Szent István University

THE IMPACT OF DIET ON FATTY ACID PROFILE AND MEAT QUALITY OF COMMON CARP

Thesis of Ph.D. dissertation

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1. PRELIMINARIES AND OBJECTIVES

Impact assessment of European Commission has shown that average consumption of fish and aquaculture products is 22 kg per capita which covers the human protein intake of 15%. The consumption varies widely from country to country, ranging from 5 kg to 30 kg per year (EURÓPAI BIZOTTSÁG 2011). In Hungary, to calculate with total resident population (9.958 million) in 2011, our consumption of fish was 3.99 kg / capita / year (JÁMBORNÉ and BARDÓCZ 2012).

Unfortunately, the population of Hungary is unhealthy dining nations headed. It is caused by poor diet foods improperly chosen, and their misuse.

The first Hungarian Representative Nutritional Assessment (1985-1998) found that the main features of the Hungarian population dietary habits are high energy, fat, and low consumption of polysaccharide (ANTAL 2000).

In contrast, 70% out of those consumers who fed consciously and healthily consume regularly fish. The fish oil contains greater amounts of polyunsaturated fatty acids (n-3 fatty acids), which are physiologically extremely important and essential for the development of the nervous system, the optimum functioning of the immune system (SIMOPOULOS 2006). Furthermore, moderate levels of fat in the blood; regulate blood pressure, thus enabling them to reduce the risk and progression of heart or blood vessel disease coronary heart disease (SCHACKY 2010).

However, mammalian body is not able to convert the n-6 fatty acids to n-3 fatty acids, due to the lack of the necessary n-3 desaturase, thus should receive the appropriate quantity through food. In the human body, linoleic (LA) and α-linolenic acid (ALA) compete for metabolism provided by Δ6-desaturase. They believe that it is important for health because of excessive intake of LA Δ6-desaturase reduce the amount of ALA metabolism, which may increase the risk of heart disease.

150 years has shown that parallel with the growth of n-6 fatty acid intake and the decrease of n-3 fatty acids, the number of heart diseases has been increased. Thus, it evolved the concept of the ideal ratio of dietary n-6/n-3 fatty acids.

With the consumption of the two main sources of Mediterranean countries - olive oil and marine fish – the optimum ratio of LA and ALA, or n-6 / n-3 ratio (1:1-4:1) is adequate in nutrition. This helps to lower cancer mortality in these countries. In our country, linoleic acid and α-linolenic acid ratio has shifted unfavorably (15:1-17:1) because of the high linoleic acid contented sunflower oil and low fish consumption (SIMOPOULOS 2002, 2008).

Fish body is well suited to show the influence of feeds on fatty acid composition of fish (STEFFENS 1997). In Hungary, fat and fatty acid content of common carp (*Cyprinus carpio* L.) cultured in farm conditions has been examined since 1970' fatty acid and lipid content values from the 1970s (FARKAS and CSENGERI 1976, CSENGERI 1996a, 1996b).

1.1 Objectives

The primary objective of my work was to analyze meat of common carp reared in Hungarian pond farms, on the other hand to compare analysis of fatty acid composition of fillet and diets. In particular, the objectives were set out additional tasks:

1. To determine how feeding of diets containing vegetable oils but different content of fat affects production parameters in fish and fish meat composition.
2. The diets contain same amount of fat but different vegetable oils causes any difference in fish body composition and fatty acid profiles of carp fillets.
3. To compare rearing and feeding in different systems and analyzing fish body composition and fatty acid profile.
4. To investigate the possibilities of practical use.

2. MATERIALS AND METHODS

2.1 Feeding experiments and methods

In the dissertation, meat quality was examined of common carp reared in pond, and four feeding experiments were carried out.

