Potravinarstvo® Scientific Journal for Food Industry

Potravinarstvo, vol. 9, 2015, no. 1, p. 263-267
doi:10.5219/477
Received: 25 March 2015. Accepted: 17 April 2015.
Available online: 1 August 2015 at www.potravinarstvo.com

ISSN 1337-0960 (online)

THE EFFECT OF FEEDING WHEAT WITH PURPLE PERICARP ON THE GROWTH OF CARP

Jan Mareš, Tomáš Brabec, Tomáš Vyhnánek, Václav Trojan, Klára Štiasna, Mária Presinszká, Eva Mrkvicová, Luděk Hřivna, Ladislav Havel

ABSTRACT

This study assessed and compared the influence of feeding wheat with purple pericarp (variety Konini) and standard coloured wheat (red variety Bohemia) on the growth characteristics of fingerling carp (*Cyprinus carpio* L.) of the "Amurský lysec" line. The total content of anthocyanins converted to cyanidin 3-glucoside in the control Bohemia wheat was 24.95 $mg.kg^{-1}$ and in the Konini purple wheat 41.70 $mg.kg^{-1}$. Two experimental variants for feed were evaluated: dipped wheat grain and crushed wheat grain. The feed dose for wheat was 1.5% of the fish stock weight and for natural food (frozen Chironomid larvae) was 0.2% of fish stock weight to all variants. Growth parameters (body length, body weight, Fulton's condition factor and feed conversion ratio) of the fish were evaluated after one month of administration. The feed consumption and physico-chemical parameters (temperature, oxygen saturation, pH, N-NH4 +, $N\text{-}NO_2^-$, $N\text{-}NO_3^-$ and Cl^-) of the environment were observed. During the feeding test, no major differences in food consumption among variations feeding on either wheat and on Chironomid larvae were noted. Satisfying results for mas and length gain were achieved in V2 wheat with purple pericarp (Konini variety – dipped grain), where the average total body length was 156.56 mm and the average unit mass was 60.81 g. In this variant, higher values of the parameters were achieved compared to the control group (100.6%, resp. 104.2%). A positive impact of wheat with purple pericarp on the evaluated parameter of fish condition factor was demonstrated. This trend was confirmed in all variants. No effect was demonstrated for mechanical disruption of kernels on the level of utilization of nutrients. In further experiments on growth characteristics we would like to determine antioxidant parameters in the blood and liver of fry.

Keywords: purple pericarp of wheat; carp; growth; feeding test

INTRODUCTION

Wheat grain is considered a good source of fibre, phenols, tocopherols and carotenoids. Anthocyanins are another group of bioactive agents contained in blue and purple wheat grains. It is well known that herbal anthocyanins play a role as antioxidants and they also have antibacterial and anti-carcinogenic effects **(Varga et al., 2013)**. In addition to white and red grains, wheat with a purple colour can occur. The purple colour of the grain is caused by anthocyanins in the pericarp. Purple grains occur mainly in tetraploid wheats from Ethiopia, and one kind of bread wheat is known from China **(Zeven, 1991)**.

The first testing of the feeding value of some cultivars of purple wheat with broilers was carried on in 1976 by **Gregoire et al. (1976)**. However, the cultivation process has advanced for wheat since then. The higher antioxidation effect could lead to a reduction in the oxidation of fats in food derived from animals fed on coloured wheat. Effect of feeding purple wheat on quality in hens was studied by **Ruckschloss et al. (2010)**. The result was a higher average body weight of hens fed with purple wheat (up to 6.22% comparing to the control group). On the contrary, **Šťastník et al. (2014)** found no statistically significant effect on the weight of broilers' performance and carcass parameters when fed with purple wheat. Increased antioxidant capacity of the liver in rats fed with purple wheat was described by **Karásek et al. (2014).** No similar study of the effect of feeding coloured wheat to fish has yet been realized.

