of reached individual weight values and figured out HSI at particular experimental variants were not statistically significant.

Differences in the growth intensity and the feed conversion have expressed mainly at the fish fed with 40% rape seed stampings diet, where the nutrition advantages of technologically processed stampings (MRS) have positively showed up. Reached individual weight of fish fry variant MRS/40 was averagely 22.2% and the SGR values were 28.2% higher comparing with variant URS/40.

The highest production effectiveness as figured out at the feed variant MRS/40 where the highest feed conversion per growth (FCR value 1.88), the highest SGR value (1.91 $\%.d^{-1}$) and the best results of other production indicators were reached (Fig. 2). Opposite to this, using the same parameters, as the less suitable feed variant was the URS/40 assessed. The fish fed by this feed have reached the lowest growth in all variants. Also, there was the lowest ability of feed conversion per growth assessed (FCR 2.45). This proves the positive productive impact of using the rapeseed expeller with the decreased glucosinolates-PROENERGOL content. Applying the diet with 40% unmodified stampings (URS/40), there was worse conversion of feed averagely about 12.4% with the FCR = 2.45,

IV: *The values of length-weight and fitness fish fry indicators*

	INPUT	URS/35	MRS/35	URS/40	MRS/40
	A ± Sd	A ± Sd	A ± Sd	A ± Sd	A ± Sd
Length-weight indicators					
TL [mm]	98.70 ± 6.38	131.22 ± 8.59^{ab}	132.83 ± 8.94^{ab}	125.44 ± 8.40^{a}	134.72 ± 9.97^{b}
SL [mm]	76.80 ± 4.69	105.22 ± 7.30^{ab}	107.00 ± 7.84^{ab}	100.00 ± 7.10^{a}	108.39 ± 8.80^{b}
H [mm]	29.30 ± 2.45	39.22 ± 3.31^{AB}	39.94 ± 2.72^{AB}	36.56 ± 3.15^{A}	41.67 ± 3.27^{B}
W [mm]	14.90 ± 1.79	20.06 ± 8.78^{AB}	20.33 ± 1.76^{AB}	18.28 ± 1.24^{A}	21.11 ± 2.38^{B}
w [g]	15.83 ± 3.17	39.66 ± 8.78	42.33 ± 8.89	34.99 ± 6.78	42.71 ± 9.87
I_H -	2.63 ± 0.10	2.69 ± 0.11^{AB}	2.68 ± 0.08^{AB}	2.74 ± 0.12^{A}	2.60 ± 0.07^{B}
I_W [%]	19.38 ± 1.80	19.02 ± 2.39	19.01 ± 1.03	18.31 ± 1.12	19.44 ± 0.91
Fitness indicators					
Kf	3.45 ± 0.12	3.35 ± 0.20	3.41 ± 0.19	3.47 ± 0.24	3.30 ± 0.12
Kc	2.96 ± 0.11	2.93 ± 0.18^{ab}	2.96 ± 0.16^{ab}	3.07 ± 0.19^{a}	2.88 ± 0.10^{b}
HSI [%]	3.08 ± 0.38	2.80 ± 0.52	2.79 ± 0.40	3.03 ± 0.45	2.82 ± 0.35

V: *The average values of observed production indicators of the carp fry*

		URS/35	URS/35	MRS/40	MRS/40
Input			**22.11.2003**		
Number of fish	[pcs]	50	50	50	50
Weight	[g]	752	747	766	734
Individual weight	[g]	15.04	14.90	15.32	14.68
End of experiment			**19. 1. 2004**		
Number of fish	[pcs]	50	50	50	50
Weight	[g]	1 977	2 223	1 817	2 221
Individual weight	[g]	39.54	44.46	36.34	44.42
Surviving	[%]	100	100	100	100
Time of testing	**[days]**		**60**		
Growth	[g]	1225	1476	1051	1487
Individual growth	[g]	24.50	29.56	21.20	29.74
Daily ind. growth	[g.d^{-1}]	0.42	0.50	0.36	0.50
RGR	[%]	162.9	198.4	137.2	202.6
100%	[days]	36.22	29.74	43.00	29.12
SGR	[%.d^{-1}]	1.67	1.88	1.49	1.91
Feed consumption	[g]	2 671	2 775	2 575	2 796
FCR	-	2.18	1.88	2.45	1.88
FCE	[g]	0.46	0.53	0.41	0.53
FCR/SGR	-	1.31	1.00	1.64	0.98
PER	-	1.44	1.69	1.30	1.69

