www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 15: 593-600 (2015) DOI: 10.4194/1303-2712-v15_3_02

The Effects of Using Mechanically Modified Cereals on the Growth, Feed Conversion, Fat Content and Fillet Yield of Market Size Common Carp Grown in Ponds

Jan Másílko[1,*], Martin Bláha[1], David Hlaváč[1], Pavel Vejsada[1]

[1] University of South Bohemia in České Budějovice, Faculty of Fisheries and Protection of Waters, South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses, Institute of Aquaculture, Husova tř. 458/102, 370 05 České Budějovice, Czech Republic.

* Corresponding Author: Tel.:+ 420387 774 645 ;
E-mail: masilj00@frov.jcu.cz

Received 13 June 2014
Accepted 29 July 2015

Abstract

Effect of supplemental feeding with whole triticale and processed triticale on the growth, feed conversion, fat content, and fillet yield of 4-year-old carp was studied under semi-intensive pond farming conditions. The trial was conducted in 83-day-experiment in duplicate experimental ponds. Fish fed pressed or ground triticale reached significantly ($P<0.05$) higher mean individual weight gain (IWG 1.00 and 0.95 $kg.ind^{-1}$, respectively) and specific growth rate (SGR 0.70 and 0.68% d^{-1}, respectively) than that of carp fed whole triticale (IWG 0.86 $kg.ind^{-1}$ and SGR 0.61% d^{-1}). Processed filet yield with skin did not significantly differ between groups fed processed and whole triticale (44.33 and 44.78%, respectively). We found moderate positive correlation (Spearman's ρ test;r^2= 0.38) between fillet yield and correlation (r^2= 0.11) between fillet yield and standard body length. Significantly ($P<0.05$) lower mean values of IWG (0.65 $kg.ind^{-1}$), SGR (0.49% d^{-1}), fat content (4.6%), and fillet yield (41.9%) were observed in a group of fish dependent only on natural zooplankton. Common carp is able to better utilize pressed and ground triticale compared to whole triticale, which was indicated by the decreased FCR of 14.1% and 9.5%, respectively.

Keywords: *Cyprinus carpio*, fat deposition, processed cereals, triticale.

Introduction

Common carp (*Cyprinus carpio* L.) is among the most widely cultured species of freshwater fish, with a total global production of ~3.2 million tonnes in 2010 (FAO, 2012). Much of the production takes place in Central Europe, especially in the Czech Republic where pond farming of common carp is a 1000 year old tradition and an integral part of the socio-cultural milieu (Edwards, 2007). Common carp is the best choice for commercial utilization of pond resources in the temperate climate of Central and Eastern Europe (Woynarovich *et al*., 2011).

In Central Europe, including the Czech Republic, common carp is cultured in supplementary feeding-based extensive or semi-intensive ponds, considered to be an environmentally sound animal protein production (FAO, 2006; 2013). Typically, the semi-intensive ponds utilize a combination of natural food and supplementary feeding with energy-rich cereal grains such as barley, maize, rye, triticale, and wheat (Edwards, 2007). Such cereals contain high proportions of carbohydrate and often make up 35-45% of the total diet (Przybyl and Mazurkiewicz, 2004).

Common carp can utilize large amounts of carbohydrates due to high levels of amylase and maltase activity (Urbánek *et al*., 2010). However, the utilization of raw starches, which form the major constituent of cereal grains, can vary from 60 to 70% depending on the characteristics of the cereal (Hernández *et al*., 1994; Medale *et al*., 1999; Krogdahl *et al*., 2005). Higher digestibility can be obtained by subjecting cereals to pre-treatment, especially thermal-basedsuch as roasting, cooking, and expanding (Przybyl and Mazurkiewicz, 2004). However, such treatments are expensive and economically unfeasible in pond culture of common carp, which is currently experiencing static production and a negative market image (FAO, 2006-2013).

A further problem associated with use of carbohydrate-rich feed for common carp is excess fat deposition (Yamamoto *et al*., 2003), which affects its sensory qualities (Oberle *et al*., 1997) and, consequently, marketability and consumption. Common carp has an outstanding significance in freshwater aquaculture and will remain an important species in those areas where it has been traditionally farmed. Research will need to focus on, among other things, improved rearing techniques, product quality control, product diversification, and marketing (FAO, 2004; 2013).The objectives of the study were to determine the growth, condition, feed conversion, fat content, and fillet yield of common carp in semi-intensive pond culture fed supplements of processed and whole cereals.

