EFFECT OF ADDITION OF MANNAN OLIGOSACCHARIDES AND ORGANIC ACIDS IN THE FEED ON CARP (*Cyprinus carpio* L.) FLESH COLOUR CHARACTERISTICS, TECHNOLOGICAL AND SENSORY PROPERTIES

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Abstract. The aim of this study was to analyse the influence of addition of mannan oligosaccharides (MOS) and organic acids (OA) in the feed on carp flesh colour characteristics, technological and sensory properties.

Carp feed was enriched with 0.2% mannan oligosaccharides (group 2) and composition of 0.2% MOS + 0.2% OA (group 3). Group 1 was fed with compound feed only and was analysed as control.

The results showed that MOS and OA practically had no influence on pH or cooking loss of carp flesh. Colour characteristics such as lightness (L*), yellowness (b*) and colour intensity (C) were not affected by carp feed composition, but the addition of MOS or MOS + OA increased the redness value (a*).

Muddy odour and taste were most intensive for the control samples, while the addition of the supplements to carp feed decreased intensity of this characteristic. Muddy flavour is common for freshwater fish grown in different ponds, but as it is unpleasant for some consumers, more detailed investigation is necessary with the aim to analyse the possibility to use MOS and MOS + OA for elimination of this flavour.

Other sensory properties were not affected by feed compositions; thus, the analysed supplements can be added to carp feed without altering carp flesh quality.

Keywords: carps, mannan oligosaccharides, organic acids, flesh, quality, colour, sensory attributes

Introduction. Fishery is a sector of economy that has long traditions and experience in Lithuania. Aquaculture and fish processing activities create a significant number of jobs in different regions of Lithuania. Economic viability of fisheries and the aquaculture sector is closely related to the sustainable use of marine and inland water resources, fisheries resource management, conservation and restoration, environmental compliance, rational planning and maintenance (Masiulienė et al., 2013).

In Lithuania, the most common aquaculture ponds mainly produce carps: in 2013, carp realisation comprised 89% of the realised production in the aquaculture sector and 80% of its value (LR ŽŪM, 2014). This species is the oldest fish introduced into ponds in Lithuania. It is believed that they originated in Lithuania in the 17−18th century (Pečiukėnas, 2006).

Lithuania produces compound feed for carps, but the effect of feed modification by different concentrations of added prebiotics (mannan oligosaccharides) and organic acids on carp meat quality and sensory properties has not been investigated. However, other research studies show that different amounts of the MOS injection into the feed give a positive effect on the growth rate of carps (Staykov et al., 2005; Culjak et al., 2006). Organic acids also have a positive effect on the body of carps. They have been long used as a feed supplement, which promotes animal health and productivity. Organic acids promote protein and improve digestibility of amino acids, absorption of minerals, digestive tract microflora composition and morphology of the intestinal mucosa. Organic acids increase the activity of enzymes, reducing the pH value of the digestive tract, while inhibiting ammonia and biogenic amines. Organic acids are used in fish compound feed and bring positive results (Khajepour et al., 2012; Lückstädt, 2008).

The aim of this study was to analyse the effect of addition of 0.2% of mannan oligosaccharides and composition of mannan oligosaccharides with organic acids in compound feed on carp flesh colour characteristics, technological and sensory properties of carp flesh.

Materials and methods.

The object of the research is carp meat. Carps were grown in the same ponds (0.9 hectares). Group 1 (control) was fed only compound feed. The feed in group 2 (experimental) was supplemented with 0.2% of mannan oligosaccharides (MOS), and in group 3 (experimental) with 0.2% of mannan oligosaccharides (MOS) + 0.2% of organic acids (OA).

For the research purposes, 900 carps of 1 year old were selected. Their average weight was 104 g. All carps were Šilavotas x German crossbred. Carps were added in ponds in April 2014 and were taken out in October 2014 at the end of an intensive feeding period. For slaughter, 10 carps of each group were selected randomly.