The experiments by the production structure were the followings:

1. **Study of conventional fish farms:** Analysis of natural feed and conventional fodder based feeding of three year old common carp (hereinafter referred to as Pond experiment).
2. **Experiment on a conventional fish farm:** Analysis of natural feed and conventional fodder – extracted rapeseed meal and semolina (1:1 ratio) mixture - based feeding of two year old common carp (hereinafter referred to as Pond pre-experiment).
3. **Experiment in a recirculation system:** Analysis of different vegetable oils in diet effecting three year old common carp parameters (Experiment in intensive system).
4. **Experiment in an intensive and conventional production system:** Analysis of extracted rapeseed meal and semolina mixture based feeding of two year old common carp reared in cages in pond (Experiment in a semi-intensive system).

2.2 Introduction of parameters of each experiments

Experiments were done at Zalaszentgrót fish farm of Tógazda Co.; Department of Aquaculture, Faculty of Agriculture and Environmental Science of Szent István University; Centre of Aquaculture and Aquatic Ecology, Faculty of Animal Science, Kaposvár University. Chemical analysis (diet and fish meat) was done at National Institute for Food and Nutrition Science, Department of Food Chemistry and Analysis.

2.3 Introduction of 'Pond experiment'

Market size common carp from five different Hungarian fish farms were collected and analysed in order to compare their diet supplemented with cereals and their meat quality. The following fish farms were involved in the experiment: Aranyponty Fishing Inc., Attala Haltermelő és Értékesítő Co., Hortobágyi Fish Farm Co., Körösi Fishing Co., Tógazda Halászati Co. Measurements of samples from the carp from each fish farms were marked randomly called C1-C5. Each fish farm was processed and analyzed 10-10 dining sized carp. A 20-20g sample of each individual from dorso-lateral portion was taken, until analysis samples were kept in -27°C. Lipid content, fatty acid, lipid peroxidation parameters (MDA, dien) and heavy metal contents (iron, copper, zinc, manganese) were assayed.

2.4 Introduction of 'Pond pre-experiment'

Two lakes with the size of 3 ha of Zalaszentgrót fish farm of Tógazda Halászati Co. were used in a feeding experiment in July. One lake was fed with wheat grid only, the other one was fed with extracted rapeseed and wheat grid mixture (50:50%) and the natural yield of the lake was counted. Lipid content, fatty acid, lipid peroxidation parameters (MDA, dien) of fish meat, fat content and fatty acid profile of diet were assayed.

2.5 Introduction of 'Experiment in intensive system'

After preventive bath treatment of two-year-old carp from Rétimajor fish farm of Aranyponty Fishing Inc. were transported to recirculation system of Kaposvár University. The experiment was conducted in a 10 m^3 useful volume recirculation system for 42 days with 162 carp. I placed 18 fish per tank (density: 19.7 ± 1.2 kg/m^3).

Food pellets used in the experiment was produced at Haltáp Ltd., Szarvas, and the Department of Animal Nutrition, Kaposvár University was re-produced the pre-agreed formula of experimental feed. Before treatment, the feed (‘T’ feed) had a 37% protein, 6% fat content and was a 3mm particle tilapia feed.

The pelleted ‘T’ feed was divided to three groups and linseed (‘L’), sunflower (‘N’) and soybean oil (‘Sz’) were supplemented to 12% fat content. Feeding occurred three times per day. During the experiment, individual measurements were made (body length, body weight) on the 0. and 42. day. After weighing, fish were selected from each group at random for samples for chemical analysis, which were stored at -27 ° C until analysis. Lipid content, fatty acid, lipid peroxidation parameters (MDA) of fish body and fillet, and dry matter, ash, protein, fiber, fat content and fatty acid profile of diet were assayed.

2.6 Introduction of ‘Experiment in a semi-intensive system’

The experimental population was two summer old mirror carp, which is transported from the lake of Aranyfácán Co., Hatvan. After preventive bath treatment (0.5% NaCl) fish were introduced to cages and were fed with commercial tilapia feeds until beginning of experiment.