Materials and Methods

Study Area and Experimental Ponds

The experiment was carried out from June 30 to September 20 2010 in Třeboň, Czech Republic in eight experimental ponds with depth of 1 m and an area of 309.6 ± 6.4 m^2 each. The fish were divided into four groups in duplicate ponds (triticale, grinded triticale and pressed triticale). Fish in two of the ponds were used as controls, kept only on natural zooplankton. The ponds were stocked with three-year-old Třeboň scaly common carp (Pokorný *et al*., 1995), mean weight 1271.9 ± 145.2 g at a density of 363 fish.ha^{-1}.

Feeds and Feeding

Experimental treatments consisted of triticale fed as pressed, ground and whole grain. Pressed cereals were prepared using the Himel GQ 43 (Germany), distance between a rollers 1.3 mm. Grinding used a roller grinding mill (Bühler DZFL 1500Switzerland), particle size triticale 1.3 mm).

Fish were fed supplements three times a week (Monday, Wednesday, and Friday) with the cereal placed in a concrete feeding pit from 8.00 to 9.00 at an initial rate of 2,1 % of fish average weight fish stocks biomass.day^{-1}. Supplementary feeding was divided and slightly modified according to Janeček and Přikryl (1982) during the rearing period. Feeding rates were 15 %, 35 %, 40 % and 10 % in June, July, August and September, respectively, calculated from the total amount of feed, fed during the whole experiment (Figure 1). This way of supplemental feeding is frequently used in pond aquaculture in this region. The major objective was to regulate the amount of feed to achieve an amount providing uniform energy level across all experimental groups, relative to the individual fish in the experimental ponds.

Pond Water Quality and Zooplankton

Pond water quality was measured using YSI Professional Plus (6050000, YSI Incorporated, Yellow Springs, USA). Water temperature (°C) and dissolved oxygen (mgL^{-1}) were monitored 3 times weekly from 08.00 to 08.30, and were 21.0 ± 2.7°C and 6.2 ± 1.6 mg.L^{-1}, respectively. The pH was 7.1 ± 0.4.

The zooplankton community in each experimental pond was sampled bi-weekly from the beginning of July to the beginning of September. Samples of zooplankton were taken from all ponds using a 10 L Schindler's quantitative sampler (200µm mesh). The samples were pooled and preserved with 4% formaldehyde in polyethylene tubes. Quantitative and qualitative analyses were carried out under a stereomicroscope (Olympus BX51 binocular microscope fitted with an Olympus E-510 digital camera) in a Sedwick-Rafter chamber. Mean abundance of zooplankton was 204±127 ind.L^{-1}. Cladocerans (especially *Bosmina longirostris*) were dominant throughout the experiment (83%). Copepods, represented mainly by *Thermocyclops crassus*, comprised 13% of the zooplankton community. Rotifers represented 4%.

Chemical Analyses of Feeds

Composition of the cereals was determined following standard methods (AOAC, 1984): dry matter was calculated by drying at 105°C to constant weight; crude protein (N x 6.25) by the Kjeldahl method after acid digestion; crude lipid by petrol ether extraction in a Soxtec System HT; ash by combustion in muffle furnace at 550ºC for 12 h; gross energy by micro-bomb calorimeter (Table 1).

Digestible energy (DE) in cereals was calculated according to Steffens (1989) (Table 2).

DE = 0.0168 * protein + 0.0335 * fat + 0.0147 * carbohydrate

Pond Management Parameters

Weight gain and growth (length) during the experiment was determined by weighing and measuring all fish individually at the start and at the end of the experiment.

Survival rate, Fulton'scondition factor (FC), fish weight gain, feed conversion ratio, and specific growth rate, were calculated as follows:

Survival rate [SR %] = 100 x final fish number/initial fish number.

Fulton'scondition factor

$$FC = \frac{m}{BL^3} * 100$$

where m is the body weight [g] and BL is the body length [cm].

Feed Conversion Ratio [FCR]: $= \frac{F}{(w_t - w_0)}$

where w_t is the final body weight [kg], w_o is the initial

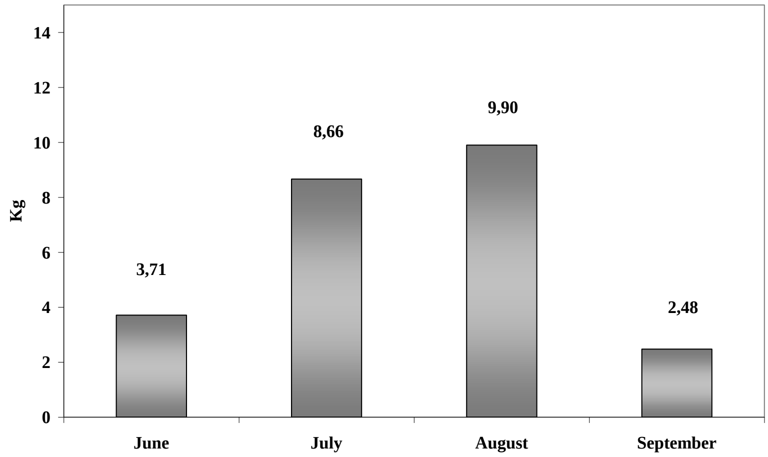

Figure 1. Feeding rations during the growing season (kg per experimetal pond).