VI: *Haematological indicators of tested fish*

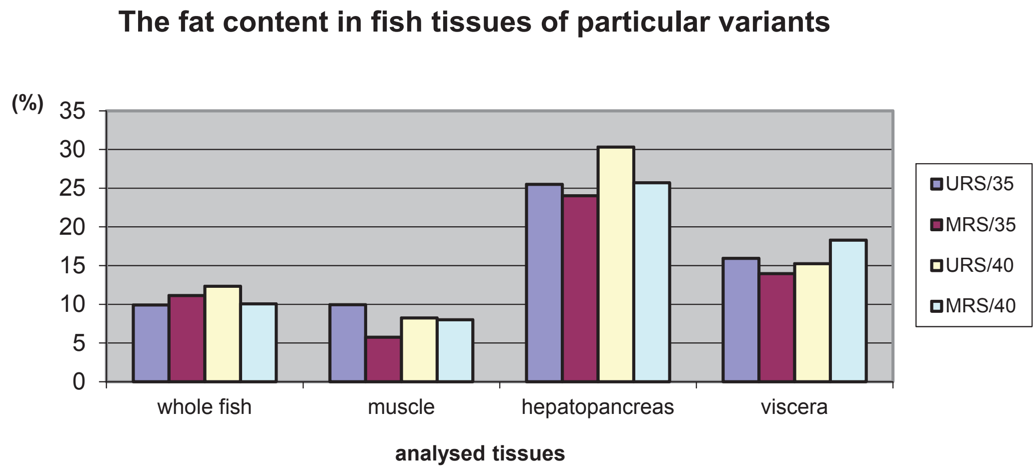
		URS 35	MRS 35	URS 40	MRS 40
Ery	[T.l^{-1}]	1.56 ± 0.12	1.48 ± 0.17	1.70 ± 0.14	1.63 ± 0.22
Leu	[G.l^{-1}]	73.17 ± 7.29	67.26 ± 13.07	61.14 ± 7.66	56.00 ± 11.26
Hc	[l.l^{-1}]	0.30 ± 0.01^{A}	0.31 ± 0.01^{A}	0.33 ± 0.02^{A}	0.38 ± 0.03^{B}
Hb	[g.l^{-1}]	84.28 ± 6.35	84.83 ± 3.69	86.59 ± 5.80	87.89 ± 2.65
MCV	[fl]	192.16 ± 20.66^{A}	210.62 ± 20.06^{AB}	195.24 ±10.91^{A}	242.76 ± 23.00^{B}
MCHC	[l.l^{-1}]	0.28 ± 0.02^{B}	0.27 ± 0.01^{B}	0.26 ± 0.01^{B}	0.23 ± 0.02^{A}
MCH	[pg]	55.22 ± 7.67	57.78 ± 5.70	51.26 ± 5.00	54.86 ± 7.47
TP	[g.l^{-1}]	26.93 ± 1.02	27.64 ± 1.60	26.50 ± 3.31	26.46 ± 1.58
Glu	[mmol.l^{-1}]	2.65 ± 0.51	3.24 ± 0.41	4.68 ± 1.35	4.09 ± 0.66
Chol	[mmol.l^{-1}]	3.43 ± 0.35	3.52 ± 0.35	3.76 ± 0.39	3.95 ± 0.38
TL	[g.l^{-1}]	9.13 ± 1.79	8.79 ± 1.33	8.93 ± 2.93	8.93 ± 1.05

Ery-Erythrocytes; Leu-Leucocyty; Hc-haematocrit; Hb-haemoglobin; MCV- mean cell volume; MCHC- mean corpuscular hemoglobin concentration; MCH- mean corpuscular hemoglobin; TP –total protein; Glu-glucose; Chol-cholesterol; TL-total lipids