During the experiment, 16 carp were kept in each cage and were fed for 42 days by automata feeders, which were running for 8 hours per day. Three cages of carp were fed by semolina and *chironomus* mixture (98:2 ratio), while the other three cages got semolina, extracted rapeseed meal and *chironomus* larvae mixture (49:49:2 ratio).

During the experiment, each water quality parameters such as water temperature, oxygen level and oxygen saturation were measured twice a day, pH, conductivity, the oxygen balance, ammonium, nitrite, nitrate ion and ortho phosphate ion concentration were measure once per week. Lipid content, fatty acid, lipid peroxidation parameters (MDA) of fish body and fillet, and dry matter, ash, protein, fiber, fat content and fatty acid profile of diet were assayed .

2.7 Sampling and chemical analysis used in the experiments

2.7.1 Fish sampling

At the end of the experiment, fish were euthanized with an overdose of anaesthetic clove oil, with the permission of "Feeding and rearing experiments done on different kind of fish species" denominations, of 28 March 2008., 243/1998. Government Regulation No 1 under Annex given by Budapest and Pest County Agricultural Office, Food Chain - Safety and Animal Health Directorate, Health and Welfare Department.

2.7.2 Chemical analysis

- Determination of main nutritional components and lipidoxidation parameters were done at National Food and Nutrition Institute, Food Chemistry - Analytical Department and at the Department of Animal Nutrition, SZIU. Following methods were used:
- *Determination of dry matter content drying in oven to constant weight, 105ºC;*
- *The crude protein content was determined by the Kjeldahl method (MSZ ISO 937:2002),*
- *Determination of crude ash content cremation,*
- *Determination of crude fiber content of the feed enzymatic hydrolysis (MÉ 3-2-2008 / 1 II. m.);*
- *Determination of fat content by FOLCH et al. (1957) and Soxhlet extraction (MSZ ISO 1443:2002),*
- *The fatty acid composition determination (sample preparation according to MSZ 19928-86; gas chromatographic analysis MSZ ISO 5508:1992;*
- *Determination of micronutrient content (MSZ EN 14084:2003 6.4.2).*
- *Determination of conjugated diene (AOAC 1984) and malondialdehyde by MENOYO et al. (2003).*

2.8 *Statistical methods*

Data were analysed by SPSS 21.0.0, 2012 for Windows program discriminal analysis. Tukey post hoc test and two sample t-test were used for data evaluation of fatty acid and chemical composition of fish fillet, depending on the results of ANOVA, ($P<0,05$), a Test of Homogeny. The conclusions are found in all cases at 95% confidence level.

The standardized principal component analysis (PCA) PAST (ver. 2:12) software was used to the assessment of the spatial relationship between the variables.

3. RESULTS

3.1 Result on 'Pond experiment'

3.1.1 Results for total fat content

Statistically significant differences were found at total fat content. The highest value (23.77 ± 4.06 g/100g) was measured in pond fish sampled at C5 farm. It can be concluded that a large amount of corn was consumed by carp from C4 and C5 fish farm during the harvest month, this caused more fat deposition.

The C4 and C5 fish farms fed their fish 1500 kg/ha/day corn in October. Fish taken from C1, C2, and C3 farms showed lower fat content, since these farms fed less supplemental feed in the last two month. The C2 farm did not use additional feed grain, while C1 company (first two weeks of October) and C3 company only a minimum quantity fed wheat in October.

3.1.2 Result on fatty acid profile of common carp from each fish farms

Ratio of saturated and unsaturated fatty acid was significantly in composition of fatty acid profile of carp from each fish farms. Out of saturated fatty acids, palmitic acid and stearic acid had the highest value. There was a significant difference between saturated stearic acid and unsaturated oleic acid in carp meat of fish farms. Fish from C1 and C2 farms showed the lowest value both fatty acids.