Table 1. Supplementary diet composition

Supplement source	Dry matter ($g\ kg^{-1}$)	Protein (g)	Fat (g)	Carbohydrate (g)
Triticale pressed	869	89	15	649
Triticale ground	865	86	16	651
Triticale (whole grain)	863	87	14	655

Table 2. Digestible energy (DE) in cereals used as supplementary diet for carp

Digestible energy Food source	Triticale pressed	Triticale ground	Triticale (whole grain)
Protein DE [MJ kg^{-1}]	1.495	1.445	1.462
Fat DE [MJ kg^{-1}]	0.503	0.536	0.469
Carbohydrate [MJ kg^{-1}]	9.540	9.570	9.629
Total DE [MJ kg^{-1}]	11.538	11.551	11.559
Total cereal consumption [kg]	24.750	24.750	24.750
Total DE [MJ]	285.566	285.875	286.088
DE [MJ per carp]	25.961	25.989	26.008

body weight [kg], and F is the feed consumed [kg].

Specific Growth Rate [SGR (% d^{-1})]

$$SGR = \frac{\ln w_t - \ln w_o}{t} * 100$$

where w_t is the final body weight (kg), w_o is the initial body weight (kg), t is culture period.

Determination of Fillet Percent Age with Skin

Filleting of fish at the end of the trial was conducted by one person to ensure consistency. The trimmed fillets were immediately weighed, and the yield was calculated as percent of bodyweight according to the following formula:

Fillet percent age with skin (%) = 100 * weight fillet/final body weight

Estimation of The Fat Content of The Fish

The fat content of the fish was determined using a portable Fish Fat meter Kit FM 692 Distell (Distell, Fald house, West Lothian, Scotland) with modifications (Figure 2). The Fish Fat meter is response to measure lipid content of fish meat simply, and non-destructively. The accurancy of the Fat meter ranges from an uncertainly in the fat content between 2 and 15 % up to ± 1% (95% confidence interval).

Data Analyses

Data were subjected to one-way ANOVA followed by Duncan’s multiple range test. All data

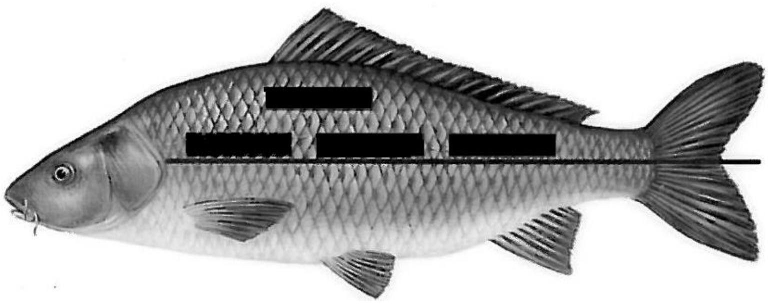

Figure 2. Dark bands indicate the position of the instrument head for measurement of fat content (according to the manufacturer's instructions).

were analysed using STATISTICA 10.0 for Windows, and Spearman's ρ test was used for the analysis of correlation between weight and fillet yield and between body length and fillet yield.

Results

The main management and production data (stocking density of fish biomass, initial and final weight, cereal consumption, and calculation of production indices) are shown in Table 3. There were no mortalities during the experiment. The highest final mean weight at the end of experiment (2.26 ± 0.22 kg) was observed in carp fed pressed triticale, but there were no significant differences in production characteristics among the supplementary fed fish groups. Mean weight of carp in the control group (1.86 ± 0.21 kg) at the end of the trial was significantly lower than the supplementary fed groups.

The highest values of individual weight gain (IWG) were recorded in the treatment with pressed (1.00 ± 0.04 kg.ind^{-1}) and ground (0.95 ± 0.01 kg.ind^{-1}) triticale. Individual weight gain in the control group (0.65 ± 0.01 kg.ind^{-1}) was significantly lower than in all other treatments. Individual weight gain in the group fed whole triticale differed significantly from both pressed and ground. The lowest mean condition factor, 3.02 ± 0.38, was observed in the control group, while the highest mean value was observed in the group fed whole triticale (3.52 ± 0.25). Lower FC values were observed in fish fed with pressed triticale and ground triticale, (3.44 ± 0.28 and 3.33 ± 0.22, respectively). The FC values differed significantly between the controls and supplementary fed groups. Differences in FC between pressed and whole grain of triticale groups were not significant, but the group supplemented with whole grain showed a significantly higher FC value compared to the ground triticale group. However values of FC in the pressed triticale group did not differ from other supplementary fed groups.