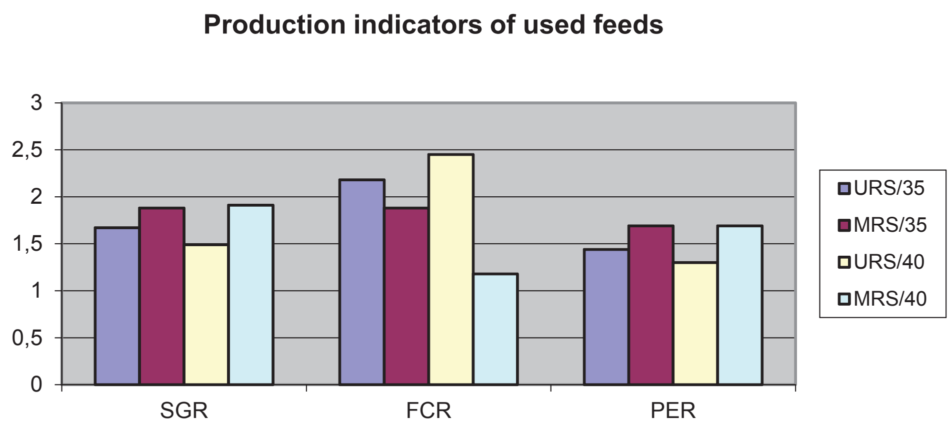
resp. 2.18 comparing with variant URS/35. On the contrary, higher incorporation of PROENERGOL into MRS/40 diet had no unfavorable impact on the reached feed conversion and FCR (both var. FCR 1.88) compared with variant MRS/35. The different content of modified stampings had no show neither at the effectiveness of feed protein using during the fish biomass growth (PER). In this case both variants reached the same value 1.69. When using unmodified stampings, the using of protein at the URS/40 feed decreased about 10%. The positive production effect reached by high rapeseed expeller presence could be influenced by the fact that rape protein was secondarily supplemented with fish-flour protein and soya protein. Haematological and biochemical indicators observed in blood plasma of tested fish (Tab. VI.) ranged at normal physiological values for common carp (SVOBODOVÁ *et al.*, 1986). There was highly significant difference ($P < 0.01$) of haematocrit value comparing to other variants figured out by the MRS/40 at the end of the test. Nevertheless, this value had not crossed over the physiological range above (SVOBODOVÁ *et al.*, 1986). The increasing of haematocrit value at

VII: *Biochemical composition of experimental fish bodies (in % of fresh mass)*

Variant	Tissue	Dry basis	NS	Fat	Ash
URS/35	The whole fish	26.08	15.32	9.90	1.85
	Muscle mass	28.42	18.13	9.96	-
	Hepatopancreas	38.04	-	25.50	-
	Viscera	30.09	-	15.93	-
MRS/35	The whole fish	27.08	14.77	11.13	1.95
	Muscle mass	24.88	17.78	5.75	-
	Hepatopancreas	37.52	-	24.02	-
	Viscera	26.34	-	13.97	-
URS/40	The whole fish	26.52	15.22	12.32	1.71
	Muscle mass	25.92	18.42	8.23	-
	Hepatopancreas	40.56	-	30.31	-
	Viscera	27.58	-	15.24	-
MRS/40	The whole fish	27.23	15.39	10.06	1.83
	Muscle mass	24.89	17.19	8.00	-
	Hepatopancreas	37.61	-	25.71	-
	Viscera	32.13	-	18.30	-



1: *The influence of used diet on the fat content in particular tissues of bred fish*



2: *Values of chosen production indicators reached by particular feed variants* the increasing number of erythrocytes statistically non significant (P = 0.23–0.94) lead to statistically significant increasing of MCV value by MRS/40 ($P < 0.05$) comparing to MRS/35, resp. ($P < 0.01$) comparing to var. URS/35 and URS/40. The MCHC value was at the var. MRS/40 showed the significant decrease ($P < 0.01$) comparing to other variants. Anyway, values of stated indicators don't cross over the physiological range (SVOBODOVÁ *et al.*, 1986). The increasing ratio of rapeseed expeller in diet had caused statistically non-significant increasing of haemoglobin content (P = 0.88, resp. 0.76) regardless of the processing (URS, resp. MRS).