As the source of mannan oligosaccharides, prebiotic Agrimos® − specific mannan oligosaccharides (MOS) and glucose (beta-glucan) combination – was used, which was obtained from Saccharomyces cerevisiae yeast of cell walls. Agrimos® was obtained from autolysed yeast cells at high temperature and pH control. After autolyses of yeast, the cell wall and yeast extract are centred for separation, and the cell walls are dried. Agrimos® is pale yellowish brown powder, stable in all types of animal feed: flour, granules and liquids.

Lumance ® was used in a mixture of organic acids.

Table 1. **Nutrition value of compound feed for carps**

Composition	Feed composition		
Group	1	2	3
Dry materials, %	88.74	88.74	88.32
Crude proteins, %	20.18	20.18	20.00
Crude fat, %	4.78	4.78	4.00
Crude ash, %	5.40	5.40	5.14
Crude fibre, %	4.59	4.59	4.50
Mannan oligosaccharides (MOS)	-	0.2	0.2
Organic acids (OA)		-	0.2

Table 2. **Composition of feed additive LUMANCE®, %**

Composition	%
Butyric acid	8.070
Propionic acid (E 280)	4.380
Sorbic acid (E 200)	1.250
Low molecular weight saturated fatty acids (capric, caprylic acids)	4.000
Lauric acid	4.000
Essential oils	1.470
Substances of herbal extracts	2.250
Natural resins of herbal substances	0.800
Yeast (*Saccharomyces cerevisiae*)	10.00
Anti-caking agents: kremnezem, talc, bentonite	23.500
Carriers: fatty acids and glycerine, maltodextrin	40.280
Total:	100

Each pond was supplemented with 900 one-year old carps. After 198 days of feeding, carps were fished out. For further research, 10 carps of each group were randomly selected.

The experiment was carried out at the Lithuanian Ministry of Agriculture Fisheries Service Inland and Aquaculture Department Šilavotas section, Animal Productivity Laboratory of the Lithuanian University of Health Sciences Veterinary Academy, and Laboratory of Sensory Analysis of Kaunas University of Technology Food Institute.

pH of meat was measured by pH-meter InoLab 730 immediately after carps were slaughtered.

Colour characteristics of the raw and cooked samples were measured using a CR-400 handheld chroma meter (Konica Minolta), calibrated with white plate. Random readings, each average of 3 measurements, were taken at 3 different locations on the freshly sliced samples. The measurements were averaged and the colour of each sample was expressed in terms of CIELAB values for L* (light/dark), a*(red/green) and b*(yellow/blue), and from these values colour intensity C and hue angle h were calculated as follows:

$$C^*=((a^*)^2+(b^*)^2)^{1/2}$$

$$h_{ab}=\arctan (b^*/a^*)$$

For thermal treatment, the samples were placed into aluminium foil, baked in a convection oven (METOS CHEF40) with steam at 210°C for 20 min. The baked samples were sliced into 8 slices and each slice was wrapped into aluminium foil and then placed in a plastic box coded by 3 digital numbers. The temperature of meat during sensory analysis was about 55°C. Water, warm tea and unsalted bread were provided to clean the palate between evaluations of the samples.

Quantitative descriptive sensory analysis (QDA) was carried out with the baked carp flesh samples. A sensory panel consisted of 6 assessors (staff of KTU Food Institute) with experience in sensory evaluation of food. The assessors were selected and trained according to ISO 8586. A structured numerical scale was used for evaluation of the intensity of each attribute. The left side of the scale corresponding to the lowest intensity of an attribute was given value of 1, and the right side corresponding to the highest intensity was given value of 15. All sessions were conducted in a climate-controlled sensory analysis laboratory equipped with individual booths. The assessors were instructed to clean the palate with water or tea between evaluations of each sample. The samples were presented to the assessors monadically. A data collection system for automatic acquisition of the assessors' scores and data analysis was used (FIZZ, Biosystems, France).

Cooking losses were measured for the samples prepared for sensory analysis, by cooking them packaged in foil in a convection oven at 210°C for 20 min. The flesh samples were weighed, cooked, cooled at room temperature and weighed again. Cooking loss was calculated as a percentage and calculated as (initial weight-final weight) / (initial weight) ×100.