The highest FCR was observed in the group fed whole grain (2.62 ± 0.07). The FCR of this group differed significantly from the groups fed pressed and ground triticale, in which FCR was similar (2.25 ± 0.06 and 2.37 ± 0.05, respectively). Use of pressed and ground triticale decreased FCR as compared to the whole grain by approximately 14.1% and 9.5%, respectively.

The lowest final individual weight (1.86 ± 0.21 kg.ind^{-1}) and the lowest specific growth rate (SGR) were found in the control group, which was significantly different from supplementary fed groups (0.49 ± 0.01). The mean SGR recorded in groups fed pressed and ground triticale were 0.70 ± 0.02 and 0.68 ± 0.01, respectively.

Fat content was significantly higher in the pressed triticale group than in the other groups, and significantly lower in the control compared to supplemented groups. No significant differences were observed between groups of fish fed ground and whole triticale (Table 3).

Fillet yield was significantly higher (44.33-44.78% BW) in groups fed triticale compared to controls (41.96%) (Table 3). Fillet yield was positively correlated (r^2 = 0.37) with weight and positive correlation (r^2= 0.11) of fillet yield with body length was found (Figure 3).

Discussion

Management Data

The stocking density of common carp used in this experiment was based on long-term experience and traditional stocking density for semi-intensive culture of carp in the Czech Republic. This stocking density allows a sufficient level of zooplankton throughout most of the season (Urbánek *et al*., 2010).

If carps are supplemented with feed, it is very important that the used feed is suitable for common carp. Cereals can provide valuable components of nutrition in fish, as reported by Przbyl and Mazurkiewitz (2004) and Viola and Arieli (1983). Triticale (× *Tritico secale sp.* Wittmack ex A. Camus, 1927) is an anthropogenic cereal designed to incorporate the functionality and high yield of wheat (*Triticum spp*. L) and durability of rye (*Secale cereale* L) (McGoverin *et al*., 2011). This cereal has already been shown to be suitable for supplementation of common carp (Urbánek *et al*., 2010).

Most plants including cereals are characterised

Table 3. Management and production data:weight, Fulton's condition factor, fat content and filet yield (mean ± SD; n = 22)

	Triticale pressed	Triticale ground	Triticale (whole grain)	Natural food – zooplankton (control)
Pond area (m^2)	309.6 ± 6.4	309.6 ± 6.4	309.6 ± 6.4	309.6 ± 6.4
Stocking density(ind.ha^{-1})	363	363	363	363
Initial individual weight (kg)	1.26 ± 0.11^a	1.28 ± 0.13 ^{a}	1.32 ± 0.14 ^{a}	1.21 ± 0.15 ^{a}
Final individual weight (kg)	2.26 ± 0.22 ^{a}	2.23 ± 0.23 ^{a}	2.18 ± 0.24 ^{a}	1.86 ± 0.21 ^{b}
Individual weight gain (kg)	1.00 ± 0.04 ^{a}	0.95 ± 0.01 ^{a}	0.86 ± 0.03 ^{b}	0.65 ± 0.01 ^{c}
Total cereal consumption (kg)	24.75	24.75	24.75	-
Survival rate (%)	100	100	100	100
FC	3.44 ± 0.28 ^{ab}	3.33 ± 0.22 ^{b}	3.52 ± 0.25 ^{a}	3.02 ± 0.38 ^{c}
FCR	2.25 ± 0.06^a	2.37 ± 0.05^a	2.62 ± 0.07^b	-
SGR (% d^{-1})	0.70 ± 0.02 ^{a}	0.68 ± 0.01 ^{a}	0.61 ± 0.02 ^{b}	0.49 ± 0.01 ^{c}
Fat content (%)	7.23 ± 1.22 ^{a}	6.44 ± 1.29 ^{b}	6.45 ± 1.33 ^{b}	4.6 ± 0.51 ^{c}
Fillet yield (%)	44.45 ± 0.95 ^{a}	44.33 ± 1.48 ^{a}	44.78 ± 1.22 ^{a}	41.9 ± 0.47 ^{b}