There are values of biochemical indicators characterizing the influence of used diets on the tissue structure of carp fry stated in Tab.VII. Neither different ratio of stampings nor the different technological processing have influenced the protein content in the fish muscle (17.19–18.42%). The higher content of fat in unmodified stampings showed up at the variant URS/40 by the higher deposition in hepatopancreas (averagely 30.31%) comparing to var. MRS/40 (25.71%) and URS/35 (25.50%) (Fig.1). With this corresponds the values of hepatosomatic index with the highest value at unmodified stampings variant. The feed with the content of modified stampings had more ash (var. MRS/35 about 2.57% and var. MRS/40 by 3.27% of feed dry basis comparing to URS/35, resp. URS/40). This showed up by the higher content of ash in unmodified stampings fish variants.

As limiting amount of extracted rape stampings in diet for 2-years carp 28% is considered by DABROWSKI and KOZLOWSKA (1981), 24% by TRZEBIATOWSKI and FILIPIAK (1992), 32% for 2-years carp and 24% for carp fry by SADOWSKI (2005). At next cyprinid the silverfish (*Carassius auratus gibelio*) XIE *et al.* (2001) figured out the FCR 1.93 and SGR 1.78%.d^{-1} with the rape meals ratio 62.9% of feed dry basis.

The results reached in the feed experiment are indicative of possibility to use the thermally unmodified rapeseed expeller in diet for carp. As the alternative source of protein, together with suitable diet composition, unmodified stampings up to 35% of content can be incorporated in diet for fish fry and the technologically modified stampings up to 40% of content also. The higher price of modified stampings (MRS) corresponded to higher productive effect and more effective conversion of these feeds over the stated level worse the productive effect.

SUMMARY

The breeding of common carp fry was in the recirculation experimental apparatus carried out. The experiment lasted 60 days and 4 feed with different rapeseed expeller ratio, 35 and 40%, were used. Into the diet the unmodified rapeseed expeller (URS) and rapeseed expeller with technologically processed (MRS) content of glucosinolates (commercial name PROENERGOL). The diet had content 31.5% protein and 17.3 MJ BE.kg^{-1}. The initial average individual fish weight was 15g, daily feeding ration was 4%, average water temperature during the test was 23 °C. Observed parameters: basic length-weight parameters, production parameters FCR, FCE, SGR, PER, I_H (high – backedness index), I_w (broad – backedness index), Kf (Fulton's coefficient), Kc (Clark's coeficient), HIS (HepatoSomatic index).

We carried out the haematological examination and blood plasma analysis for each variant for condition assessment of inner environment at the end of observation. The highest production effectiveness showed the feed variant MRS/40. The highest feed conversion per growth (FCR 1.88), the highest SGR values (1.91%.d^{-1}) and the best results of every other production indicators were reached by this variant. On the contrary, there was MRS/40 variant assessed as the less effective using the same parameters. The fish fed by this feed reached the lowest growth in all values and also they had the lowest ability of feed conversion on growth 2.45). This proves a positive production impact of rapeseed expeller with lowered content of glucosinolates-PROENERGOL. Using the URS/40 diet, the feed conversion got worse averagely about 12.4% at FCR 2.45, resp. 2.18 compared with URS/35 variant. On the contrary, the higher incorporation of PROENERGOL in MRS/40 diet had no negative expression on fed conversion and FCR value (both var. FCR 1.88) comparing with MRS/35 variant.

Different cont of stampings had no expression nor at the effective using feed protein for fish biomass growth (PER) where both of these variants reached the same value of 1.69. The different level of rapeseed expeller in diet had not influenced neither the fish muscle mass composition nor the biochemical parameters of blood plasma. Using the unmodified stampings had decreased the using of protein at the URS/40 variant about 10%.

Acknowledgement

This study was supported by the Research plan No. MSM6215648905 "Biological and technological aspects of sustainability of controlled ecosystems and their adaptability to climate change", which is financed by the Ministry of Education, Youth and Sports of the Czech Republic and project NAZV QH 71305.

REFERENCES

ALLAN, G. L., BOOTH, M. A., 2004: Effect of extrusion processing on digestibility of peas, lupins, canola meal and soybean meal in silver perch *Bidyanus bidyanus* (Mitchell) diets. *Aquaculture Research*, 35, 10: 981–991. ISSN 1355-557X.