Data analysis. An analysis of the variance was used to determine if there were significant differences among the properties of the carp meat samples. The differences were classified by the Duncan multiple comparison test ($P < 0.05$). SPSS software, version 15.0 (Chicago, IL, USA, 2006), was used for the statistical analysis of the sensory data.

Results and discussions

Live freshwater fish pH depending on variety ranges from 6.9 to 7.3 (U.S. Food and Drug Administration 2015). Fish meat pH decreases due to decomposition of glycogen and lactic occurrence (Susanto et al., 2011). Meat pH is an important qualitative indicator of longer storage options and some technological properties (Jukna et al., 2007).

The results of pH measurements in our experiment showed that the tested samples did not differ in relation to the changes in carp feed composition (Table 3). The determined pH values were similar to those presented by other authors, although some pH differences regarding the used stunning method (Daskalova, Pavlov, 2015), duration and conditions of storage (Puchala et al., 2005), or carp strains (Varga et al., 2010) were detected in these studies. From our and other researchers' observations, it is clear that pH values of carp flesh vary between 6.4 and 6.8.

Table 3. **Effect of feed additives on carp flesh quality parameters**

Parameter	Groups		
	1	2	3
Cooking losses, %.	17.36	17.66	15.50
pH value	6.70	6.68	6.49
a, b - Means within a row with different superscript differ significantly ($P < 0.05$)			

During thermal treatment, especially during baking, nutrient content in fish is altered in comparison with raw material: content of vitamins and some minerals decreases, but protein bioavailability increases (Severi et al., 1997).

Water holding capacity is a very important factor, affecting technological properties such as yield of the final product. The cooking loss percentage of the carp flesh samples did not differ significantly between all the tested groups (Table 3) and varied by about 16−17%. These data are in agreement with values determined in other studies: cooking losses for Hungarian carps vary between 14.7% for Hortobágy lean to 21.4% for Attala mirror (Varga et al., 2010). It has been noticed that water holding capacity of carp flesh is relatively low (Varga et al., 2010), especially in comparison with other fish species. Similar values of cooking losses have been found for other representatives of the carp family, e.g. the cooking loss for grass carps (Ctenopharyngodon idella) is 12−15% (Hua-Fu Zhao et al., 2015). Wide variation in water holding properties of carp muscle samples has also been described in other studies (Varga et al., 2010), but water holding capacity is similar to that determined in European catfish (about 68%, Fauconneau et al., 1996).

Colour of the product is one of most important criteria for consumers during selection of a suitable product in a supermarket, as it is a good parameter of expected freshness and quality, especially of meat (Garmienė et al., 2010).

Table 4. Effect of feed additives on carp flesh colour characteristics

Colour characteristic	Groups		
	1	2	3
L*	45.11±2.08	45.83±1.11	43.15±2.10
a*	2.82±0.63 ^{a}	4.26±0.22 ^{b}	5.05±1.69 ^{b}
b*	2.41±0.65	3.46±0.18	2.95±1.21
h	0.70±0.05 ^{b}	0.68±0.04 ^{b}	0.52±0.04 ^{a}
C	3.71±0.89	5.49±0.17	5.85±2.07
a, b - Means within a row with different superscript differ significantly ($P < 0.05$)			

Colour characteristics (Table 4), such as lightness (L*), yellowness (b*) and colour intensity (C), were not affected by carp feed composition. The addition of prebiotics or mixture of prebiotics with organic acids increased the redness value (a*) ($P < 0.01$). Changes in the hue angle value (h) were detected only for group 3 samples, which was lower in comparison with other samples. Other studies have revealed similar values of lightness 44.13 ± 1.59 for raw carp flesh (Abdelaal et al., 2014), but the values of other colour characteristics have not be found different from those determined in our study (a = 8.47 ± 1.60, b = 11.58 ± 1.34).

The mean values of intensities of sensory properties are presented in Table 5. All the tested samples had an intensive overall odour with a very clearly expressed odour typical of fresh fish with some hue of sweetness.

Muddy odour and taste were most intensive for the control samples (Table 5), while the addition of the supplements to carp feed decreased intensity of this odour. Muddy flavour is common for freshwater fish grown in different ponds: carps (Persson, 1980), bighead carp (Zhang et al., 2016), etc., and is not very pleasant to consumers. Therefore, continuous studies are carried out with the aim to eliminate this flavour.