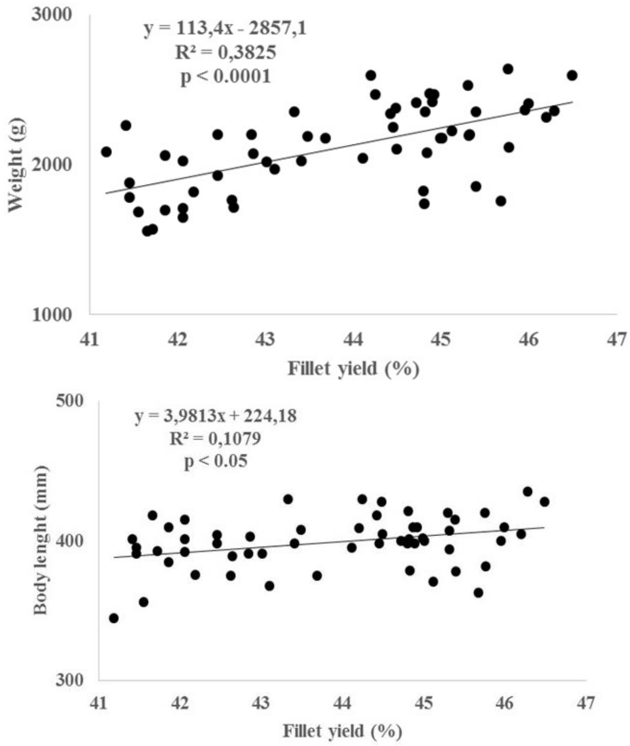

Figure 3. Fillet yield of investigated carps against weight and body length (n = 56).

by having the majority of their phosphorus bound in phytate (Ca-Mg salt of phytic acid). The bioavailability of phosphorus in phytate is limited to most fish because they lack the digestive enzyme phytase. One way to counteract this, is the inclusion of microbial phytase in the feed to increase phytic phosphorus bioavailability (Rodehutscord and Pfeffer, 1995; Oliva-Teles *et al*., 1998). This may have additional benefits by reducing the risk of phytate binding to essential minerals, and it also alleviates any potentially negative effects of phytate on digestive enzyme function. Besides, as some antinutritional factors (ANFs) are present in seed hulls, a treatment like dehulling, pressing or grinding of the cereals prior to use as fish feeds will reduce ANF to levels where they may have only minor negative effects on feed intake, nutrient utilization and growth (Robiana *et al*., 1995; Burel *et al*., 1998; Refstie *et al*., 1998; Glencross *et al*., 2007).Our results might be partially due to these effects.

Results of the present trial show that the mechanically processed triticale was associated with significantly higher IWG and SGR than found in common carp fed whole cereals or zooplankton only. This is contradicting to Przbyl and Mazurkiewitz (2004) and Przbyl *et al*. (1994) who found a high effectiveness of feed containing processed triticale in the intensive production of carp in ponds (initial weight 200 g ± 10 g), but no significant differences in weight gain, SGR, or FCR in fish fed diets of different cereal grains. Which is in contrast with our study.

Zajic *et al*. (2013) found FC values of 3.3-3.7 for 4-year-old common carp, and concluded that carp supplemented with cereal or rapeseed/linseed pellets had higher FC than carp on a natural diet. Our results support this interpretation. Bauer and Schlott (2009) found that Fulton condition factor (FC) as an indicator of fish condition for healthy well-fed carp was in the range of 1.9-2.2, but they used total body length (TL) for the calculation, while we used standard body length (BL). The difference is that TL refers to the length from the tip of the snout to the tip of the longer lobe of caudal fin while BL refers to the length of a fish measured from the tip of the snout to the posterior end of the last vertebra. After recalculation our values were comparable to those calculated from Bauer and Schlott (2009). Also when compared to other studies (Gela *et al*., 2003; Urbánek *et al*., 2010) using BL for calculation of FC, ourvalues are similar (3.2-3.7 and 2.9-3.7, respectively). Urbánek *et al*. (2010) used the same carp breed (Třeboň scaly common carp) whereas Gela *et al*. (2003) used four different common carp crossbreeds.