DABROWSKI, K., KOZLOWSKA, H., 1981: Rapeseed meal in the diet of common carp reared in heated waters. I. Growth of fish and utilization of the diet. In: *Proc. World Symp. on Aquaculture in heated effluents and recirculation systems, II, Stavanger. May 28.–30. 1980*, Berlin: Heenemann Verlagsgesellschaft, 263–274. ISBN 3-87903-055-3.

GLENCROSS, B., HAWKINS, W., CURNOW, J., 2004: Nutritional assessment of Australian canola meals. II. Evaluation of the influence of the canola oil extraction method on the protein value of canola meals fed to the red seabream (*Pagrus auratus*, Paulin). *Aquaculture Research*, 35, 1: 25–34. ISSN 1365-2109.

JIRÁSEK, J., PRAVDA, D., HAMPL, A., 1980: Efektivní metoda odběru krve pro hromadná hematologická vyšetření. *Acta Univ. Agric. Brno*, 28, 2: 175–182. ISSN 0524-7403.

KISSIL, W., LUPASCH, L., HIGGS, D. A., HARDY R. W.,(2000: Dietary substitution of soy and rapeseed protein concentrates for fishmeal, and their effect to growth and nutrient utilization in gilthead seabream *Sparus aurata* L. *Aquaculture Research*, 31, 7: 595–601. ISSN 1365-2109.

POUL, J., DVOŘÁK, R., ŠIMEK, M., MLÁDEK, Z., 2002: Možnosti využití upraveného řepkového krmiva PROENERGOL ve výživě zvířat. *Krmivářství*, 5, 5: 6–8. ISSN 1212-9992.

SADOWSKI, J., 2005: Okreslenie przydatności pasz o roznej zawartoszci poekstracyjnej sruty rzepakowej w zywieniu narybku i kroczka karpia (Cyprinus carpio L.) chowanych w wodzie pochlodniczej. In: *Rozprawy. Akademia Rolnicza w Szczecinie, (231)* Szczecin: Akademia rolnicza w Szczecinie, 1–50 p. ISSN 0585-265X

SVOBODOVÁ, Z., PRAVDA, D., PALÁČKOVÁ, J., 1986: *Jednotné metody hematologického vyšetřování ryb.* Vodňany: VÚRH, 22, 36 s.

TACON, A. G. J., JACKSON, A. J., 1985: Utilization of conventional and unconventional protein sources in practical fish feeds. In: C.B. Cowey, A.M. Mackie, J.G. Bell (eds.). *Nutrition and Feeding in Fish*. London: Academic Press, Harcourt Brace Jovanovish Publ. 119–145. ISBN 978-0121940553)

THIESSEN, D. L., MAENZ, D. D., NEWKIRK, R. W., CLASSEN, H. L., DREW, M. D., 2004: Replacement of fishmeal by canola protein concentrate in the feed to rainbow trout (*Oncorhynchus mykiss*). *Aquaculture Nutrition*, 10, 6: 379–388. ISSN 1353-5773

TRZEBIATOVSKI, R., FILIPIAK, J., 1992: Uzycie poekstrakcyjnej sruty rzepakowej w granulowannych mieszankach paszowych dla karpi K_{1-2}. *Zesz. Nauk. Academia rolnicza Wroclaw, ser. Zootechn.*, 37: 97–103. ISSN 0867–7964.

XIE, S., ZHU, X., CUI, Y., YANG, Y., 2001: Utilization of several plant proteins by gibel carp (*Carassius auratus gibelio*). *Jour. Appl. Ichtyol.*, 17, 2: 70–76, ISSN 0175-8659.

Address

Ing. Vladimír Kukačka, Ph.D., Rybářství Třeboň a. s., Rybářská 801, 379 01 Třeboň, Czech Republic, doc. Ing. Radovan Kopp, Ph.D., doc. Dr. Ing. Jan Mareš, Department of Fishery and Hydrobiology, Mendel University in Brno, Czech Republic,, Zemědělská 1, 613 00 Brno, Czech Republic, e-mail: vladimir.kukacka@email.cz, kopp@mendelu.cz, mares@mendelu.cz