All the major PUFA fatty acids showed significant differences in carp from each fish farm. EPA (C20: 5n-3) and DHA (C22: 5n-3) show beneficial impact on the health, these omega-3 fatty acids had a very large difference between treatments ($P < 0.05$). The EPA for C1 (4.01 ± 1.60%) group differed from mean value of C4 (0.62 ± 0.21%) and C5 groups (0.14 ± 0.27%) results. DHA (2.98 ± 0.96%) value in C2 fish group was a multiple of the group average value of C4 (0.41 ± 0.16%) and C5 (0.14 ± 0.2%). The amount of omega-3 fatty acids spread from 1.23 to 11.11%, and the nutritional important n-6/n-3 ratio showed a statistically significant difference between the C1-C3 and C4-C5 farms.

3.1.3 Result on micronutrient content of carp from each farms

Iron, copper, zinc and manganese content of common carp from C1-C5 ponds was 1.02-5.21 respectively, 0.29-0.65; 5.15-10.1 and 0.11-0,14 μg/g values. The measured iron, copper and zinc have much lower values than those of the international nutrient data table.

3.1.4 Result on the lipid peroxidation values of carp from each farms

Values of lipid peroxidation parameters were the followings. Conjugated diene characteristics are varied 0.16-5.60 mmol/kg; and malondialdehyde values were between 6.66-21.92 mmol/kg. The carp of C3 farm had lowest value, while the C5 farm was highest. Relationship between micronutrient content and lipid peroxidation parameters were statistically analyzed. A significant correlation exists between the iron content and conjugated dienes, and the copper content and the amount of conjugated dienes, although the connection is medium ($r = 0.480$ and $r = 0.499$, $p <0.05$).

3.2 Result on 'Pond pre-experiment'

3.2.1 Result on growth parameters

Statistically significant difference between body weights was found between the specimens caught from the two lakes at beginning of the experiment. The cause should be the different age of fish living in the ponds. The experimental feeding started in July when the lake had a high temperature (23 ± 3 ° C) and low oxygen levels.

In addition, the mass remaining uneaten protein-rich feed water quality deteriorated over a large amount of extracted rapeseed meal feeding. Water quality if first lake was degraded after four weeks. The company of fish farm stopped the experiment in attempt to save fish health. Thus, instead of the proposed 60 days 32 days were examined. On the day of 32, data was recorded but data was not statistically different from the values measured at the beginning of the experiment, for the first and second values of lake. Still it was concluded that the fish fed with wheat SGR ratio was higher than the semolina-extracted canola meal fed a mixture.

3.2.2 Result on fat content and fatty acid profile of common carp from two ponds

Fish from the two lakes showed low difference in fatty acid profile. Between two sampling there was significance difference in fatty acid composition within one lake. During first sampling erucic acid, eicosatetraenoic acid, docosapentaenoic acid and docosahexaenoic acid were not detectable.

The stearic acid (C18: 0) and oleic acid (C18: 1n-9) ratio was significantly reduced in both groups. Linoleic acid is statistically differed from samples of the two lakes; linoleic acid content of lake fed with semolina has increased.

3.2.3 Result on fish fillets lipid peroxidation parameters

Conjugated diene and malondialdehyde concentrations of examined carp fillets showed no significance difference ($P>0.05$) between the groups.

3.3 *Results on 'Experiment in intensive system'*

3.3.1 Composition of experimental feed

There was a significant difference between control feed (T) and the three experimental feed's fat content. Tilapia feed with 6% fat content was supplemented with linseed (L), soybean (Sz) or sunflower oil (N) to 12% fat content.

3.3.2 Result on growth parameters

Body weight and body length measured at start and end of experiment differed for each treatment however there was no statistically detectable difference. Each group increased to the same extent, as evidenced by the SGR index, which is not different from any statistically significant extent one group.

3.3.3 Result on experimental fish body composition

In terms of body composition, the dry matter and crude fat content did not differ between each group at the start and end of experiment the measured values. Diet supplemented with soybean oil fed carp meat was significantly higher in crude protein and fat, but the crude ash content was lower than the control diet and other two treatment groups. Total fat and fillet fat content of fish consuming the diet supplemented with sunflower oil had the lowest, but the difference was not statistically justified.