Fat Content

Final fat content of the fish can vary according to the cereal used and the amount of feed supplemented. In general, diets supplemented with cereal produce higher fat content in fish flesh compared to that in fish dependent only on natural food (zooplankton and zoobenthos) (Steffens, 1985; Urbánek *et al*., 2010; Zajic *et al*., 2013). Since cereals have a high proportion of carbohydrates as a primary source of energy (Sadowsky and Trzebiatowsky, 1995; Sargent *et al*., 2002), their oversupply results in higher deposition of fat (Yamamoto *et al*., 2003). Thus it is important to accurately calculate the amount of daily feed to ensure optimal fat content in carp flesh. Although better utilization of pressed cereals led to higher fat content in our study, the mean value was not above 10%. This is a critical value, as 10% fat content or higher has shown to adversely affect sensory properties of the flesh (Oberle, 1995; Oberle *et al*., 1997; Stein, 2005) and thus needs to be considerated from the consumers' perspective. We found a fat content in a similar range compared to other trials using cereals (Table 3) as for example 6.4 and 6.9% for barley (Pfeifer and Füllner, 2005; Bauer and Schlott, 2009), 9.4 and 7.5% for rye (Pfeifer and Füllner, 2005; Oberle *et al*., 1997, respectively). However in a study with carp fed maize higher fat content values of 13.3% have been reported (Urbánek *et al*., 2010). The fat content in fish could have been higher due to higher fat content and carbohydrates in dry matter in maize than in triticale (Urbánek *et al*., 2010). Reports of fat content in carp only on zooplankton vary from 1.2 to 4.6% (Pfeifer and Füllner, 2005; Oberle *et al*., 1997; Zajic *et al*., 2013), which are also in line with our findings.

Besides to diet, fillet fat content is associated with the pond management strategy. In the studies of Bauer and Schlott (2009) and Urbánek *et al*. (2010), ponds differed in size (6.0 -57.5 ha and 1.7- 2.8 ha, respectively) and different stocking densities were used (157-241 kg.ha^{-1}). Urbánek *et al*. (2010) used carp stocking density from 379 kg.ha^{-1} to 398 kg.ha^{-1}. We used smaller ponds in order to be able to better maintain consistent conditions among experimental groups. Kocour *et al*. (2007) found also a high heritability (> 0.5) for percent fillet fat in common carp, which presents interesting prospects for selective breeding, but a strong influence of pond management and the diet remains (Fauconneau *et al*., 1995; Anderson and De Silva, 2003).

Fillet Yield

Fillet yield of market-size common carp from European countries usually varies from 34.0 to 41.1% of BW for fillet with skin (Cibert *et al*., 1999; Kocour *et al*., 2007; Bauer and Schlott, 2009) and from 31.4 to 38.7% for skinless fillets (Oberle *et al*., 1997; Gela *et al*., 2003; Kocour *et al*., 2007). We observed higher mean fillet yield in fish fed processed and whole triticale, complementing the other favourable characteristics (FC, FCR, IWG). Compared to our results, Bauer and Schlot (2009) found lower values (34 – 35.4%). This may be related to the different carp breed used or the high variation in weight of analysed carp, which is associated with maintenance during the rearing period (Bauer and Schlott, 2009). In the present study, a positive correlation between fillet yield and body weight was observed and between fillet yield and body length. This is in agreement with Kocour *et al*. (2007) who reported a similar correlation (r^2 = 0.43) between body weight and fillet yield. These authors also found a correlation (r^2 = 0.46) between fillet yield and body length which confirm our results Bauer and Schlott (2009) and Cibert *et al*. (1999) reported neither a correlation between fillet yield and weight (r^2 = -0.16 and 0.06, respectively) no between fillet yield and total length (r^2 = -0.19). Also Cibert *et al*. (1999) reported carp with a wide range of weight (790-2310 g) resulting in a wide range of fillet yield (27.8-41.9%).

Conclusion

Based on our results, it may be concluded that common carp are able to better utilize technologically processed cereals, especially pressed and/or ground triticale, compared to whole seeds and thus reach the same or higher individual weight gain and a higher fat content as carp subsisting on natural feed or whole seeds with lower FCR.

Acknowledgements

The study was financially supported by the Ministry of Education, Youth and Sports of the Czech Republic-projects CENAKVA" (No. CZ.1.05/2.1.00/01.0024, "CENAKVA II" (No. LO1205 under the NPU I program) and by the Grant Agency of the University of South Bohemia in České Budějovice (No. 074/2013/Z). We would like to thank especially Rybářství Třeboň a.s. for their material and personal support and Dr. Sabine Samples for English correction and help.

References

Anderson, T. and De Silva, S. 2003. Nutrition.In:Lucas J.S., Southage P.C. (Eds.), Aquaculture: Farming Aquatic Animals and Plants. Blackwell Publishing, Oxford, UK. Pages 146-171.