As muddy odour is common for fish of such species, it was not included in descriptor 'non-typical odour' and was analysed separately. All the analysed samples were free from non-typical odour.

The colour of carp flesh and especially homogeneity of the colour are important criteria for consumers if they choose fillets. Group 2 samples (feed with prebiotics) had the most homogeneous colour (Table 5).

Firmness of cooked flesh was analysed by several methods, and no clear tendency was determined as to which sample had the highest value. All the samples expressed juiciness, but oiliness was lowest for group 3 samples. This may have influence on different perceptions of firmness.

All the flesh samples had an intensive overall taste. Sweetness was clearly perceived and taste was clear of any non-typical taste, as sweet taste is common for pond-raised fish (Johnsen et al., 1987).

When the assessors were asked to mark if any of the tested sensory properties could affect acceptability of cooked fish (key property), there were no critical comments, and all the samples were acceptable (Table 5). The only sensory property for which carp diet composition could have a significant effect was acceptability of taste, as 'muddy' taste of the group 1 samples was sensed and perceived as most intensive.

Table 5. **Effect of compound feed on flesh sensory characteristics**

Sensory property	Groups		
	1	2	3
Overall odour	15.0 b	13.1 a	15.0 b
Odour of fresh fish	8.5 a	12.1 c	10.2 b
Muddy odour	9.3 b	6.1 a	8.2 a
Oily odour	3.2	2.9	3.1
Non-typical odour	1.2	1.1	1.1
Homogeneity of colour	5.2 a	8.1 b	5.3 a
Firmness, evaluated with fork	6.1 b	8.7 b	4.3 a
Firmness, evaluated during first bite	5.1 b	4.3 a	5.2 b
Juiciness during first bite	11.5	11.1	11.2
Firmness during mastication	4.2 a	7.5 c	5.3 b
Oiliness during mastication	6.2 b	5.3 ab	4.2 a
Chewiness	7.3 a	9.1 b	8.3 b
Overall taste	14.1 b	13.0 a	13.0 a
Sweetness	11.1 ab	12.2 b	9.7 a
Taste typical for fresh fish	12.2	12.3	11.2
Muddy taste	10.1 b	5.8 a	8.3 ab
Non-typical taste	1.0	1.0	1.0
Aftertaste	11.1	9.2	10.2
Acceptability			
Overall	14.2	15.0	14.2
Odour	14.1	15.0	14.0
Taste	13.1 a	14.8 b	14.0 b
Texture	14.2	15.0	14.1
[a, b] - Means within a row with different superscript differ significantly ($P < 0.05$)			

An organoleptic test showed that smell, taste, texture and overall acceptability were best expressed in carp meat of group 2 (Table 5) with the maximum score (from 14.8 to 15 points). However, groups 1 and 3 demonstrated good carp estimates (from 13.1 to 14.2 points). Group 2 also showed the best homogeneity of colour, firmness evaluated with a fork and firmness during mastication, chewiness, and taste typical of fresh fish. Carp meat of the control group was evaluated by maximum overall smell, but more than other groups also showed undesirable sludge smell and taste. Group 3 according to the organoleptic characteristics of the meat took an intermediate position between group 1 and group 2 parameters.

Conclusions

The feed additive for *Cyprinus carpio* did not affect the sensory and technological properties of carp flesh. The results of pH measurements in our experiment showed that the tested samples did not differ in relation to changes in carp feed composition. The cooking loss percentage of the carp flesh samples did not differ significantly between all the tested groups and varied by about 16−17%. Colour characteristics, such as lightness (L*), yellowness (b*) and colour intensity (C), were not affected by carp feed composition. Addition of prebiotics or mixture of prebiotics with organic acids increased the redness value (a*) ($P < 0.01$). Selected concentration of added supplements to compound feed did not alter flesh taste, odour, or texture, but decreased muddy taste and odour, which is unpleasant for some consumers. Therefore, the proposed supplements could be used for *Cyprinus carpio* diet as they do not decrease product sensory quality and acceptability.

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