3.3.4 Result on fatty acid profile of experimental carp

It was concluded that all the feed supplemented with oil caused difference in fish meat fatty acid composition. The monounsaturated oleic acid content was highest in the control group, then after experiment each group had low amount despite the fact that the oleic acid content was present in all three feed ration in very high amount. The linoleic acid content showed a statistically higher value in the case of sunflower oil (N) and soybean oil (W) fed enriched groups, while α-linolenic acid was significantly reduced in these two groups ($p < 0.05$).

From polyunsaturated fatty acids, the physiologically important fatty acids EPA and DHA have shown statistically significant differences among the treatments. EPA (C20: 5n-3) was significantly different in the diet supplemented with soybean oil-fed group (0.48 ± 0.11%), while the most valuable fatty acid, DHA (C22: 6n-3) was exceptionally high (1.14 ± 0.7%) in this group, while at other group was not detectable at all.

The total PUFA content was significantly higher in the sunflower oil and soybean oil-fed groups compared with the baseline values of the samples. There was omega-6 fatty acids in the diet supplemented with sunflower oil and soybean oil fed fish meat significantly justifiable degree. The nutritional importance n-6/n-3 ratio showed a statistically significant difference between sunflower oil and soybean oil fed fish.

3.3.5 Result on fish fillets lipid peroxidation parameters

MDA values of starting sample and the soybean oil enriched carp fed showed the most significant difference, although the degree was not significant ($p = 0.061$). All groups had a higher MDA values in the second sampling then the first time.

3.4 Results on 'Experiment in a semi-intensive system'

3.4.1 Result on growth parameters

The experimental groups (extracted rapeseed meal and semolina mixture, and semolina) increased body weight during the experiment (42 days) showed no statistical difference. The weight gain and condition factor did not differ at the starting values or measured at the end of the experiment.

3.4.2 Result on body composition and fatty acid profile of experimental fish

In terms of body composition, fat showed a significant increase in both groups compared to baseline. All the parameters of body composition was increased during experiment (42 days) in both groups. However, because of low number of sampled fish there was no significant difference between the two groups in protein, crude ash and dry matter content.

The monounsaturated oleic acid showed no significant difference between treatment groups nor the starting samples. The n-3 and n-3/n-6 fatty acid ratio statistically decreased in both groups compared to the control group.

3.4.3 Result on fish fillets lipid peroxidation parameters

There was no statistical difference ($p > 0.05$) in the MDA values for the groups studied.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion of 'Pond experiment'

4.1.1 Conclusions from fat content results

The study results support the previous observation that the one-sided, especially high-energy content corn feeding in the last two months promotes a significant amount of fats in fillets. It can be concluded that in harvest month, a large amount of corn consumed in the C4 and C5 farms causes more fat to deposit. In the results, fish from C4 fish farm had been fed by corn and wheat before the harvest month in the ratio of 1:1, respectively, compared with the C5 farm where fish got doubled amount. Thus, the fat content of fish (10.65 ± 2.65%) is almost identical to VACHA et al. (2007) described that wheat addition of carp fed values was 11.22%.

4.1.2 Conclusion of fatty acid profile

Oleic acid was the highest fatty acid in fish fillets of carp, mainly in the fish reared on C4 and C5 farms, it can be explained by accumulation of fillets fed large amounts of grain and corn with high starch content can be explained. When extensive technology is used: the less supplementary feed was fed to pond of farm, and fish could eat more natural food in lakes like at C1 and C2 farms, were higher in polyunsaturated fatty acid in fish meat, ie the amount of n-3 fatty acids (C1: 11.11 ± 3.00%; C5: 1.23 ± 0.84%). Not so the nutritional value is important α-linolenic acid (C1: 3.45 ± 0.51%; C5: 0.78 ± 0.43%). Desaturation and elongation of common carp can convert linoleic and α-linolenic acid to polyunsaturated n-6 or n-3 fatty acids by the use of Δ5 and Δ6 desaturase enzyme (Steffens 2007). In addition, the majority of n-3 PUFA fatty acids are found by carp in natural food in the lake, mainly in plankton and benthos (ADAM et al. 2004). Fish from C1 and C2 farms showed the highest accumulation of DHA, and consequently the degree of n-3 fatty acids in these was the largest.