Bauer, C. and Schlott, G. 2009. Fillet yield and fat content in common carp (*Cyprinus carpio*) produced in three Austrian carp farms with different culture methodologies. Journal of Applied Ichthyology, 25: 591-594. doi:10.1111/j.1439-0426.2009.01282.x

Burel, C., Boujard, T., Corraze, G., Kaushik, S.J., Boeuf, G., Mol, K.A., Van der Geyten, S. and Kuhn, E.R. 1998. Incorporation of high levels of extruded lupin in diets for rainbow trout (*Oncorhynchus mykiss*): nutritional value and effect on thyroid status. Aquaculture,163: 325-345. doi: 10.1016/S0044-8486(98)00241-5

Cibert, C., Fermon, Y., Vallod, D. and Meunier, F.J. 1999. Morphological screening of common carp *Cyprius carpio*: relationship between morphology and fillet yield. Aquatic Living Resources, 12: 1-10. doi: 10.1016/S0990-7440(99)80009-6

Edwards, P. 2007. Pilgrimage to traditional carp pond culture in Central Europe. Aquaculture Asia, 12(4): 28-34.ISSN 0859-600X .

FAO (Food and Agriculture Organisation of the United Nations) 2012. The State of World Fisheries and Aquaculture. FAO, Rome, Italy.

FAO (Food and Agriculture Organisation of the United Nations) 2004-2013. Cultured Aquatic Species Information Programme. *Cyprinus carpio*. Cultured Aquatic Species Information Programme inFAO Fisheries and Aquaculture Department (online), available from www.fao.org/fishery/culturedspecies/Cyprinus_carpio/en (accessed January 1, 2004).

FAO (Food and Agriculture Organisation of the United Nations) 2006-2013. National Aquaculture Sector Overview. Czech Republic. National Aquaculture Sector Overview Fact Sheets. In: FAO Fisheries and Aquaculture Department (online), available fromwww.fao.org/fishery/countrysector/naso_czechrepublic/en (accessed May 1, 2005).

Fauconneau, B., Alami-Durante, H., Laroche, M., Marcel, J. and Vallot, D. 1995. Growth and meat quality relations in carp. Aquaculture, 129: 265-297. doi:10.1016/0044-8486(94)00309-C

Gela, D., Rodina, M. and Linhart, O. 2003. Top-crossing with evaluation of slaughtering value in common carp (*Cyprinus carpio* L.) offspring. Aquaculture International,11**:** 379-387. doi: 10.1023/A:1025721723369

Glencross, B.D., Booth, M. and Allan, G.L. 2007. A feed is only as good as its ingredients – a review of ingredient evaluation strategies for aquaculture feeds. Aquaculture Nutrition, 13: 17-34. doi: 10.1111/j.1365-2095.2007.00450.x

Hernández, M., Takeuchi, T. and Watanabe, T. 1994. Effect of gelatinized corn meal as a carbohydrate source on growth performance, intestinal evacuation and starch digestion in common carp. Fisheries Science, 60: 579–582. doi: 10.2331/fishsci.60.579

Janeček, V. and Přikryl, I. 1982. The fish culture of fish stock and marketable of carps in intensification ponds. Chovnásadových a tržníchkaprův intenzifikačníchrybnících. Edicemetodik VURH, Vodňany, č.38, 16 s.

Kocour, M., Mauger, S., Rodina, M., Gela, D., Linhart, O. and Vandeputte, M. 2007. Heritability estimates for processing and quality traits in common carp (*Cyprinus carpio* L.) using a molecular pedigree. Aquaculture, 270: 43-50. doi: 10.1016/j.aquaculture.2007.03.001

Krogdahl, Å., Hemre, G-I. and Mommsen, T.P. 2005. Carbohydrates in fish nutrition: digestion and absorption in post larval stages. Aquaculture Nutrition,11: 103-122. doi: 10.1111/j.1365-2095.2004.00327.x

Mazurkiewicz, J. and Przybyl, A. 2003. Comparison of nutritional usability of cereals as carbohydrate component of extruded feeds for common carp (*Cyprinus carpio* L.) fry. Acta Scientarium Polonorum Piscaria, 2(1): 195–206.

McGoverin, C.M., Snyders, F., Muller, N., Botes, W., Fox, G. and Manley, M. 2011. A review of triticale uses and the effect of growth environment on grain quality. Journal of the Science of Food and Agriculture, 91(7):1155-1165. doi: 10.1002/jsfa.4338

Medale, F., Poli, J.M., Vallee, F. and Blanc, D. 1999. Utilisation of a carbohydrate-rich diet by common carp reared at 18 and 25°C. Cybium, 23(1): 139-152.

Oberle, M. 1995. Einfluss von Futterungsmasnahmen auf Fettgehalt und Fettsauremuster und deren Auswirkungen auf die Schlachtkorper und Fleischqualität von Karpfen (*Cyprinus carpio* L.). PhD thesis.(In German).