The common carp *Cyprinus carpio* (L.), is the most frequently raised fish species in Central and Eastern Europe, with production levels reaching more than 80% of total fish production in some countries, including the Czech Republic **(Adámek et al. 2012)**. The species is commonly reared in earth ponds using extensive and semi-extensive management regimes, thereby allowing the use of natural resources for growth and development **(Adámek et al. 2012)**. Fish production in the Czech Republic is based on the principle of maximum utilisation of the full nutrient source in the form of natural food to promote growth but on the other hand to minimize energy conversion losses. For this reason cereals play an important role in carp production, as they are inexpensive and a rich source of energy. Nutritionally, cereals cannot be considered a fully-fledged food, because they contain a low amount of protein which is poor in essential amino acids (lysine and methionine) without which the synthesis of body tissues cannot occur. Therefore, increasing carp production is limited due to the availability of natural food **(Hůda, 2009; Przybyl and Mazurkiewicz, 2004)**. For additional carp feeding all sorts of cereals can be used, but which is the most valuable is still in question **(Hůda, 2009)**. According to **Przybyl and Mazurkiewicz, (2004)** wheat has the highest nutritional values of cereals for carp protein, followed by rye – triticale – barley. Wheat is the primary source of energy due to the high starch content of about 70% of the dry mass **(Heuzé et al. 2013)**. The starch digestibility of the whole grains is around 70% in carp **(Ćirković et al. 2002)**. Technological treatment of cereals can increase the production efficiency of the feed. Heat treatment of the kernels can increase the starch digestibility to 90% **(Przybyl and Mazurkiewicz 2004)**. Additional feeding with cereals in the absence of natural food for the carp causes an increase in visceral fat content and fat in muscle tissue. The feed intake and metabolism of carp is affected by many biotic and abiotic factors. Aside from age and pedigree the content of dissolved oxygen and water temperature also have an influence. Water temperature affects the activity of digestive enzymes in carp fry. At water temperature of 22 – 28 °C activity of α-amylase is higher than above that range.

The aim of this study was to evaluate the growth characteristics of carp fingerlings fed on purple wheat (Konini variety).

MATERIAL AND METHODOLOGY

Common carp (*Cyprinus carpio L.*) fingerlings of the "Amurský lysec" line (Figure 1) from Rybníkářství Pohořelice Inc., in the Czech Republic, were used for the feeding test. Fish were placed in 200 L glass tanks, 50 fish per tank (100 fish per variant) (Figure 2). The rearing tanks were connected to a recirculation system with mechanical and biological phases of water treatment. Tanks were sorted into four groups, each with two replicates: V1 dipped standard wheat – control, V2 dipped wheat with purple pericarp, V3 crushed standard wheat – control, V4 crushed wheat with purple pericarp. The Feed dose for wheat was 1.5% of fish stock weight and for natural food (frozen Chironomid larvae) was 0.2% of fish stock weight for all variants. The whole grain wheat was weighed out dry and subsequently dipped for 14-16 hours. A table grinder was used to grind the wheat. The grinding process was set to maximum graininess for mechanical disruption of each grain. Such prepared wheat was not further dipped. The feeding strategy was set at three feeds per day during the light period at 8am, 1pm and 6pm. Both forms of prepared wheat were divided into two sub-parts and administered to fish at 8am and 1pm. Natural food was administered at 6pm. The light regime was set as 13 hours light and 11 hours dark. Fish were weighed in groups once a week for modification of the feeding dose. The total content of anthocyanins converted to cyanidin 3-glucoside in the control Bohemia red wheat was 24.95 $mg.kg^{-1}$ and in Konini purple wheat 41.70 $mg.kg^{-1}$ (Figure 3). The Konini variety (pedigree: Fortuna/Arawa//Kopara/Purple-Hilgendorf) was grown for research purposes in Brno-Tuřany. Seeds of genetic resources were obtained from Agrotest fyto Ltd. Kroměříž (Ing. Petr Martinek, CSc).

The basic physicochemical parameters of the water were measured twice per day during the test. Samples of water for chemical analysis were taken once per day. The range of values is given in Table 1.

Parameters such as Fulton's condition factor (FC) and the

Figure 1 Common carp – the "Amurský lysec" line.

Figure 2 Glass tanks.

Figure 3 Comparison of Bohemia (left) and Konini (right) grain varieties.

feed conversion ratio (FCR) were calculated as follows: $FC = (w/TL^3)*100$, where w is the body weight (g) and TL is the total body length (cm); $FCR = F/(w_t – w_0)$, where w_t is the final body weight (g), w_0 is the initial weight (g), and F is the feed consumption (g). The values obtained were compared using ANOVA at p <0.05.