However, a lower amount of linoleic acid was measured at fish reared at C4 and C5 farms, it was insufficient to convert it to arachidonic acid and docosapentaenoic acid. According to TAKEUCHI (1997) for carp n-6 and n-3 fatty acid requirement is between 0.5-1.0%.

The C1, C2, C3 from fish farms in n-6/n-3 ratio approaching this limit, however, the C4 and C5 from fish farms is significantly higher than the recommended value. The n-6/n-3 ratio is important not only for fish, but also to human health aspect is interesting.

4.1.3 Conclusion of micronutrient content of carp

Iron content of meat is prominent in the trace elements, because iron plays a central role in the building of red blood cells, the body's oxygen supply. Zinc also occurs in the meat in large quantities, which is involved in the functioning of the enzymes, provided the integrity of the cell, regulates muscle contractility (MÉZES 1997). Our examination showed that the studied micronutrients have lower values compared to CSENGERI et al. (1999) measured values, both samples from natural waters and freshwater ponds.

4.1.4 Conclusion of fish fillets lipid peroxidation parameters

There were no correlation between malondialdehyde and conjugated diene values. Significant correlation was detected between the iron content and conjugated dienes, and the copper content and the amount of conjugated dienes, which was caused probably by the lipid peroxidation when iron complex is degraded and the iron is released (BALLA et al. 1991).

4.2 *Conclusion of 'Pond pre-experiment'*

4.2.1 Conclusion of fatty acid profile and fat content

Since the beginning of the experiment have found significant difference in body weight of fish from the two lakes, it is difficult to draw any conclusion about the weight gain. The fatty acid of experimental feed was significantly different in composition: palmitic acid, palmitoleic acid, oleic acid, linoleic acid, α-linolenic acid content. The content of extracted rapeseed meal and semolina mixture of oleic acid was four times larger than the semolina. The oleic acid in experimental fish was reduced but eicosatetraenoic acid increased. GLENCROSS et al. (2003) obtained similar results, it was found that weight gain was decreased in the group of rapeseed oil-enriched diets fed bass, but the fillet fatty acid composition was favorable for positive values of rapeseed oil.

4.2.2 Conclusion of fish fillets lipid peroxidation parameters

The experimental feeding did not induce significant differences in the conjugated diene and MDA values. Likely that during the short period of the fish did not get sufficient quantities of the feed, the contents of fatty acids were not incorporated into the fish's body.

4.3 Conclusion of 'Experiment in intensive-system'

4.3.1 Conclusion of fatty acid profile and fat content

The experimental groups consumed three-enriched vegetable oil (linseed, sunflower and soybean oil) diets. The treated feeds, expressed as a percentage of total fatty acid values of oleic acid, linoleic acid, α-linolenic acid showed significant differences. Crude fat content of the starting tilapia feed with additional 6% fat content influenced the feed intake. It can be concluded that in the experiment each group has taken feed supplemented with extra vegetable oil.

The experiment lasted for 42 days; this time was too short for a greater difference in weight gain with an average body weight of 1000 grams of carp. While, in many experiments large amount of fatty acids in the diet added resulted in a weight loss (NG et al. 2001; DU et al. 2008) until each group's weight and body length is increased in the present experiment. Crude protein and fat content were significantly the highest in fish fed with soybean oil supplemented diet.

One of the most precious is DHA (C22:6n-3), which was very high in soybean oil-fed group (C), while at the other group it was absolutely not detected.

The n-6/n-3 ratio in the flesh of fish fed with linseed oil diet was closest to the most appropriate value, so these carp fillet are the most valuable nutritional meat.