Oberle, M., Schwarz, F.J. and Kirchgessner, M. 1997. Wachstum und schlachtkorperqualitat von karpfen *(Cyprinus carpio L.)* bei verfütterung von verschiedenen getreidearten, lupinen oder zooplankton. Archiv für Tierernaehrung,50(1): 75-85. doi: 10.1080/17450399709386120

Oliva-Teles, A., Pereira, J.P., Gouveia, A. and Gomes, E. 1998. Utilisation of diets supplemented with microbial phytase by seabass (*Dicentrarchus labrax*) juveniles. Aquatic Living Resources, 11: 255-259. doi: 10.1016/S0990-7440(98)80008-9

Pfeifer, M. and Füllner, G. 2005. Einfluss der Fütterung untershiedlicher pflanzlicher Futtermittel auf die Produktqualität von Speisekarpfen. [In German], Infodienst 07/2005, Freistaat Sachsen, Sächsische Landesanstalt für Landwirschaft, 55-66.

Przybyl, A., Madziar, M. and Tarlowski, I. 1994. Assesment of the suitability of triticale in the extruded feed for table carp. Archiwum Rybactwa Polskiego, 2:103-112.

Przybyl, A. and Mazurkiewicz, J. 2004. Nutritive value of cereals in feeds for common carp (*Cyprinus carpio*

L.). Czech Journal of Animal Science, 49(7):307-314.

Refstie, S., Storebakken, T. and Roem, A.J. 1998. Feed consumption and conversion in Atlantic salmon (*Salmo salar*) fed diets with fish meal, extracted soybean meal or soybean meal with reduced content of oligosaccharides, trypsin inhibitors, lectins and soya antigens. Aquaculture, 162: 301-312. doi: 10.1016/S0044-8486(98)00222-1

Robiana, L., Izquierdo, M.S., Moyano, F.J., Socorro, J., Vergara, J.M., Montero, D. and Fernandez Palacios, H. 1995. Soybean and lupin seed meals as protein sources in diets for gilthead seabream (*Sparus aurata*): Nutritional and histological implications. Aquaculture,130: 219-233. doi:10.1016/0044-8486(94)00225-D

Rodehutscord, M. and Pfeffer, E. 1995. Effect of supplemental microbial phytase on phosphorus digestibility and utilization in rainbow trout (*Oncorhynchus mykiss*). Water Science and Technology, 31: 143-147. doi:10.1016/0273-1223(95)00433-N ;

Sadowski, J. and Trzebiatowski, R., 1995. Fish feeds. Pasze Polskie 1/2, 110-118. (In Polish)

Sargent, J.R., Tocher, R. and Bell, J.G. 2002. The lipids. In Halver J.E., Hardy R.W. (Eds.), Fish Nutrition, Academic Press, London, UK, 181-257.

Steffens,W.1985. Grundlagen der Fischernährung. VEB Gustav fisher Verlag, Jena, , Germany, 226 pp.

Steffens, W. 1989. Principles of Fish Nutrition. Halsted Press, New York, USA, 384 pp.

Stein, L.H. 2005. The effects of stress and storage temperature on the colour and texture of pre-rigor filleted farmed cod (*Gadus morhua* L.). Aquaculture Research, 36: 1197-1206. doi: 10.1111/j.1365-2109.2005.01339.x

Urbánek, M., Hartvich, P., Vácha, F. and Rost, M. 2010. Investigation of fat content in market common carp (*Cyprinus carpio*) flesh during the growing season. Aquaculture. Nutrition, 16: 511-519. doi: 10.1111/j.1365-2095.2009.00690.x

Viola, S. and Arieli, Y. 1983. Evaluation of different grains as basic ingredients in complete feeds for carp and tilapia in intensive culture. Bamidgeh, 35: 38-42.

Woynarovich, A., Bueno, P.B., Altan, Ö., Jeney, Z., Reantaso, M., Xinhua, Y. and Van Anrooy, R.2011. Better Management Practices for Carp Production in Central and Eastern Europe, the Caucasus and Central Asia. FAO Fisheries and Aquaculture Technical Paper No. 566. Ankara, Turkey

Yamamoto, T., Shima, T., Furuita, H. and Suzuki, N. 2003. Effect of water temperature and short-term fasting on macronutrient self-selection by common carp (*Cyprinus carpio*). Aquaculture, 220: 655-660. doi: 10.1016/S0044-8486(02)00541-0

Zajic, T., Mraz, J., Samples, S. and Pickova, J. 2013. Fillet quality as a result of purging of common carp (*Cyprinus carpio* L.) with special regard to weight loss and lipid profile. Aquaculture, 400-401: 111-119. doi: 10.1016/j.aquaculture.2013.03.004