RESULTS AND DISCUSSION

During the feeding test, no major differences in food consumption among variations fed each of the wheats and the Chironomid larvae were noted (Table 2).

Conversely, differences in growth parameters, i. e. length and weight of individual fish between the feeding variants were found (Table 3).

Differences in basic growth characteristics in both variants can be explained by the method applied to kernels. Satisfactory results in the growth characteristics of carp were achieved in V2 (Table 3) at a FCR (Food Conversion Ratio) value of 11.15. The bioavailability of nutrients from kernels the structure of which was treated with water before administration increased in comparison with mechanical disruption of the grain. This is demonstrated by the relatively high value of FCR in the V4 variant (70.54).

Table 1 The range of values of basic physico-chemical parameters during the feeding test.

Parameter	Average	Min.	Max.
Temperature (^oC)	24.34	23.4	25.2
Oxygen saturation (%)	81.74	64.4	90.0
pH	7.13	5.71	7.82
$N\text{-}NH_4^+$ ($mg.L^{-1}$)	1.31	0.0	7.5
$N\text{-}NO_2^-$ ($mg.L^{-1}$)	0.19	0.06	0.61
$N\text{-}NO_3^-$ ($mg.L^{-1}$)	61.01	44.37	89.80
Cl^- ($mg.L^{-1}$)	55.28	44.86	64.64

Table 2 Feed consumption during the feeding test.

	Wheat (g)	Chironomids larvae (g)
V1	2828.3	433.0
V2	2904.7	436.1
V3	2827.0	428.3
V4	2786.8	421.3

V1 – Bohemia (dipped), V2 – Konini (dipped), V3 – Bohemia (crushed), V4 – Konini (crushed)

Table 3 The average values of the basic growth characteristics of fish.

	Total body leght (mm) ±SD	Weight (g) ±SD	Fulton's condition factor ±SD
Begining of the test	151.80 ±11.30	56.75 ±13.36	3.15 ±0.19
v_x	7.44%	23.54%	6.15%
End of the test			
V1	155.64 ±25.23	58.34 ±22.72	3.05 ±0.47
v_x	16.21%	38.95%	15.98%
V2	156.56 ±12.78	60.81 ±13.58	3.17 ±0.30
v_x	8.16%	22.33%	9.57%
V3	155.87 ±10.27	58.81 ±10.93	3.17 ±0.32
v_x	6.59%	18.58%	10.24%
V4	153.47 ±13.07	57.91 ±11.52	3.23 ±0.35
v_x	8.52%	19,89%	10.72%

V1 – Bohemia (dipped), V2 – Konini (dipped), V3 – Bohemia (crushed), V4 – Konini (crushed)

Table 4 Composition of whole fish (carp given in (%).

	Dry matter ±SD	Fat ±SD	Protein ±SD
V1	31 ±0.74	13.03 ±0.96	14.77 ±0.51
Vx	0.02%	0.07%	0.03%
V2	31.53 ±1.31	13.32 ±1.04	15.18 ±0.54
Vx	4.15%	7.83%	3.58%
V3	34.43 ±2.71	14.73 ±2.25	15.93 ±1.31
Vx	7.88%	15.27%	8.24%
V4	30.54 ±1.77	11.96 ±1.94	15.27 ±0.59
Vx	5.81%	16.22%	3.88%

Values are given as a fresh matter. SD – standard deviation, v_x – coefficient of variation, V1 – Bohemia (dipped), V2 – Konini (dipped), V3 – Bohemia (crushed), V4 – Konini (crushed)

The values of production parameters are influenced by the quality of diet. Under controlled conditions without the presence of natural food we used a complete feed mixture for the type and age category of the farmed fish. When testing the cereal in recirculating systems used to treat water and natural food in the form of frozen Chironomids at a dose of 0.2 to 0.5%. A higher proportion negatively affects the intake of the tested cereals. To improve digestibility of the feed given different methods are used to improve the availability of nutrients. One is crushing (squeezing) the kernels or dipping. As is apparent from the results the values of the monitored parameters are influenced by the treatment of the kernels (Tables 3 and 4). Relative feeding coefficient values of cereals (in pond conditions with natural food available) generally range between 2 to 5. The value is influenced in part by environmental conditions feed quality and proportion of natural food. **Másilko et al. (2014)** gave FCR test values ranging from 2.08 to 2.50 with depending on the cereals used and method of treatment. A decline in the share of natural food leads to an increase in FCR values to greater than 10.