4.3.2 Conclusion of fish fillets lipid peroxidation parameters

Since vegetable oils rich in unsaturated fatty acids sensitive to oxidation a (TURCHINI et al. 2009), therefore I have analised MDA value. Lower value of MDA in fish treated with sunflower oil clearly shows that it is less susceptible to oxidation. A soybean oil enriched diet resulted in higher values of MDA in ‘Sz’ group, while the best value in lipid peroxidation was presented by fish fed with sunflower oil-treated diet. These values mean a longer shelf-life for fish meat, although not statistically significant differences were detected ($p > 0.05$).

4.4 Conclusion of ’Experiment in a semi-intensive system’

4.4.1 Conclusion of fatty acid profile and fat content

In the experimental lake plankton population could be found during the 42 days, beside *chironomus* larvae were given for experimental groups. It was necessary that natural condition and feed would be simulated beside wheat and rapeseed diet for common carp. The experimental groups grew during 42 days, groups fed by extracted rapeseed diet did not show negative growth and despite high rate of rapeseed fish did not reject it (49% extracted canola meal, 49% wheat meal, 2% *chironomus* larvae). α-linolenic acid content in extracted rapeseed and semolina experimental diet was 9.3% , and n-3/n-6 ratio was 0.31%. Results of PICKOVA and MORKORE (2007) were consistent with these values. At the end of the experiment, EPA was higher in fillet of extracted rapeseed enriched fed carp as a percentage of the total fatty acid values, but there was no statistically verifiable differences between the treatments.

4.5 Recommendations

- In pond carp production, fish should be fed by feed forage mixture containing low saturated fatty acids before two months of harvest in according to sufficient fatty acid composition and fat content. It also depends on plankton amount at autumn season.
- DHA fatty acid was observed at the fillet of group fed with feed enriched with 6% soybean-oil while the other groups showed no detectable amount. Consequently, I suggest increasing the amount of supplementation more than 6% of vegetable oils to achieve the appropriate fatty acid composition profile in the fish fillet, and more long-term feeding test.
- More experiments should be done with a mixture of 3-3% soybean, linseed and rapeseed-oil mixture. Both meat quality and lipidperoxidation parameters should be measured.
- Furthermore, antioxidant should be added to any feed contains vegetable oils in according to oxidative stability.

5. NEW SCIENTIFIC RESULTS

1. I have proved that carp feeding in the last two months before harvest in pond farms significantly influence fat content and fatty acid composition. Maize and triticale forage feeding mixture containing extremely low in saturated fatty acids leads to carp fattening and polyunsaturated fatty acids in decline.

2. In an intensive system common carp fed with soybean oil enriched feed had the highest value of crude protein and crude fat content in fillet and fish body during the 42-day experiment. I found that the soybean oil-treated carp fillets had 1.14 ± 0.74% DHA (C22: 6n-3), while the linseed oil or sunflower oil-treated feeds for carp was no detectable amount.

3. The ratio of n-6/n-3 in fillet of carp fed with linseed oil enriched fed was the most suitable with 3:1 rate with a 6% fat enrichment. This rate was 5:1 in carp fillet fed with soybean oil enriched feed, while 7,5:1 in carp fed with sunflower oil enriched feed.

4. I have proved that carp growth and meat quality parameters have not decreased during feeding experiment with vegetable oil enrichment diet (6% supplementation) in intensive system. 6% of soybean oil and linseed oil containing high polyunsaturated fatty acids in the fish diet provides valuable nutrients for carp.

5. During my research I determined that a diet containing 6% vegetable oil supplementation with higher PUFA fatty acids did not significantly affect the concentration of MDA in fillets of common carp. However, the shelf-life of carp meat is negatively affected by decreasing its oxidative stability.

6. I found that feeding of common carp with extracted rapeseed (50% rate in diet) is undesirable in a semi-intensive system, since both water quality and fish growth parameters are negatively affected of the high amount of vegetable rate.

Publications related to the topic of the Dissertation

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