In Table 4 the chemical composition of whole fish are presented. Technological dipping treatment did not affect the chemical composition of whole fish in variants V1 and V2. Differences in composition were observed in technological treatment with homogenization, when in variant V3 (control) higher values were achieved in all monitored indicators in comparison with V4 and throughout the test. **Hůda (2009)** obtained in pond conditions similar results for fat content 13.27 ±0.36% in the muscle of carp fed with corn supplements to our variants V1 and V2, where in wheat values the fat content was 11.21 ±0.31% and so nearest to variant V4. The food (cereals) used significantly affects the composition of tissues produced in carp, especially the fat content and its composition **(Urbánek et al. 2010)**.

Adult carp are an omnivorous species utilizing a relatively high proportion of animal prey in its diet, mainly chironomids and other benthic invertebrates **(Anton-Pardo et al. 2014)**. Carp as an omnivorous species has a high level of amylase activity in the digestive tract in comparison with piscivores. The production efficiency of wheat feed can be improved by increasing the bioavailability of nutrients from the kernels. The production efficiency of cereal feed processed in different ways was studied by **Másilko et al. (2014)** who observed the growth of carp fed with different kinds of cereal in fishponds. The highest individual weight was discovered in carp fed technologically unprepared rye, while the lowest individual weight was discovered in the pressed wheat and oilseed variant. Not only the means of technological modification of kernels but also the kind or a variety can possibly affect the utilization of nutrients in carp. For the purposes of the elimination of differences between group trends, further observations are necessary. The positive impact of coloured wheat on the value of the evaluation parameter of fish condition factor (FC) was demonstrated (Table 3). The method of treating wheat (crushing x dipping) may affect the achieved output parameters, as is evident from the data in Table 3 and the composition of the tissues (Table 4). However, the difference observed was not statistically significant.

CONCLUSION

In this work it was found that inclusion of wheat with purple pericarp (Konini) in feed can influence the growth parameters of the fish. These were mainly the weight of the fish, and this change was reflected in changes in Fulton's condition factor. Within further experiments with growth characteristics we would like to establish the determination of antioxidant parameters in the blood and liver of fry, but these experiments are more financially demanding.

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Acknowledgments:

We would like to thank Ing. Petr Martinek, CSc. for experimental material. This work was supported by grant IGA FA MENDELU No. TP 4/2015.

Contact address:

Jan Mareš, Mendel University in Brno, Faculty of Agronomy, Department of Zoology, Fischeries, Hydrobiology and Apiculture, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: jan.mares@mendelu.cz.

Tomáš Brabec, Mendel University in Brno, Faculty of Agronomy, Department of Zoology, Fischeries, Hydrobiology and Apiculture, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: tomas.brabec@mendelu.cz.

Tomáš Vyhnánek, Mendel University in Brno, Faculty of Agronomy, Department of Plant Biology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: tomas.vyhnanek@mendelu.cz.

Václav Trojan, Mendel University in Brno, Faculty of Agronomy, Department of Biology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: vaclav.trojan@mendelu.cz.

Klára Štiasna, Mendel University in Brno, Faculty of Agronomy, Department of Biology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: stiasna.k@gmail.com.

Mária Presinszká, Mendel University in Brno, Faculty of Agronomy, Department of Biology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: m.presinszka@gmail.com.

Eva Mrkvicová, Mendel University in Brno, Faculty of Agronomy, Department of Animal Nutrition and Forage Production, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: eva.mrkvicova@mendelu.cz.

Luděk Hřivna, Mendel University in Brno, Faculty of Agronomy, Department of Food Technology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: ludek.hrivna@mendelu.cz.

Ladislav Havel, Mendel University in Brno, Faculty of Agronomy, Department of Biology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: ladislav.havel@mendelu.cz.